

# Disease Specific Documents for XII Plan

*Malaria*



**INDIAN COUNCIL OF MEDICAL RESEARCH**

# Disease Specific Documents for XII Plan

## Malaria

**High Power Committee to Evaluate the Performance of ICMR, 2012-13**



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## ICMR INSTITUTES WORKING ON MALARIA

1. National Institute of Malaria Research, New Delhi (lead institute)
2. Regional Medical Research Centre (RMRC), Dibrugarh
3. Regional Medical Research Centre (RMRC), Bhubaneswar
4. Regional Medical Research Centre for Tribals, Jabalpur
5. Desert Medicine Research Centre (DMRC), Jodhpur
6. Vector Control Research Centre (VCRC), Puducherry
7. Regional Medical Research Centre, Port Blair
8. Division of Epidemiology and Communicable Diseases, ICMR Hqrs

### 1. Current situation of Disease with contribution of ICMR

Vector borne diseases pose a major public health problem in India of which malaria ranks at number one in terms of magnitude of morbidity, distribution and mortality. Before the launch of National Malaria Control Programme (NMCP) in 1953, the scourge of malaria used to cause around 75 million cases and 8 lakh deaths. The success of NMCP led to the launching of National Malaria Eradication Programme (NMEP) which brought down the cases to 0.1 million per annum with almost zero deaths by 1965. However, there was resurgence of malaria in 1976 when the incidence was reported as 6.4 million and many deaths. The country has witnessed many transformations in the National Malaria Eradication Programme from National Malaria Control Programme (NMCP) to NMEP, then National Anti Malaria Programme (NAMPA) and now National Vector Borne Disease Control Programme (NVBDCP) with periodic changes in strategies. In 1977, with the introduction of Modified Plan of Operation (MPO), the incidence of malaria came down to around 2 million cases annually which remained so till 1984. Since then the annual incidence of malaria is under two million with frequent outbreaks. The incidence of malaria cases fluctuated between 1.3 and 1.6 million per year for the past five years (2007-2011) with about 50% of *P. falciparum* cases at the national level. In the year 2011, there were 1.31 million reported cases of malaria in the country with high endemicity in Odisha, Northeastern states, Jharkhand, Chhattisgarh and Madhya Pradesh (Fig.1). About 95% population in the country resides in malaria endemic areas and 80% of malaria reported in the country is confined to areas consisting 20% of population residing in tribal, hilly, difficult and inaccessible areas. The state of Odisha with 4% of the country's population, contributes to 23% of the total malaria cases recorded in the country with disproportionate number of deaths. The western part of India particularly Rajasthan, Gujarat, Haryana, parts of Karnataka and Brahmaputra valley are epidemic prone areas.

However, the reported figure of morbidity and mortality in the country are grossly under reported (\*Dhingra *et al* 2010 *Lancet*, November 20; 376(9754): 1768–1774). In hospital based studies, case fatality rate due to cerebral malaria in M. P. was 21% while 38% in Chhattisgarh. Infant parasite rate was found more than 20% in M.P. Therefore, it is essential that countrywide epidemiological studies needs to be carried out in order to estimate the actual burden of malaria including severe malaria for guiding the national programme for effective programme planning & logistic management. It is proposed to undertake study in this direction by the National Institute of Malaria Research (NIMR) in collaboration with National Institute of Medical Statistics (ICMR) and NVBDCP.

Malaria is a complex disease determined by various factors. The variables may be categorized into four groups, *i.e.* a) Parasite load and characteristics, b) vector dynamics, C) environmental conditions like temperature, rainfall, Relative Humidity and landscape and d) population dynamics including community susceptibility to the parasite, socioeconomic conditions like migration of population due to developmental activities or natural calamities (floods,drought,earthquake,cyclones *etc*). The endemicity of malaria in different parts of the country is determined by these factors and form different ecotypes, *i.e.* rural plains, plain and hilly forest, urban, industrial and coastal. The hard core malarious areas in country fall under forest, plain and hilly forest (Fig 1). The areas which are now free from malaria due to low temperature may become suitable with the projected rise in temperature. Such ecotypes should be constantly studied in order to determine the changing receptivity of the area and vulnerability of the communities to malaria. As such the studies related to ecotypes of malaria are crucial for prediction of malaria transmission and for guiding the programme planning for appropriate interventions.

The NVBDCP at present has three pronged strategy. Early detection of malaria cases & complete treatment in order to deplete the reservoirs of infection in the community. However, the parasite susceptibility to antimalarials has been changing due to drug selection pressure. The chloroquine which was the drug of choice for the treatment of malaria for both *P. vivax* and *P. falciparum* is now ineffective against *P. falciparum* due to development of resistance. NIMR and other regional institutes of ICMR conducted regular studies on the susceptibility of the malaria parasite to antimalarial drugs which ultimately led to change in the National Drug Policy in the year 2010 for treatment of *P. falciparum*. Such studies have to be continued in different eco-epidemiological situations in order to monitor the susceptibility of the parasite to recently introduced Artemisinin based combination Therapy (ACT) as well as susceptibility of *P. vivax* to chloroquine.

Basic research on vectors and parasite related to ecology and molecular epidemiology are also crucial for understanding the mechanism of resistance to insecticides by vector and to drugs by malaria parasite for identification of target genes for further development of drug molecules.

Integrated Vector management is the strategy recommended globally which includes the use of integrated methods like, insecticides, nets, larvivorous fishes and biolarvicides *etc*. For the control of malaria vectors, different strategies have to be adopted depending upon the bionomics of the six major anopheline vectors of malaria in India which are prevalent in different eco-epidemiological types. The principal vector, *An. culicifacies*, is widely distributed in plains & riverine areas of India and contribute almost 60-65% of malaria. *An. stephensi* is the urban malaria

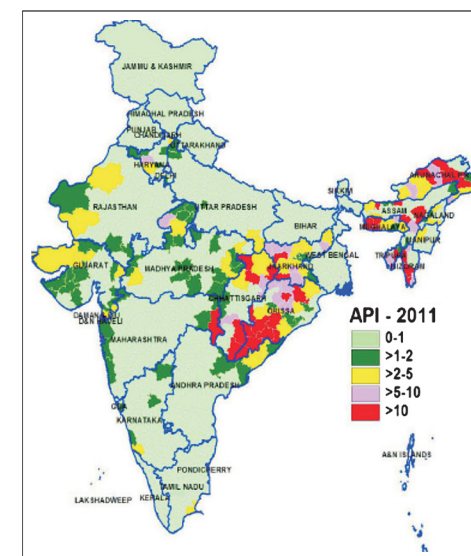
vector while *An. minimus*, *An. fluviatilis* and *An. baimii* (dirus) are the vectors of foothills, forest and forest fringe areas like NE states, parts of Odisha, Chhattisgarh, Jharkhand and M. P. However, with the change in ecology there may be succession of original vector species by some other vector species influencing the malaria epidemiology. Therefore, there is a need for the study of vector biology & bionomics in different ecological scenarios in order to suitably modulate the intervention measures.

Programme has used indoor residual spray of DDT since the inception of NMCP in 1953. However, the major vector of malaria, *An. culicifacies* has developed resistance to DDT in most parts of the country and therefore other groups of insecticides like malathion, synthetic pyrethroids were introduced in the programme after the scientific evidence generated by the NIMR and RMRCs in different parts of the country. Such studies are continuously pursued in order to determine the level of tolerance/resistance in vector species to the insecticides being used by the programme, besides carrying out studies on the vector bionomics. Since DDT has been described as a Persistent Organic Pollutant (POP) by the Stockholm Convention and has been allowed to be used for public health with some restrictions, other tools like larvivorous fishes, biolarvicides etc need to be studied and evaluated for their use in different ecotypes.

Long Lasting Nets (LLNs) have recently been introduced in the programme and gradually being upscaled in malaria high endemic areas after evaluation studies conducted by NIMR and other ICMR institutes. The effectiveness studies of the nets need to be carried out in order to provide evidence based feedback to NVBDCP for appropriate control measures.

With so many determinants and complex dynamics of transmission, one strategy does not last long which necessitates the need for research. The felt need was fulfilled by the Indian Council of Medical Research by setting up of Malaria Research Centre (now National Institute of Malaria Research) at Delhi and Vector Control Research Centre at Pondicherry in 1976. Gradually, in order to pay focused attention on local health problems including malaria, particularly in highly endemic tribal areas, Regional Medical Research Centres were also set up at Port Blair, Bhubaneswar, Dibrugarh, Jabalpur and Jodhpur (Table I and Fig 1). The various institutes of ICMR are providing scientific back up to NVBDCP in finding solution to outstanding problems in malaria control through basic, applied and operational research.

One long term project, i.e. Integrated Disease Vector Control (IDVC) project with its ten field units located in different eco-epidemiological zones of the country is running since 1986 at NIMR. The project provides technical support to national programme, local health authorities and serves as testing site for evaluation of insecticides, diagnostics and drug trials related to malaria, dengue and other VBDs. Another extramural project funded to NIMR, New Delhi is Malaria Parasite Bank was set up in 1990 is also a long term project which is a repository of around



**Fig 1.** Endemicity of Malaria in India with location of ICMR institutes engaged in malaria research

1300 cryopreserved parasites which provides opportunity for development of diagnostics and experimental studies on malaria transmission aspects etc.

In view of aforesaid background, research studies related to malaria can be categorized into:

- i). Basic Research (on parasite and vector)
- ii). Clinical Research (diagnostics, therapeutic efficacy and drug trials)
- iii). Epidemiological/Operational research (transmission dynamics, evaluation of vector control tools).
- iv). Translational Research (transfer of research outcome for use by national programme/industry/policy makers etc)

## **2. MAJOR ACHIEVEMENTS WITH LEADS EMERGED DURING XI PLAN**

### **Basic Research**

- Indigenous production of monoclonal antibodies PfHRP II and pLDH achieved.
- Micro-PCR based RT-PCR method of malaria diagnosis showed better detection level than RDT and microscopy.
- Survey of drug resistance genes in *P. falciparum* from high malaria endemic regions of the Odisha state indicated high prevalence of PfCRT (82.7%) and PfMDR1 (56.9%) and about 1.05% of DHFR + DHPS mutations. Microsatellite analysis has revealed that the parasites have evolved de novo in this geographic region.
- The prevalence of quintuple mutation (DHFR triple mutation and DHPS double mutation) found in North-eastern region can be used as a tool to screen clinical isolates by PCR based assay for monitoring SP resistance.
- Natural infection of *Plasmodium vivax* and *P. falciparum* has been detected in *An. annularis* and *An. splendidus* in Jharkhand.
- *An. culicifacies*, a vector in rural plains was recorded from North-Eastern States.
- Evaluated a DNA based tool for assessment of antimalarials activity.
- The (High Mobility Group) HMGB1 HMGB2 behave as proinflammatory cytokine and released cytokine like TNF-  $\alpha$ , IL6, IL8 and IL1 $\beta$ , suggesting their role in pathogenicity in malaria infection.



## Clinical Research

- Therapeutic efficacy studies of ACT, artesunate-sulphadoxine-pyremethamine (AS and SP), artemether-lumefantrine, artesunate-amodiaquine, artesunate-mefloquine, combination of dihydroartemisinin and piperaquine, pyronaridine-artesunate were found with high efficacy. In a Phase II study (multi-country trial) of artemolane maleate plus piperaquine phosphate was also found to have good efficacy.

## Epidemiological/Operational Research

- Study on estimation of malaria morbidity burden in India revealed that if we increase the Annual Blood Exam rate (ABER) matching with fever rate, the estimated malaria burden will be close to actual burden.
- Re-evaluation of Fenthion larvicide for vector control led to withdrawal from the vector control programme due to development of resistance.
- A software developed at DMRC, Jodhpur was implemented in 8 CHCs/ PHCs in Jaisalmer district to collect real-time malaria data using existing infrastructure and through health workers.
- A well-characterized field site at Jabalpur (M.P) has been established to understand the epidemiology of the disease, immune response to malaria antigens, diversity of parasite genes and vector characteristics .
- An integrated strategy for vector control developed. Identified ecological risk factors of malaria. Developed strategic action plan. The findings were disseminated to SHO, MO of UKP area, State Programme Officer and Health Commissioner of Karnataka state.

## Translational Research

- Technologies transferred to National Programme: (1) Introduction of ACTs in National Drug Policy for malaria; (2) Introduction of Rapid Diagnostic Tests (RDTs), Olyset and Permanet for personal protection, in National Programme and (3) Regulation of ban of marketing of artemisinin monotherapy in India.
- Developed village level risk map of malaria in problematic districts of southern and northern Karnataka (UKP) using satellite remote sensing.
- Identified rainfall and satellite derived vegetation index as important indicators for early warning of malaria in desert districts.
- Operational feasibility, social acceptance and sustainability of an indigenous larvivorous fish, *Aphanius dispar* for malaria control under the vector-borne disease control programme was demonstrated in semi-arid area of Kutchh, Gujarat.



- Patents filed: 1) antimalarial activity of fractions isolated from *Artemisia roxburghiana*; 2) insecticidal activity of essential oil of *Psoralea corylifolia* against mosquitoes and 3) an immunodiagnostic reagent for the detection of *P.vivax* antigen.
- The technology developed for the production of mosquito larvicide, *Bacillus thuringiensis* var. israelensis transferred to a total of four firms.
- Developed three types of fly ash based biopesticidal formulations, water dispersible powder (WDP), briquette (BR) and granular (GR), for controlling mosquito vector breeding in polluted (*Culex quinquefasciatus*) and clean water (*Culicines/Anophelines/Aedes aegypti*) habitats.

### **3. RESEARCH PAPERS PUBLISHED: 389**

### **4. TECHNOLOGIES TRANSFERRED TO INDUSTRY**

- Based on clinical trials carried out by NIMR, three artemisinin based combinations registered in India: artesunate amodiaquine, artesunate mefloquine and arterolane piperaquine.
- Various vector control tools including insecticide treated nets were evaluated. This led to the registration of insecticide treated bed nets like Permanet 2.0 and Olyset net which are being used by the NVBDCP in the country.

### **5. TECHNOLOGIES READY FOR TRANSFER**

- New drug formulation for malaria having gametocytocidal and schizontocidal activity (Patent No. 189970).
- Herbal composition containing *Solanum nigrum* in hexane solvent was found effective larvicidal agent for controlling mosquitoes (Patent No. 2344279).
- New botanical formulation for mosquito control (*Valeriana Jatamansi*) Application No 2405/DEL/2007)
- A herbal antimalarial candidate obtained from the roots of *Brucia mollis* (Application no. 31/DEL/2008).
- Immunodiagnostic reagent as an antibody probe from detection of *Plasmodium vivax* antigen (Application no. 1606/DEL/2008)

### **6. TECHNOLOGIES TRANSFERRED TO NVBDCP/ OTHER HEALTH AGENCIES**

- Insecticide resistance is being monitored in the country and this has helped in revising the insecticide policy based on the data generated.

- The efficacy and safety of antimalarials used in NVBDCP is being monitored. Inputs on the basis of evidence generated led to revision of the national drug policy for malaria from time to time.
- Evaluations of RDTs carried out led to introduction of malaria RDTs in NVBDCP and bivalent RDTs will also soon be introduced. Further, the quality of RDTs used in NVBDCP is also being monitored.
- Operational research carried out in project areas like Indirasagar, Sardar Sarovar led to malaria control.

## 7. List of patents filed

Sr. No.	Year of filing	Title of Patent	Institute
1	2007	A new botanical formulation for mosquito control [2405/DEL/ 2007]	NIMR (MRC), New Delhi
2	2008	Immunodiagnostic reagent as an antibody probe from detection of <i>Plasmodium vivax</i> antigen [1606/DEL/2008]	NIMR(MRC), New Delhi
3	2008	Highly active extract(s) from the roots of the plant <i>Brucia mollis</i> for in vitro antiplasmodial/ antimalarial activity.	RMRC, Dibrugarh
4	2008	A cyclic lipopeptide of <i>Bacillus subtilis</i> sp. <i>subtilis</i> (VCRC B471) with potential to kill mosquito stages	VCRC, Puducherry
5	2008	New bacterial culture media for the production of mosquito pathogenic Bacilli using industrial wastes	VCRC, Puducherry

## 8. MANPOWER TRAINED

The Following Manpower was trained during XI<sup>th</sup> Plan

1. Public Health Personnel	:	4500
2. Scientists	:	38
3. District VBD Consultants	:	56
4. Students/Teachers	:	2630
5. MCD Health Officials	:	360

6. Entomologist/Biologist	:	120
7. Laboratory Technicians (DMLTs, NVBDCP)	:	340
8. Malaria Technical Supervisors	:	225
9. WHO Fellow	:	7
10. Spray Squad	:	55
11. Insect Collectors	:	171

### **9. NEW HUMAN RESOURCE GENERATED**

• Ph D degree awarded	:	33
• Persuing for Ph D degree	:	32
• M.Sc. Dissertation	:	121
• M.D	:	2

**Table.1 Status of Completed Research Studies undertaken during XI Plan**

Sr. No	Thematic area and Title of the Study	Objectives	Completed with outcome of the study	If off-shoot, Refer to XII <sup>th</sup> plan study	Institution
<b>Basic Research</b>					
1	Population and evolutionary genomics of Indian malaria vectors	To genetically characterize X-chromosome of <i>An. gambiae</i> and use the information in determining molecular phylogenetics, comparative genomics and population genomics of <i>An. minimus</i>	<ul style="list-style-type: none"> <li>i) Based on the genetic characterization of the X-chromosome of <i>An. gambiae</i>, the only malaria vector with whole genome sequence information, we have retrieved DNA sequence information of <i>An. minimus</i>.</li> <li>ii) Based on the DNA sequence information on the X-chromosome of <i>An. gambiae</i>, multilocus DNA markers had been retrieved and molecular phylogeny has been inferred.</li> <li>iii) Based on the whole genome sequence information of the <i>An. gambiae</i> evolutionary patterns of different genes of the three insecticide resistance gene families were inferred.</li> <li>iv) Based on the DNA sequence information multiple DNA sequences identified in <i>An. minimus</i> have been utilized in inferring population evolutionary history. Part ii and iii completed.</li> </ul>	<ul style="list-style-type: none"> <li>(i) A new study proposed (Table 3)</li> <li>(ii) New study proposed (Table 3)</li> </ul>	NIMR, New Delhi
2	Gene and genome diversity and evolution in Indian malaria parasites	To understand evolutionary history of Indian <i>Plasmodium vivax</i>	Utilizing the whole genome sequence information, novel multiple molecular markers were developed and utilized to infer evolutionary history of Indian <i>P. vivax</i> . Study completed	No	NIMR, New Delhi
3	Evolutionary genetics of immune system genes involved in malaria pathogenesis and pharmacogenomics in Indians	To understand genetic basis of host parasite interaction and pharmacogenomics in Indian populations	<ul style="list-style-type: none"> <li>(i) For the Duffy gene, comparative bioinformatics studies completed and sequencing the Duffy gene in 250 Indians revealed strong association between <i>P. vivax</i> malaria susceptibility and prevalence of two different allele associated.</li> <li>(ii) The NAT2 gene, which is responsible for determination of acetylation profile, have been sequenced in 250 Indians and each individual has been categorized as fast or slow acetylator Part i) completed</li> </ul>	ii).A new study proposed (Table 3)	NIMR, New Delhi

4	Development of PCR-based molecular diagnostic assays for kdr genotyping in <i>An. culicifacies</i> and <i>An. stephensi</i> .	To develop PCR based assay for identification of Kdr gene in major malaria vectors	PCR-based assays were developed for identification of kdr (knockdown resistance) alleles L1014F and L1014S in two malaria vectors <i>An. culicifacies</i> and <i>An. stephensi</i> . The findings will help in early detection of pyrethroid insecticide resistance in vectors. Study completed	No	NIMR, New Delhi
5	Identification and characterization of candidate antigens of malaria vector <i>Anopheles stephensi</i> for vector directed transmission blocking anti mosquito immunity	The effect of anti-mosquito antibody(s) on infectivity/ development of malaria parasite in mosquitoes.	Identification of target molecules from different tissues can be exploited for the development of immunological as well as recombinant DNA techniques to alter the ability of the mosquito to transmit malaria.	No	Extramural funding, ICMR Hqrs
6	A study on immunoregulation and genotyping for cytokine polymorphism in human cerebral malaria	To quantify T-regulatory cells a) CD4+CD25+ b) CD4+ CTLA 4+ cells in circulation and CSF in human cerebral malaria	ELISA responses to several <i>P. falciparum</i> proteins (vaccine candidates) indicated that antibodies against severe malaria (SM), cerebral malaria (CM) and patients developing multiorgan dysfunction (MOD) were present but significantly higher (2 to 3-fold) in the SM cases .	No	Extramural funding, ICMR Hqrs
7	Evaluation of DNA based tools for antimicrobial drug screening against plasmodium <i>falciparum</i> and studies with modified (RPNI) medium"	To evaluate DNA based tools using microfluorimetric method as well as green fluorescence pigment (gfp) producing transgenic parasites for antimalarial drug screening.	The findings revealed that the MSF assay is most suitable assay for bio evaluation of new molecules and RPNI medium gas potential to be used for chemo sensitivity studies.	No	Extramural funding, ICMR Hqrs
8	Development of potent mosquitocidal agents from natural resources	To develop base line information for molecular and biochemical markers for the mosquito vector <i>Aedes aegypti</i> and to screen mosquito populations for intraspecific differences using these markers in different geographical population.	A simple method for identification of the main vectors of the mosquito in the selected region of Gujarat state (India) involving PCR amplification of mitochondrial 16S rRNA gene and other molecular DNA markers, followed by sequencing has been developed.	No	Extramural funding, ICMR Hqrs

9	Pre-erythrocytic malaria differential gene expression and identification of transcription factors as potential targets.	To identify parasite molecules (transcripts and their corresponding proteins) that play a role in malaria parasite development inside the hepatocytes . Selected gene candidates and proteins will be thereafter used for identifying putative specific inhibitors able to impair (or alter) the exo-erythrocytic development of the parasite.	The (High Mobility Group) HMGB1 HMGB2 behave as proinflammatory cytokine and released cytokine like TNF- $\alpha$ , IL6, IL8 and IL1 $\beta$ , suggesting their role in pathogenicity in malaria infection.	No	Extramural funding, ICMR Hqrs
<b>Clinical Research</b>					
1	Monitoring therapeutic efficacy of antimalarials	To monitor therapeutic efficacy of antimalarials being used in the national programme.	Study completed. Chloroquine efficacy was monitored in <i>P. falciparum</i> malaria. Wide spread resistance was found which provided an evidence to revise the National Drug policy on malaria.	No	NIMR, New Delhi
2	Effect of malaria on pregnant women and pregnancy outcome	To understand the effect of malaria on pregnancy outcome in Assam	In Assam, normal delivery was recorded in only 53.4% malaria positive pregnant women against 82.8% malaria negative women. Normal pregnancy outcome was higher in women who contracted malaria during the 1st trimester .Stillbirths were more common in those who developed malaria in the 2nd and 3rd trimester as compared to the 1st trimester	No	RMRC, Dibrugarh
3	Therapeutic efficacy of chloroquine among <i>P. falciparum</i> malaria in central India	To assess the therapeutic efficacy of chloroquine (CQ) treatment against uncomplicated <i>P. falciparum</i> infections in a tribal population of central India	Overall, treatment failure occurred in 53% of participants. Children under 5 years of age showed significantly more CQ resistance than adults with prevalent (61.29%) double mutant genotype S72V73M74N75T76. On the basis of this finding CQ is replaced by ACT as first-line treatment in Dindori district in 2008.	No	RMRC, Jabalpur
<b>Epidemiological/operational Research</b>					
1	In-depth review of malaria and independent assessment of new tools such as rapid diagnostic kits, insecticide treatment of community owned nets etc. in Orissa.	To assess the availability and use of rapid diagnostic kits to health workers and use of ITN by the community.	Study revealed that there was satisfactory acceptance of insecticide treated nets and Rapid diagnostic kits were available for use by the peripheral workers in field. Report was submitted to the Govt of Orissa and new comprehensive case management study launched in Orissa.	No	NIMR, New Delhi

2	Estimation of malaria morbidity burden in India	To estimate the actual burden of malaria in selected area of Jharkhand	Study undertaken in Jharkhand revealed that if we increase the Annual Blood Exam rate (ABER) matching with fever rate, the estimated malaria burden will be close to actual burden. In view of controversial figures given by a couple of published papers and need for generating evidence based data on malaria morbidity and mortality in the country, "Estimation of malaria burden in India: A prospective national study to validate recently proposed methodologies of burden estimation in India" has been planned to determine malaria incidence and deaths attributable to malaria in India	A new study has been proposed in XIIth Plan (Table 3)	NIMR, New Delhi
3	Role of <i>An. stephensi</i> in transmission of malaria in rural area of North Gujarat established.	To find out the role of <i>An stephensi</i> in rural areas of North Gujarat	<i>An. stephensi</i> was found transmitting malaria in rural area of North Gujarat. Sporozoites were detected in a few specimens. It was found breeding in Khet talawadi, wells and intra-domestic water containers.  Study completed.	No	NIMR, New Delhi
4	Developed village level risk map of malaria in problematic districts of southern and northern Karnataka using satellite remote sensing.	To develop village level ecological risk map of problematic areas in Karnataka using satellite remote sensing	Identified ecological risk of malaria in 153 villages of Tumkur &, Chitradurga districts in Southern Karnataka and 30 villages under Almatti & Narayanpur in UKP area. Seepage drains originated from irrigation canals close to human settlements and presence of rocky river bed pools were major ecological risk factors of malaria. Strategic action plan was submitted to concerned.	No	NIMR, New Delhi
5	Regional level mapping of malaria vectors using RS and GIS in northeastern states in India to develop strategic plan for malaria Control.	To map distribution of malaria vectors viz. <i>An. minimus</i> , <i>An. fluviatilis</i> and <i>An. dirus</i> at regional level and identify malaria risk free areas	Entomological and parasitological data was collected from the field for validation of GIS mapping of favorable areas for vector distribution.  Village wise malaria situation was compared and it was found that malaria is high in villages falling in favorable zone.	No	NIMR, New Delhi
6	Field trial of Temephos and Fenthion (both, larvicides) for vector control in different breeding habitats.	To evaluate the efficacy of Temephos and Fenthion as antilarval measures.	200gm active ingredient of temephos resulted in reduction of larval density of Culex. With fenthion used @ 200ml/hectare resulted in only 43% reduction after one week in the density of Culex.  Completed and report submitted to programme.	No	NIMR, New Delhi



7	Demonstration and evaluation of integrated vector management (IVM) under enhanced vector borne disease control programme (ENVBDGP) in a malaria endemic tribal area of Odisha state, India	To demonstrate the feasibility of implementing integrated vector management (IVM) approach for the control of <i>Anopheles fluviatilis</i> transmitted malaria in tribal area.	Control of <i>Anopheles fluviatilis</i> breeding was demonstrated in down-stream area, in a tribal village in Odisha State by environmental method – by integrating the minor irrigation scheme of the state govt. for constructing a bed-dam with sluice gates. This could be incorporated as one of the components of integrated vector management (IVM) in malaria control programme.	An intervention study is proposed in the XII plan to control <i>Anopheles fluviatilis</i> transmitted malaria in the tribal areas of Odisha (Table 3).	VCRC, Puducherry
8	Studies on underlying mechanisms of insecticide resistance in the field population of <i>Anopheles fluviatilis</i> , <i>An.culicifacies</i> and <i>An.annularis</i> , the malaria vectors in India.	To update the distribution map of vector resistance, to study the biochemical mediated mechanisms underlying resistance to DDT and to determine <i>kdr</i> allele frequency in DDT resistant populations of the vector species.	Involvement of Glutathione S transferase (GST) enzyme-mediated resistance to DDT in <i>An. culicifacies</i> was confirmed. There was no significant relationship between <i>kdr</i> mutations with phenotypic expressions. This biochemical assay could be an additional tool for field screening of vector population for DDT resistance.  Study completed	No	VCRC, Puducherry
9	Vector bionomic studies in Singhbhum hills (east central India)	To elucidate the role of malaria vectors' seasonality, breeding, resting, feeding and biting behaviour and insecticide susceptibility status in the area.	Led to the change in the insecticide use/selection of insecticide for malaria vector control in the district.  Study completed	No	VCRC, Puducherry
10	Mapping of anti-malarial drug sensitivity using in-vivo, in-vitro and molecular markers in this region	To find out the status CQ drug resistance in different districts of Orissa.	Completed. Mapped the <i>P. falciparum</i> CQ resistance areas in Odisha.	No	RMRC, Bhubaneswar
11	Studies on prevalence of 76Tcrt / 86Ymdr1 <i>Plasmodium falciparum</i> isolates in severe malaria cases of Orissa and it's biological advantage	To investigate because of high incidence of severe malaria in the states.	Completed. Around 70% of the hospitalized severe cases harbors <i>P. falciparum</i> isolates that carry CQ resistance markers (76Tcrt / 86Ymdr1) indicating that the high incidence of severe malaria in this zone of the country might be due to treatment failure.	No	RMRC, Bhubaneswar

12	Molecular analysis of drug resistance genes and prediction of treatment failure in <i>P. falciparum</i>	To map the CQ resistance using molecular marker and to study the origin of the mutations responsible for the resistance.	Analysis reveals de novo evolution of resistance in this geographic region. This demands rational use of antimalarials to combat resistance.	Yes ( New proposal on Artemisinin resistance (Table 3)	RMRC, Bhubaneswar
13	A randomized clinical trial with Chloroquine and alternative regimens to study the comparative efficacy in treatment of uncomplicated <i>P. falciparum</i> malaria in endemic districts of Odisha	To test the efficacy of the different drug regimens for treatment of uncomplicated malaria.	Completed. Study has shown that the <i>P. falciparum</i> isolates circulating in this area are susceptible to Artemisinin and Sulphadoxine-Pyremethamine.	No	RMRC, Bhubaneswar
14	ABCA1 gene and cerebral malaria: Role in pathogenesis & relevance in genetic susceptibility	To study the mechanism of pathogenesis of severe malaria	Observed endothelial dysfunction in severe malaria and there is association of -477C/T and -320 G/C gene polymorphism of ABCA1 with uncomplicated malaria and low production of Microparticles . NOx found to reduce endothelial dysfunction.	A new proposal has been proposed (Table 3)	RMRC, Bhubaneswar
15	The effect of Chloroquine chemo prophylaxis during pregnancy among the compliant and non-compliant mothers of Orissa	To find out the effect of CQ chemoprophylaxis on pregnancy outcome and mothers health.	Completed Birth outcome in terms of LBW babies and Hb level was found to be better amongst CQ compliant mothers indicating benefit effect of chemoprophylaxis	No	RMRC, Bhubaneswar
16	Malariogenic stratification of Angul district of Orissa on the basis of distribution of sibling species	To stratify the malariogenic area based on eco system and sibling species of mosquito vectors. Development of comprehensive vector control strategy for vector borne diseases in irrigation canal command area. (ii) Development of a specific strategy for urban mosquito control.	Based on the prevalence of the sibling species and using GIS the district has been stratified in to three distinct zones of malaria. Hence three different control measures have been developed.	New proposal on comprehensive vector control including urban areas has been proposed (Table 3).	RMRC, Bhubaneswar

17	Characterization of <i>P. falciparum</i> strains from north-east India (Collaborative study with NIMR, Delhi)	This study investigated drug resistant <i>P. falciparum</i> cases, its molecular markers, correlation of clinical, parasitological and molecular data and parasite diversity in North Lakhimpur and Hailakandi districts of Assam.	ACPR to chloroquine varied from 10.4 (Hailakandi) to 27.7% (N. Lakhimpur) and for SP from 85.4 (Hailakandi) to 87.2% (N. Lakimpur). In <i>in vitro</i> sensitivity test 95% isolates were found resistant to chloroquine in Hailakandi district. Overall 99% Pf isolates had resistant allele (76T) of <i>pfcr1</i> gene, only 1% were wild type (K-76). In case of <i>pfmdr1</i> gene, 65.8% isolates were mutants (86Y) and 32.1% were wild (N86) type	No	RMRC, Dibrugarh & NIMR, New Delhi
18	Understanding malaria-HIV interaction in malaria endemic regions	To understand interaction of malaria and HIV in malaria endemic areas with reference to antimalarial drug resistance & CD4 count	There was 100% adequate clinical and parasitological clearance after treating with artesunate plus sulphadoxine /pyrimethamine combination (ACT) both in HIV-infected and HIV-uninfected malaria cases in Mizoram & Manipur.	No	RMRC, Dibrugarh & NARI, Pune
19	Sibling species profiling of forest malaria vector <i>An. dirus</i> in north-east India	To study the distribution of member species of <i>An. dirus</i> complex mosquitoes in north-east India	Molecular studies revealed that <i>An. baimaii</i> (earlier species D) was the predominant, nearly exclusive, member species of <i>An. dirus</i> complex present in NE India, except in Sikkim. In addition, presence of species X of China (unnamed species under <i>Dirus</i> complex) was detected in NC Hills, Assam	No	RMRC, Dibrugarh
20	Morphological variation & molecular characterization of <i>An. minimus</i> species complex in Assam & Arunachal Pradesh	To study the distribution of member species of <i>An. minimus</i> complex mosquitoes in north-east India	Molecular studies revealed the presence of only one species i.e. <i>An. minimus</i> s.s. (earlier sp A) under <i>Minimus</i> complex in these two states. No morphological variants were found.	No	RMRC, Dibrugarh
21	Molecular & morphotaxonomic studies on <i>An. philippinensis/nivipes</i> group mosquitoes	To study the distribution of <i>An. philippinensis</i> and <i>An. nivipes</i> and their vectorial role in NE India	Molecular characterization revealed the predominance of <i>An. nivipes</i> in Assam and Nagaland, of <i>An.philippinensis</i> in Arunachal & Mizoram & equal distribution of these 2 species in Meghalaya & Tripura. <i>An. nivipes</i> was incriminated as vector in Assam-Nagaland border areas	No	RMRC, Dibrugarh
22	Transmission Dynamics of Malaria in Tribal areas.	To study the transmission dynamics of malaria and the bionomics of vector species to develop appropriate control strategies.	An intervention based study for control of Malaria is being undertaken to develop a model for similar forested areas of the country	No	RMRCT, Jabalpur

23	Development of a Real time IT based health informatics for malaria in Jaisalmer ( Rajasthan)	To develop an IT based health information system for real time collection and management of malaria cases for rapid action	<p>A software predictive of a malaria epidemic in desert, based on quantitative inter-relationship among vector population, animal and human baits and number of patients available in villages, has been developed, tested under field conditions and was found effective in forecasting prospective malaria situation. Utility of this software will be communicated to NVBDCP and will be tested/validated in other endemic areas with support from NIMR, New Delhi</p> <p>A Real-Time IT based intelligent health informatics management system has also been developed to collect data on malaria through existing health functionaries and implemented in 8 CHCs/ PHCs under block Pokaran in Jaisalmer.</p>	Yes, a new proposal has been proposed (Table 3)	DMRC, Jodhpur
24	Development of predictive software for malaria	<ol style="list-style-type: none"> <li>1. Development and testing of malaria transmission prediction module software through prediction and its confirmation in the adopted study villages.</li> <li>2. Computer programme development using introduction and transmission quantum of malaria in a group of villages to develop epidemic forecasting system.</li> </ol>	Study was completed and software was developed which was tested under real live conditions of the field.	No	DMRC, Jodhpur
25	Screening of solanum and Withania for mosquito control in Rajasthan	To evaluate extracts of <i>S. xanthocarpum</i> and <i>W. somnifera</i> for vector control	Synergistic larvicidal efficacy of seeds and fruits of <i>Solanum xanthocarpum</i> and <i>Withania somnifera</i> was found 4 to 5 times more on malaria vectors as compared to when used individually.	No	DMRC, Jodhpur
26	Study on association between socio-economic status and transmission of Malaria in desert	<ol style="list-style-type: none"> <li>1. To study the socio-economic factors associated with malaria transmission in desert.</li> <li>2. To find out the social solutions to control desert malaria.</li> </ol>	Study on association between socio-economic status and transmission of Malaria in desert indicated statistically significant association of malaria cases with socio-economic status of the community.	No	DMRC, Jodhpur
27	Investigation of outbreaks of Malaria in Nancowry group of islands and Billiground in Middle Andaman	To understand the cause of the outbreaks including the assessment of Anophelines and to suggest control measures	In an Outbreak of malaria in the post tsunami rehabilitation/ construction activity at Nancowry, Migration of laborers was found to be a cause of the outbreak in Nancowry. At Billiground, it was observed that <i>An. sundaicus</i> which is the established vector for malaria in these islands was not observed. However, <i>An. barbirstris</i> was found to be predominant. Hence detailed studies are needed to understand the role of this species in malaria transmission.	A new proposal has been planned during the XII <sup>th</sup> plan (Table 3)	RMRC, Port Blair

28	Preparation of a field site for malaria vaccine trial in and around Jabalpur, Madhya Pradesh	The rationale of the study is to develop a well-characterized site, where the epidemiology of the disease, immune responses to malarial antigens, diversity of parasite genes, malaria paradigm changes and vector characteristics are well understood. This site would be useful for testing of any tools for the control and prevention of malaria, such as antimalarial vaccines and diagnostic reagents	A well-characterized field site at Jabalpur (M.P) has been established to understand the epidemiology of the disease, immune response to malaria antigens, diversity of parasite genes and vector characteristics.	No	Extramural funds, ICMR Hqrs
<b>Translational Research/Techniques Developed</b>					
1	Transfer of Technologies to National Programme		The institute (NIMR) works in close collaboration with the National Programme and many technologies eg. introduction of ACTs in National Drug Policy for malaria; introduction of Rapid Diagnostic Tests (RDTs), regulation of ban on marketing of artemisinin monotherapy in India etc. were transferred to National Programme /local health authorities. In addition, the institute is also involved in revising different policies of the programme. It is an ongoing activity.	Ongoing activity	NIMR, New Delhi
2	Application of Remote Sensing (RS) and Geographical Information system (GIS) in northeastern states	To map the malaria vectors using remote sensing technique	<i>An. culicifacies</i> was incriminated as vector from deforested areas of Sonitpur district of Assam and situation specific control strategy was suggested. The study has been completed.	No	NIMR, New Delhi
3	Development of a field site for malaria vaccine trials at Rourkela (Orissa).	To generate long term epidemiological data on selected cohort regarding transmission indices of malaria	Data on all the epidemiological indicators required for vaccine trial is available for the field site for malaria vaccine trials. Study was concluded.	No	NIMR, New Delhi

**Table 2. Important and essential activities which need to be continued in 12<sup>th</sup> plan (ongoing studies)**

Sr. No.	Thematic area and title of the study	Justification	Time frame	Deliverable outcome with public impact	Institution
<b>Basic Research</b>					
1	Malaria Parasite Bank: Collection of Plasmodium field isolates, adaptation, cryopreservation and characterization of <i>P. falciparum</i> isolates for malaria parasite bank.	Since the inception of this facility in 1990, more than 1300 isolates of human malaria parasites have been collected so far and have been characterized for drug resistance and various other parameters. The resource has also proved useful in promoting malaria research in the country. The malaria parasite bank provides biological material to the researchers of the country and also trains them. It also supports various research activities of the institutes.	It is an ongoing activity through XII <sup>th</sup> plan.	A resource facility for the country for parasitological studies, drug sensitivity and developing diagnostic tools etc.	NIMR, New Delhi
2	Mixed infection of malaria parasites.	Mixed infection of <i>P. vivax</i> and <i>P. falciparum</i> up to the tune of 46% ( <i>P. falciparum</i> and <i>P. vivax</i> ) detected from various parts of the country. A proposal to study 3,000 malaria positive cases for verifying the high incidences of mixed parasite infection in India will soon be taken up.	2013-2016	The outcome will help the national programme in planning appropriate management of malaria cases.	NIMR, New Delhi
3	Evolution of insecticide resistance in malaria vectors	Characterization of the three insecticide-resistant gene families have provided with the information on the basic evolutionary trend of these gene which can be utilized in other species of India.	2013-2017	Knowledge of mechanism of insecticide resistance will help in management of insecticide resistance.	NIMR, New Delhi
4	Differential proteomics of insecticide resistant and sensitive <i>An. stephensi</i>	Differential annotated proteins have been identified. Genomic validated catalogue of these proteins needs to be prepared and this can have role in insecticide resistance mechanism of <i>An. stephensi</i> .	2013-2015	A genomic validated catalogue of different/ annotated proteins will be available. This will help in finding new metabolic mechanisms for vector control.	NIMR, New Delhi
5	Testing and development of vector control tools using herbal, microbial and chemical products	60 plants were screened for insecticidal and mosquito repellent activity against mosquitoes. Of these 4 plants were identified for further testing and development. The work will be continued in 12 <sup>th</sup> five year plan to develop a suitable herbal molecule/ formulation with insecticide/repellent activity .	To be continued till 2015	The outcome will provide a potent herbal tool for vector control	NIMR, New Delhi

6	Understanding the molecular genetics of mosquito vector competence in indian malarial vectors	The physiological responses of different mosquito tissue on the vector competence and pathogenic transmission, to explore the role of mosquito immune factor modulating parasite development, functional characterization of genetic factors influencing parasite transmission, exploring the role of mosquito gut flora affecting anti-Plasmodium responses.	2012-2015	The study will expand our knowledge on the genetic factors that influence the Plasmodium transmission and vector competency in malaria vector <i>An. culicifaacies</i>	Supported by extramural research NIMR, New Delhi
<b>Clinical Research</b>					
1	A randomized controlled trial of Artesunate Sulfadoxine-Pyrimethamine (ASP) vs ASP + Primaquine	To assess the utility of addition of primaquine to Artesunate+SP to reduce transmission of falciparum malaria.	2013-2015	It is expected that addition of primaquine to artesunate+SP would reduce gametocytaemia and thus transmission.	NIMR, New Delhi
2	Monitoring therapeutic efficacy of antimalarials along international borders, and other high risk areas	The antimalarials used in national programme are being monitored for therapeutic efficacy. ACT is implemented as the first line treatment of <i>P. falciparum</i> malaria since 2010. Therefore therapeutic efficacy monitoring is necessary to assess the efficacy of ACT.  Studies are planned along international borders, NE states, tribal and forested areas and BSF troops in Rajasthan.	2013-2017	The study will help in early detection of antimalarial drug resistance along the international borders and other high risk areas in the country.	NIMR, New Delhi RMRC, Jabalpur RMRC, Dibrugarh, RMRC, Bhubaneswar, VCRC, Puducherry, DMRC, Jodhpur
3	Clinical drug trials	Five artemisinin based fixed dose combinations underwent clinical trials, three of which have been registered with DCGI. Hence the activity of evaluation of new antimalarials/ combinations/ new dose regimens needs to be continued for <i>P. falciparum</i> and <i>vivax malaria</i> . New antimalarials/FDCs need to be available in country in the wake of threat of drug resistance for which Phase III trials are regulatory requirement.	Throughout 12 <sup>th</sup> Plan	New antimalarials/Fixed Dose Combinations will be available for better management of malaria	NIMR, New Delhi
4	Study on treatment practices and Pharmacovigilance programme for antimalarials.	The artemisinin monotherapy use was found widespread across India. This study resulted in notifications to all state drug controllers in India to withdraw the oral artemisinin formulations from the market.  Follow up of this study has been planned and prescription practices with special reference to the phasing out of artemisinin monotherapy. In addition, compliance to primaquine therapy will also be studied.	2013-2015	The study will generate data on treatment practices and thus enable take corrective action for better management of malaria.	NIMR, New Delhi



5	Quality assurance of malaria Rapid Diagnostic Tests	<p>Quality Assurance Programme of malaria RDTs used in the national programme was established. Five different brands of malaria rapid diagnostic tests were evaluated. Quality Assurance Programme of malaria RDTs was also established. The kits being used in the National Programme are satisfactory.</p> <p>It is essential to assure the quality of malaria RDTs in order to ensure quality diagnosis. Poor quality diagnosis may miss some malaria cases and thus result in increased morbidity / mortality. SOPs for QA of RDTs developed and standardized. Activity needs to be continued for strengthening and procurement of bivalent RDTs. Accreditation of the institute will also be done.</p>	2013-2017	The quality assurance of malaria RDTs being used in the programme will be assured.	NIMR, New Delhi
6	Evaluation of rapid and economical diagnostic assays for malaria.	<p>Assays like Loop Mediated Amplification Assays, multiplex PCR based assays, vision based assays were evaluated apart from rapid diagnostic tests. They can have role in improving malaria diagnosis.</p> <p>It is important to develop assays which can simplify malaria diagnosis and are rapid, economical. Research in this direction is important to improve diagnosis of malaria.</p>	2013-2017	New diagnostic tests for detection of malaria will be in offing.	NIMR, New Delhi RMRC, Bhubaneswar, RMRC, T Jabalpur
7	Micro-PCR based RT-PCR method of malaria diagnosis	The method showed better detection level than RDT and microscopy. Follow up is needed for field evaluation. Will be completed by 2014.	2012-2014	A potent rapid diagnostic test for use in field will be available	NIMR, New Delhi
8	Study on genetic polymorphism in Pfhrp2 and Pfhrp3 genes of <i>P. falciparum</i> isolates and their possible effect on performance of RDTs.	The genetic variability of Pfhrp2 and Pfhrp3 genes of <i>P. falciparum</i> isolates and their possible effect on performance of RDTs was assessed. Ten different types of PCR products were observed for PfHRP-2 and nine for PfHRP-3. It was found that they affected RDT performance. Deletions of these genes were also reported. Therefore, studies will be undertaken to evaluate the presence or absence of PfHRP2 and PfHRP3 gene expression (based on gene deletions) in six malaria endemic states of India in M P. and other high risk areas.	2012-2015	Data generated on sensitivity and specificity of kits will help to choose most suitable rapid diagnostic kits.	NIMR, New Delhi RMRC, Jabalpur

9	Validation of prognostic utility of IL-1ra in cerebral malaria	Studies undertaken on prognostic markers revealed that there was a strong correlation between IL-1ra with cerebral malaria. Further studies are required to validate the findings on IL-1ra and its role as a prognostic marker for cerebral malaria which will help in better management of the disease by identifying the patients at risk of mortality.	2013-2014	Establishing role of IL-1ra as a prognostic marker will help in assessing the response to treatment in cerebral malaria.	RMRC, Jabalpur
<b>Epidemiological/Operational Research</b>					
1	IDVC Project: Field stations (located at Bangalore, Chennai, Goa, Guwahati Haridwar, Jabalpur, Nadiad, Ranchi, Raipur and Rourkela) under Integrated Disease Vector Control project with coordination from NIMR HQ.	The field units are providing technical support to National as well as local vector control programme in finding solution to outstanding problems mainly in transmission of malaria and serving as site for evaluation of insecticides and drugs by NIMR. The activities of field units will also be extended to other vector borne disease like dengue, chikungunya, filariasis and leishmaniasis as recommended by Scientific Advisory Committee (SAC) from time to time. It is an ongoing activity which will be continued in 12 <sup>th</sup> Plan.	It is a long term project. To be continued throughout the 12 <sup>th</sup> Five year Plan	The project provides technical support to National as well as local vector borne disease control programme.	NIMR, New Delhi
2	Ecological succession of anopheline and other mosquitoes in North-Eastern States.	Ecological changes resulted in the succession of vector revealed <i>An. minimus</i> and <i>An. dirus</i> in low number whereas <i>An. culicifacies</i> was recorded in high density from Assam, Meghalaya, Manipur, and Sikkim. <i>An. culicifacies</i> was incriminated as vector. The study is being extended to Terai region of UP, Uttarakhand and Bihar states.	RMRC part is complete. NIMR part needs to be continued till 2013	The information on changing profile of new malaria vector species will be known which will help national programme in planning vector control	NIMR, New Delhi and RMRC Dibrugarh
3	Operational feasibility, social acceptance and sustainability of an indigenous larvivorous fish, <i>Aphanius dispar</i> for malaria	The feasibility of use of <i>Aphanius dispar</i> , its social acceptance and sustainability as an indigenous larvivorous fish had been demonstrated for malaria control under the programme in North Gujarat. Need to be extended in the command areas of SSNL in North Gujarat	2013-2015	A new biological control agent for mosquitoes will be ready for up scaling for vector control	NIMR, New Delhi

4	Insecticide resistance against malaria vectors	The study has been carried out in 13 states and 156 districts as suggested by DDT mandate committee (GoI). Study completed and report submitted. However, monitoring of insecticide resistance in vectors would continue as ongoing activity.	2012-2015	The outcome would help the NVBDCP in planning IRS activities.	NIMR, New Delhi DMRC, Jodhpur
5	Studies on the bionomics, species complexes, distribution, and transmission dynamics of malaria in different geographic areas	1) Distribution of the members of <i>Fluviatilis</i> / <i>Minimus</i> / <i>Culicifacies</i> complexes was mapped in unexplored areas of north-eastern, central and peninsular India and their biological characteristics and malaria transmission potential were studied. The study has stratified malarious areas that are primarily under the influence of <i>Culicifacies</i> , <i>Fluviatilis</i> or <i>Minimus</i> Complexes. Further studies are required in different ecotypes (forest, rural plain and urban)  2) Molecular characterization of so called <i>An. fluviatilis</i> in Assam revealed that they are misidentified <i>An. minimus</i> . A new sibling species (species V) was identified in the <i>Fluviatilis</i> Complex based on molecular and cytological attributes. Molecular and cytological characterization of other malaria vectors is to be continued to understand heterogeneity and genetic barrier in cryptic species. PCR based diagnosis of various complexes of <i>An. culicifacies</i> is also planned to be studied.	2013-2017	The outcome would help to ascertain the relative role of species different vectors in different ecological settings for planning effective vector control strategies in different geographic areas.	NIMR, New Delhi RMRC, Dibrugarh RMRC, Bhubaneswar and VCRC, Puducherry
6	Malaria treatment seeking behaviour and acceptability of intervention measures in tribal areas of Odisha state.	Long lasting insecticide treated mosquito nets (LLINs) are distributed to the population by the NVBDCP for the control of malaria in place of IRS. Chloroquine has been replaced with ACT as the first line drug for treatment of <i>falciparum</i> malaria. Operational research is necessary to understand the acceptability of these new interventions by the tribal population with diverse socio-cultural backgrounds.	2012- 2015	This information would help in optimizing the benefit of these measures to the community for better coverage.	VCRC, Puducherry
7	Molecular Epidemiological Study of <i>Plasmodium falciparum</i> field isolates and the incidence of Malaria in endemic regions of Central India	<i>P. falciparum</i> Field isolates also exhibit redundancy in their invasion pathways and a high degree of polymorphism in their genome that allows these parasite lines invade human erythrocytes through multiple pathways as well as evade the host immune system.	2011- 2016	A Complete understanding of the invasion phenotypes and genotypes of <i>P. falciparum</i> Indian field isolates would help in designing vaccines for application in endemic regions of India.	RMRCT, Jabalpur

8	Developing strategy for optimizing the accessibility and utilization of national malaria control programme in endemic areas and to study the natural course of malarial infection	The gaps in the implementation of malaria control programme have been assessed. In the tribal district the providers are in position but the low literacy of providers and non availability of the diagnostic kits/drugs caused hindrances in utilization of control programme. There are variations in the reasons for lower utilization of programme in different geographical region. Since the study needs more study population & various geographic regions it needs to be continued.	2010-2015	Based on the findings a formative research will be planned to develop an innovative method of control.	RMRC, Bhubaneswar
9	Mapping malaria receptivity in tribal areas of district Ranchi, Jharkhand using GIS.	Priority areas under major threat of malaria identified along with risk factors in tribal areas of Ranchi district, Jharkhand. The study will provide decision support to develop strategic action plan for malaria control in areas representing five major paradigms in all geo-climatic zones	2013-2015	The findings of study will provide strategic action plan for control of malaria in major paradigms of malaria in Ranchi district	NIMR, New Delhi
10.	Surveillance of pyrethroid resistance in important malaria vectors of western Rajasthan and studies on genetic and biochemical mechanisms of pyrethroid resistance in <i>An. Stephensi</i>	Monitoring of insecticide susceptibility/resistance of <i>An. Stephensi</i> and <i>An.culicifacies</i> , development of pyrethroid resistant strains of <i>An.stephensi</i> in the laboratory and investigate inheritance pattern of pyrethroid, elucidation of biochemical mechanisms of pyrethroid resistance in <i>An. Stephensi</i> .	2012-2014	The findings would reveal whether the populations of <i>An.stephensi</i> and <i>An.culicifacies</i> select for resistance to cyfluthrin/deltamethrin/alpha-cypermethrin or not in the field. The knowledge of the genetic and biochemical mechanisms of resistance would be useful in resistance management and control of <i>An. stephensi</i> .	Supported in extramural research (DMRC, Jodhpur)
11.	Studies on the influence of various hydrophytes on structure and composition of mosquito vector population in Vaigai river basin of Tamilnadu	To study the structure and functional attributes of various hydrophytes and their influence on mosquito density, diversity and abundance, to analyze the impact of physiochemical characteristics of water on breeding behavior of mosquitoes under different hydrophyte dominated ecosystems, to analyse the impact of flash floods in the spread of mosquito vectors and to study the possible use of phytochemicals as mosquito control agents	2012-14	The hydrophytes in the Viagra river basin will be characterized .The phytochemicals will be analyzed for their mosquitocidal activities. Also the impact of flash floods in the spread of mosquitoes will be elucidated. The study focusses on association between mosquito fauna and hydrophytes.	Supported in extramural research (Kamaraj University Madurai)

Translational Research/Technological Development					
1	Technical and epidemiological/operational support to National Vector Borne Disease Control Programme (NVBDCP).	(1) Introduction of ACTs in National Drug Policy for malaria; (2) Introduction of Rapid Diagnostic Tests (RDTs) in National Programme and (3) Regulation of ban of marketing of artemisinin monotherapy in India have been transferred to industry/NVBDCP	It is a continuous activity	Very useful for NVBDCP/industries for malaria control	NIMR, New Delhi and other RMRCs
2	Development of monoclonal antibodies based immunodiagnosics against <i>P. vivax</i>	Few hybridoma clones have been developed which are reactive against <i>P. vivax</i> only. Laboratory based evaluation of these clones has been done and will be transferred to company for development of diagnostic kit. Validation of kit will also be done.	2012-2014	A RDK will be available for <i>P. vivax</i> which will help in rapid diagnosis of malaria	NIMR, New Delhi
3	Generation of evidence-based data on Impact of Climate Change on malaria and malaria vectors.	Evidence based data on biophysical determinants of malaria are being generated in north and northeastern states. The impact of climatic parameters on different malaria vectors will be studied under laboratory conditions and extension to other vector borne diseases. The mechanism of adaptation of mosquito vectors in extremely hot conditions in the context of changing ecology will be studied. Ultimate aim is to develop risk map of malaria.	It is long term project. To be continued through 12 <sup>th</sup> Five year Plan.	The outcome of the study will help in formulating policy for planning control of malaria and other VBDs in vulnerable areas.	NIMR, New Delhi
4	Early detection of malaria epidemics using satellite and environmental data.	Based on the study, cumulative rainfall from May to September and satellite derived Vegetation index were identified as potential indicators for early warning of malaria 1-2 months in advance in selected districts of Gujarat and Rajasthan. The study was supported by Michigan University but after April 2013, ICMR support will be required. The study is planned to develop a web based operational system and to be extended to early warning of dengue outbreaks.	2013-2016	The outcome will guide the NVBDCP in rapid response to outbreaks of malaria well in time	NIMR, New Delhi
5	Disease surveillance system for malaria using mobile platform	This 2 years study was initiated in 2012 and being the committed activity need to be continued in 12 plan as per schedule	2012-2014	IT technology based malaria surveillance system is expected to be delivered	RMRC Dibrugarh

6	Assessment of the effectiveness of intensive intervention measures on malaria control programme in Balaghat and Dindori districts (M P).	To assess the effectiveness of the introduction of the long lasting insecticide treated mosquito nets (LLINs), IRS, bivalent RDTs and ACT for malaria control in tribal villages of Balaghat and Dindori districts.	2013-2016	An intervention model for malaria control in tribal-forested areas on the border of M P and Chhattisgarh will be available.	RMRCT, Jabalpur
7	Screening of indigenous medicinal plants and seaweeds and sponges in different geographic areas for antimalarial/anti vector activities	Of 20 plants screened, 4 plants were found with very good antimalarial properties in vitro by NIMR. Active compounds were crystallized for preparation of herbal formulation. Attempts are being made to make herbal formulation for malaria treatment. In NE, a plant <i>Brucea mollis</i> and <i>Linostoma decandrum</i> have been of potential anti-larval use. It is an ongoing activity which will be continued for search of new antiplasmodial molecules. Andaman & Nicobar islands, Northeastern states and Odisha states have also potential indigenous plants. Study will also be undertaken on desert plants	2013- 2017	Secondary metabolites of seaweeds and sponges could potentially have antimalarial activities.	NIMR, New Delhi RMRC, Dibrugarh RMRC, Port Blair DMRC, Jodhpur
8	Transfer of a molecular technique from laboratory based study to field for mapping of malaria vectors and their vectorial attributes	The diagnostic technique and mosquito preservation / transportation method developed during the 11 <sup>th</sup> plan period.	2011-15	The technology will be transferred for field use after proper validation.	RMRC, Bhubaneswar

Table 3. New proposals to be undertaken during 12<sup>th</sup> Plan

Table 3. New proposals to be undertaken during 12 <sup>th</sup> Plan						
Sr. No.	Thematic area and title of the study	Justification		Timeline	Deliverables	Institution
		Off-Shoot of an earlier completed programme	De Novo idea which is either nationally relevant or it is likely to lead to a new scientific breakthrough.			
<b>Basic Research</b>						
1	Identification of molecular marker (s) for relapse malaria in the <i>Plasmodium vivax</i>		New idea. The project could potentially lead to identification/ characterization of markers to differentiate relapse from reinfection, thus effectively carry out trials for antirelapse agents and also generate data on relapses.	2012-2015	Differentiation of new infection from old one will help plan the strategy for effective treatment of cases.	NIMR, New Delhi
2	Characterization of artemisinin resistant parasites.	Artemisinin tolerance has already been observed along Thai Cambodia and Thai Myanmar border. If artemisinin resistant isolates are found, they will be characterized further. It is important to monitor its sensitivity and also characterize the isolates.		2014-2017	The monitoring of artemisinin resistance and characterization of such parasite will guide the national programme in malaria treatment policy	NIMR, New Delhi and RMRC Bhubaneshwar
3	Studies on the dynamics of T helper cell subsets during malarial infection to determine differential macrophage/dendritic cell activation in malaria infection.		We will study the dynamics of T helper cells and their association with macrophages/dendritic cells activation. It will lead to understand the mechanism for susceptibility and resistance in malaria infection. The expression of co-stimulatory molecules on T cells will further extend our knowledge to understand the function of effector T cells & host resistance.	2012-2015	Molecules for drug targeting for malaria will be known	NIMR, New Delhi
4	Evolutionary patterns of the TNF- $\alpha$ gene responsible for cerebral malaria.		Genetic basis of susceptibility to cerebral malaria is proposed by evaluating the level of TNF- $\alpha$ and screening mutations of this gene in Odisha.	2014-2017	Molecular signature determining cerebral malaria in Indians will be known.	NIMR, New Delhi



5	Use of Nitric Oxide (NOx) as an adjunct therapy in the treatment of cerebral malaria due to <i>P. falciparum</i>	Off-shoot of our earlier study has shown that high level of NOx gives protection against severe malaria. To reduce mortality and severity of <i>P. falciparum</i> infection, in the proposed study NOx will be used as inhalation therapy along with the radical treatment.		2013-17	Adjunct therapy for cerebral malaria will be known.	RMRC, Bhubaneswar
6	Molecular mechanism of insecticide resistance in malaria vectors		Molecular characterization of cyp450 and GST gene families and their expression in Indian malaria vectors to be studied in order to understand molecular mechanism of insecticide resistance. Molecular characterization of the voltage gated sodium channel (target site of action for pyrethroids / DDT) is also to be undertaken to understand the role of alternative splicing, RNA editing and amino acid substitutions in pyrethroids resistance.	2012-2016	The outcome will help in understanding the mechanism of insecticide resistance which will help in effective management of insecticides	NIMR, New Delhi
7	Search for immunological markers for early detection of cerebral malaria using experimental model		In <i>P. falciparum</i> diagnosed cases, there is no marker to know the progression into cerebral malaria. In order to find out a marker to distinguish such patients the following proposal has been proposed where changes in the immunological parameters will be analyzed longitudinally to distinguish cerebral malaria from non cerebral malaria using <i>P. berghei</i> (ANKA strain) in mice. The data will be extrapolated to human subjects.	2014-2017	Immunological marker to distinguish uncomplicated <i>P. falciparum</i> from cerebral malaria will be known.	RMRC, Bhubaneswar

8	Evolutionary genetic pattern of <i>P. falciparum</i> and <i>P. vivax</i> and candidate genes governing host invasion and drug resistance	<p>i). Offshoot of earlier studies on scanning the whole <i>P. falciparum</i> genome and comparative genomic studies between these two species have led us to develop different de novo genetic markers in <i>P. vivax</i> and to sequence the whole mitochondrial genome of Indian <i>P. falciparum</i>. Also, preliminary studies on the evolutionary genetic patterns of chloroquine resistance have indicated contrasting results in comparison to global <i>P. falciparum</i> isolates. Based on the results of a wide population genetic study in <i>P. vivax</i> in India, a proposal to identify novel candidate genes for drug/vaccines targets in this species has been initiated.</p> <p>li) Characterized Aspartic protease gene of <i>P. vivax</i> governing protein translocation and hemoglobin digestion.</p>		2013-2016	<p>i). Since no vaccine is yet available to curb malaria, this project could be of national relevance.</p> <p>ii). First study in <i>P. vivax</i> in India with potential drug target. Inhibitor compounds may lead to a novel drug against malaria.</p>	NIMR, New Delhi
9	Whole genome sequencing of Indian malaria vectors with emphasis on Population genomics of <i>Anopheles culicifacies</i>	An offshoot of completed study. Whole genome sequencing and population genomics of five Indian malaria vectors will be studied		2013-2017	Whole genome sequence of Indian malaria vectors will be known. While population genetic structure and evolutionary history of major Indian malaria vector will be inferred which will help in understanding of spread of insecticide resistance.	NIMR, New Delhi

10	Determination of virulence factors responsible for cerebral and non-cerebral severe malaria pathogenesis by <i>in vivo</i> transcription profiling of <i>P.falciparum</i> .		This study will lead to identification of factors responsible for the severity and pathogenesis of malaria in Indian scenario.	2013- 2016	This analysis would help in generating new candidate antigens for vaccine development and prevention strategies.	RMRCT, Jabalpur
11	Interaction of host-genetic factors and anti-malarial drugs.		De novo idea likely to identify some host-genetic factors that are responsible for drugs metabolism	2014- 2017	Provide the information on how host genetic factors influence the anti-malarial drugs metabolism and guide the program for better strategies to improve its efficacy.	RMRCT, Jabalpur
12	Role of mesenchymal cells in pathogenesis of malaria		Malaria manifests as a severe splenomegaly with infiltration of cells and lymphoproliferation as major contributing factors of the immunopathology. In <i>P. berghei</i> infection the role of mesenchymal stem cells (MSCs) is not known. Whether these cells will confer resistance against malaria is yet to be determined.	2012-2015	The molecular mechanism will shed light on the factors involved in protective immunity mediated by mesenchyma stem cell adopted by the host to combat malaria infection.	NIMR, New Delhi
13	Development of genetically modified mosquitoes for potential use in malaria control.	<p>i) Studies carried out on nitric oxide gene and its elements as one of the factor responsible for parasite killing in <i>An. culicifacies</i>.</p> <p>ii) Our previous studies on exploring role of mosquito salivary glands in blood feeding, and Hemocytes &amp; midgut flora mediated mosquito immune response. Through multi-transcriptomic &amp; functional genomics approach, we plan to identify tissue specific gene targets, affecting <i>Plasmodium</i> development.</p>		A long term approach	Nitric oxide gene is naturally selected in refractory <i>An. culicifacies</i> . May lead to novel transmission/malaria control strategies.	NIMR, New Delhi

	<b>Clinical Research</b>					
1	Comparison of short course (7 day) regimen of primaquine with 14 day regimen for prevention of relapses of vivax malaria		De novo idea of national importance with the objective of improving compliance of primaquine therapy and thus reduce transmission.	2013-2015	The compliance of antirelapse therapy in vivax malaria with short course regimen (7 days) of primaquine will be improved as compared with 14 day therapy	NIMR, New Delhi
2	Studies on changing clinical profile of malaria.	The clinical profile of malaria is changing. Vivax malaria is no longer benign. It is also presenting with complications. Few cases of severe vivax malaria were investigated. Detailed studies on the changing clinical profile of malaria are needed. This will help in understanding the changing clinical features and thus better management of such cases.		2012-2015	Better management of <i>P. vivax</i> cases will be possible.	NIMR, New Delhi
3	Studies on interactions of malaria with other infectious diseases like HIV, tuberculosis etc.		Concomitant infections with other fever causing organisms or those having effect on immunity can complicate malaria. Such studies will be conducted to have better understanding of the clinical profile and thus management.	2013-2015	The outcome will help in better management of patients of malaria	NIMR, New Delhi

Epidemiological/Operational Research						
1	Estimation of malaria morbidity burden in India	<p>Study undertaken in Jharkhand revealed that if we increase the Annual Blood Exam rate (ABER) matching with fever rate, the estimated malaria burden will be close to actual burden.</p> <p>In view of controversial figures given by a couple of published papers and need for generating evidence based data on malaria morbidity and mortality in the country, "Estimation of malaria burden in India: A prospective national study to validate recently proposed methodologies of burden estimation in India" has been planned to determine malaria incidence and deaths attributable to malaria in India</p>		2012-2014	Methodology for estimation of actual burden of malaria will be available for effective planning of control measures	<p>NIMR, New Delhi</p> <p>NIMS, New Delhi</p> <p>NVBDCP, Delhi</p>
2	Studies on resistance to synthetic pyrethroids and its mechanisms in malaria vectors.	<p>Earlier studies indicated tolerance of <i>Anopheles culicifacies</i>, to synthetic pyrethroids in the southern districts of Odisha State. In view of large scale distribution of LLINs in the State for malaria control, it is important to study the dynamics of resistance development in this vector population.</p>		2012-2014	The information on the susceptibility status of vector will contribute to updating of insecticide management policy in the programme.	<p>VCRC, Puducherry,</p> <p>DMRC, Jodhpur</p>
3	Intervention model to control <i>An. fluviatilis</i> transmitted malaria in the tribal areas of Odisha.	<p>With the knowledge on malaria vectors from the field studies and the availability of newer tools for vector (LLINs) and parasite control (ACT), it is proposed to demonstrate the feasibility of integrated vector management (IVM) for the control of <i>An. fluviatilis</i> transmitted malaria in tribal areas in Odisha.</p>		2013-2016	An intervention model for malaria control in tribal areas will be available for reduction in the malaria incidence in a CHC area. Could be replicated/adapted to similar areas.	<p>VCRC, Puducherry</p>

4	Development of comprehensive vector control strategy for vector borne diseases in urban and irrigation canal command area	Off-shoot. After mapping the vector species and their abundance, a control strategy will be developed taking into account the ecological and environmental changes leading to vector proliferation and change in their biological habits, disease prevalence and community behavior in newly constructed irrigation canal areas.		2013-15	Mapping of malaria and dengue vectors in Odisha state and comprehensive vector control for irrigation command area and urban centres like Bhubaneswar and Cuttack will be available for effective planning of malaria and dengue/chikungunya control.	RMRC, Bhubaneswar
5	Study of the geographical pattern of malaria transmission in Jaisalmer district and to identify the associated factors influencing malaria using GIS and statistical techniques	It is an off-shoot of earlier study on 'Development of software of a Real-Time IT based intelligent health informatics management system in Jaisalmer district' indicating variability in malaria transmission. Validation of findings of work undertaken in Pokharan PHC will be validated in other endemic areas in consultation with NIMR		2012-2014	The findings will help the programme to strengthen the control measures in a more advanced,early response and stratified manner.	DMRC, Jodhpur
6	Ecology and Bionomics of malaria vectors and their sibling species and to establish their role in malaria transmission in different eco-epidemiological zones.	The proposed research would provide thorough understanding of the distribution, bionomics and biology of vectors responsible for high malaria transmission particularly due to cerebral and severe malaria. This information would be of immense value in formulating situation specific and cost effective vector control strategies.		2012- 2015	The role of malaria vectors in different geographic areas, particularly in Andaman's, Chhattisgarh and NE states will provide evidence for planning appropriate vector control strategy in different areas.	NIMR, RMRC Jabalpur, RMRC Dibrugarh, RMRC Port Blair
7	Expanded programme for GIS mapping of vector borne diseases in NE India	Offshoot /continuation of the past work	-	2012-2015	The study is expected to identify disease hot spots for decision making & intervention by the health planners for vector borne diseases	RMRC, Dibrugarh & NESAC, Shillong

8	Surveillance against malaria caused by <i>P. cynomolgi</i> and <i>P. knowlesi</i> parasites		It has been observed that the sporozoites of <i>P. cynomolgi</i> , which are closely related to <i>P. vivax</i> , in the vector <i>An. sundaicus</i> , and the transmission of the former to both monkeys and man in the Great Nicobar islands of Andaman is possible. Great Nicobar Tehsil of Nicobar district reported 101 API in 2011, demonstrating high endemicity. The project envisages to determine the possible existence of simian malaria parasite in Great Nicobar where monkeys and humans co-exist as has been reported from Malaysia. Latest publication ( Tyagi et al J Antimicrob Chemother. 2013 Jan 4.) reveals the presence of <i>P. knowlesi</i> in An. & Nicobar islands . It is imperative to undertake study to find out the prevalence of this species in Andamans and Northeastern states as Myanmar has also reported <i>P. knowlesi</i> .	2012-2015	Role of <i>P. cynomolgi</i> and <i>P. knowlesi</i> in human malaria transmission will be known which will help in planning appropriate preventive and control measures.	RMRC Port Blair, RMRC Dibrugarh, RMRC Jabalpur and NIMR, New Delhi
9	Evaluation of zero vector durable lining for vector control	Offshoot of an earlier study		2012-15	To develop a Model for Malaria Control in Forest Areas	RMRC,T, Jabalpur
<b>Translational Research/Technological Development</b>						
1	Establishment of climate change and vector borne disease cell	NIMR has pioneered in studies on impact of climate change on malaria. It is felt that there is need of extension of research and training in other VBDs like dengue and JE etc so as to assess the potential threat of climate change on VBDs.		A long term activity	Adaptation measures for mitigating the adverse impact of Climate change on VBDs will be known and human resource in this field will be available.	NIMR, New Delhi

2	Synthesis, pKa determination and <i>In-Vivo</i> Toxicity of new promising antimalarial 6-methoxy-5,8-di-(4-amino-1-methylbutyl-amino)-quinoline	6-Methoxy-5, 8-di-(4-amino-1-methylbutyl-amino)-quinoline [Indian Patent No.189970 [3280/DEL/98] isolated by peroxydisulfate oxidation of primaquine has been found to possess good gametocytocidal activity against <i>Plasmodium yoelli</i> infected mice. To establish the safety of 6-Methoxy-5, 8-di-(4-amino-1-methylbutyl-amino)-quinoline [P1] [P1] <i>in-silico</i> drug-likeness studies were carried out. The result of <i>in-silico</i> drug-likeness and toxicities studies showed that 6-Methoxy-5,8-di-(4-amino-1-methylbutyl-amino)-quinoline [P1] [P1] is least toxic among all primaquine analogues and obeys all drug-likeness rules. Therefore it is proposed to develop a viable route for the synthesis of 6-Methoxy-5, 8-di-(4-amino-1-methylbutyl-amino)-quinoline [P1] [P1] and investigate the safety and efficacy to establish this compound as promising antimalarial agent.		2012-2014	A new antimalarial agent will be available.	NIMR, New Delhi
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3	Development of botanical insecticide formulation of essential oils extracted from <i>Lantana camara</i> and <i>Valeriana jatamansii</i> and <i>Psoralea corylifolia</i> for the control of mosquitoes.	Recently adulticidal activity of <i>Lantana camara</i> , <i>Valeriana jatamansii</i> and <i>Psoralea corylifolia</i> have been reported. The present invention successfully isolated fractions from these plants which possess good adulticidal properties against mosquitoes and holds potential for the development of botanical insecticides against mosquitoes. It is proposed to develop a botanical insecticide formulation for the control of mosquitoes using essential oils from <i>Lantana camara</i> , <i>Valeriana jatamansii</i> and <i>Psoralea corylifolia</i> in large scale.		2012-2014	A potent herbal product for vector control will be available	NIMR, New Delhi
4	Screening of synthetic compounds/Plant extracts for antimalarial/antilarval activities	Development of an antimalarial formulation from the plant <i>Brucea mollis</i> and (ii) Mosquito larvicidal formulation from the plant <i>Linostoma decandrum</i> . Under translational research this project has been initiated by ICMR Hqrs as a fall out of earlier work done by the Centre. Plant collection has been completed and extraction is in progress.  characterization of potent plant species through DNA barcoding (a collaborative study with Guwahati University is also ongoing in 12 <sup>th</sup> plan.		2012-2015	A potent herbal products for vector control/antimalarial will be available	RMRC, Dibrugarh

5	Alternate strategy of tackling malaria in disturbed areas of Chhattisgarh		Denovo	2012-15	To develop a Model for control of Malaria in disturbed areas	RMRC,T, Jabalpur
6	Task Force project on 'Biology and Bionomics of Vectors', under Vector Born Disease Science Forum	No	Malaria epidemiology in India is complex as there are about 14-15 species (this includes major and secondary vectors, and sibling species that have been identified and incriminated as vectors) that are transmitting malaria. There is a need to generate comprehensive data	2013-2017	Data on Biology and bionomics of vectors and transmission dynamics of Malaria needs to be generated in the country. Studies on bionomics of malaria vectors are required especially for North-eastern states Maharashtra, Orissa, Chattisgarh, Jharkhand and Andhra Pradesh extensive entomological survey of malaria vectors is required	NIMR,New Delhi RMRC, Dibrugarh, RMRC, Jabalpur RMRC, Bhubneshwar
7	Evaluation of indigenous plant extracts for insecticidal and repellent activities against mosquitos of medical importance	New study	To evaluate selected plant extracts for different biological activities (larvicidal & growth regulatory) against <i>Anopheles stephensi</i> , <i>Culex quinquefasciatus</i> & <i>Aedes aegypti</i> . To evaluate selected plants for its repellent activities against <i>Anopheles stephensi</i> , <i>Culex quinquefasciatus</i> and <i>Aedes aegypti</i> . To identify the active fraction (s) and deduce the chemical structure of the active component in such fractions.	2013-2015	To study our indigenous plant resources systematically against malaria vector control. The use of herbal products will reduce environmental load, besides being cost effective and safe.	Supported through extramural research (Udaipur University)
8	Bioassay guided isolation of mosquito larvicidal principles from Western ghat plants.	New study	To find out the efficacy of different extracts and essential oils containing drugs on different species of mosquitoes like <i>Anopheles stephensi</i> , <i>Aedes aegypti</i> and <i>Culex quinquefasciatus</i> . Bioassay guided fractionation to identify the active fraction of the selected plant extracts.	2013-2015	Systematic study of larvicidal activity of selected plants to find out the fraction of the extract showing the activity and deducing the structure of chemical entity responsible for the activity by using different analytical methods.	Supported through extramural research (College of Pharmacy, Bangalore)

9	Development of New Plant based insecticide for larval and adult mosquito control	New study	Evaluation of crude solvent extracts of five plant species for their larvicidal, IGR, adulticidal and repellent activities (as per WHOPEs Protocol) against <i>Cx. quinquefasciatus</i> , <i>Ae. aegypti</i> and <i>An. stephensi</i>	2013-15	The present study is taken to identify the larvicidal, adulticidal, repellent and insect growth regulatory potential of 3 plant species viz. <i>Atalantiaracemosa</i> , <i>Glycoamiamauritian</i> and <i>Cippadessabaccifera</i> , on three species mosquitoes viz. <i>Anopheles stephensi</i> , <i>Aedes aegypti</i> and <i>Glycoamiamauritian</i> and to isolate and elucidate the structure of active principle using modern analytical methods.	Supported through extramural research (Periyar University, Salem, Tamil Nadu)
10	Task Force project on Insecticide resistance monitoring in malaria vectors under Vector Born Disease Science Forum	No	Resistance monitoring should be a continuous process and data needs to be generated from across the country. Besides monitoring of resistance, factors influencing resistance like operational factors, genetic factors etc should also be studied. Change in vector behaviour after use of LLINs and ITNs (wherever used) should also be studied	2013-2017	Country –wide data on insecticide resistance will be generated, which will be useful to decide on the national programme policy	All the ten ICMR institutes working on VBDs are involved

Table 4. Status of projects funded by other than ICMR

Sr. No.	Thematic area and title of the Study	Objectives	Completed/ ongoing with outcome of the study	Justification for continuation	Time frame	Institution	Source of Funding
<b>Basic Research</b>							
1	Mitochondrial population genomics of Indian <i>Plasmodium falciparum</i>	To infer evolutionary patterns of Indian <i>P. falciparum</i> based on whole genome sequence of mitochondria	ongoing	The data generated so far have provided interesting results. The complete study is needed for a detail evolutionary understanding and determination of if Atovaquone can be used in the program	2010-2014	NIMR	DBT, New Delhi
2	Novel approach to determine geographical & genomic barriers to gene flow in a major malaria vector (UK-India-Myanmar collaborative project)	Overall aim is to gain thorough understanding of contemporary gene flow in <i>An. baimaii</i> , the major malaria vector in South-east Asia including NE India	Ongoing	This 3 years duration study was initiated in 2010 and being the committed activity has to be continued as per schedule	2010 - 2013	RMRC, Dibrugarh, University of Manchester, UK & DMR, Myanmar	The Wellcome Trust, UK
3	Screening of indigenous medicinal plants for development of potential antimalarial drug/drug intermediates and characterization of potent plant species through DNA barcoding (a collaborative study with Guwahati University)	To search for newer plant based antimalarial drug	Ongoing	This 3 years duration study was initiated in 2012 and being the committed activity has to be continued as per schedule	2012-2014	RMRC, Dibrugarh & University of Guwahati	DBT (Twinning Scheme)
4	Synthesis of Hybrid 4-Aminoquinoline-1,3,5-triazine derivatives and evaluation of their Antimalarial Activity (a collaborative study with Dibrugarh University)	To search for synthetic antimalarial drug	Ongoing	This 3 years duration study was initiated in 2012 and being the committed activity has to be continued as per schedule	2012-2015	RMRC, Dibrugarh & University of Dibrugarh	DST New Delhi

<b>Clinical Research</b>							
1	Nutritional factors & severity of malaria- a study from north-east India (a collaborative study with NII, Mumbai)	To correlate the severity of malaria with nutritional status of population in malaria endemic areas of NE India	Ongoing	This 3 years duration study was initiated in 2011 and being the committed activity has to be continued as per schedule	2011-2014	RMRC, Dibrugarh & IIH, Mumbai	DST New Delhi
2	Folate metabolism pathway gene polymorphisms among symptomatic & asymptomatic malaria patients from NE India (a collaborative study with NII, Mumbai)	To study the gene polymorphism pertaining to folate metabolism pathway in malaria subjects	Ongoing	This 3 years duration study was initiated in 2011 and has to be continued as per schedule being the committed activity	2011-2014	RMRC, Dibrugarh	DST New Delhi
<b>Epidemiological/Operational Research</b>							
1	Phase II of Health impact assessment of entire Narmada basin in Madhya Pradesh and Sardar Sarovar Command areas of Rajasthan in districts Jalore and Barmer.	To identify major engineering problems in dam sites and to suggest situation specific mitigating measures for malaria and other VBDs control	ongoing	Narmada Valley Development Authority, MP and Govt. of Rajasthan have sanctioned project up to 2015. The emerging problems in receptivity of malaria due to developmental projects will be known and remedial measures for control will be suggested .	2012-2015	NIMR, New Delhi	NVDA, M P and Govt of Rajasthan
2	Evaluation of DRDO Defender nets against mosquitoes in Assam	To evaluate the indigenously developed LLIN by DRDO against mosquitoes in Assam	Ongoing ( Just initiated)	The study has to be continued as per schedule being the committed activity	2013-2014	RMRC, Dibrugarh; CRME, Madurai and NIMR	DRDO

3	GIS mapping of vector borne diseases in north-east India along with identification of disease foci (a collaborative study with NESAC, Shillong)	The study is aimed at creating a digital data base of vector borne diseases for easy retrieval of data and identifying disease hot spots for decision making & intervention by the health planners	Ongoing	This two- year study was initiated in 2011 and being the committed activity has to be continued as per schedule	2011-2013	RMRC, Dibrugarh & North East Space Application Centre, Shillong	Department of Space
<b>Translational Research</b>							
1	Impact of climate change on malaria in India by the year 2030.	To develop a projection model of possible malaria transmission windows in view of climate change	Completed	Based on temperature and RH, using PRECIS model, projection of malaria by 2030 revealed that a few districts of Himalayan region are likely to open transmission windows of malaria and increased intensity in northeastern states. Evidence-based data are being generated with ICMR funding	2009-2010	NIMR, New Delhi	MoEF



