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Malaria Paradigms in India and Control Strategies

S. PATTANAYAK, V.P. SHARMA[a], N.L. KALRA[a], V.S. ORLOV[b] and R.S. SHARMA[c]

The paper gives a brief history of malaria control in India through the National Malaria Control Programme (NMCP), National Malaria Eradication Programme (NMEP), implementation of the Modified Plan of Operation (MPO), strengthening of malaria control by launching *P. falciparum* Containment Programme (PfCP) and the Urban Malaria Scheme (UMS). Making reference to various evaluations of the NMEP, the paper analyses the present malaria situation and brings out reasons demanding change in the strategy of malaria control in consonance with the global malaria control strategy of the World Health Organization (WHO). The epidemiological analysis has revealed that the present adverse malaria situation concentrates mostly under the following five epidemiological paradigms viz. (i) tribal malaria, (ii) rural malaria, (iii) urban malaria, (iv) industrial malaria, and (v) border malaria. Malaria control requires specific approaches and control strategies for each paradigm.

We have suggested changes/augmentation in the organizational set-up beginning from NMEP Directorate to the most peripheral health units. The primary responsibility of malaria prevention and control including cost in developmental projects should be shared by the corporate sectors through intersectoral coordination. Residual problems during maintenance phase of the project would come under the general health services. International and bilateral cooperation increases resources availability. The available tools and their rational use for malaria control in different epidemiological paradigms has been discussed with emphasis on integrated control, selective use of chemical insecticides and adoption of cost-effective and sustainable malaria control methods. In this context, intersectoral collaboration, community participation, training, operational research and health education have been discussed as the vital components for effective malaria control.

Keywords: Control strategy, Disease management, Malaria paradigms, Transmission control

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Retired Director NMEP, B-91, Swasthya Vihar, Delhi-110 092, India.
[a]Malaria Research Centre, 20-Madhuvan, Delhi-110 092, India.
[b]World Health Organization, World Health House, New Delhi-110 002, India.
[c]National Malaria Eradication Programme, 22-Sham Nath Marg, Delhi-110 054, India.

1 BACKGROUND

Historically malaria is a disease of great socio-economic importance. Malaria in past has prevented man from invasion into new areas. It has proved to be a decisive factor in wars. It could destroy whole national economy. The history of malaria in India is dreadful[1]. In 1947, it was estimated that annually about 75 million cases with 0.8 million deaths used to occur due to malaria. These figures often increased manifold during epidemic years. In addition to huge morbidity and mortality, agricultural production suffered badly in some areas like terai area in Uttar Pradesh, Wynad in Kerala and Malnad in Karnataka. There were many instances where colonisation was impossible due to ravages of malaria and a classical example is terai area of Uttar Pradesh. Industrial development also suffered badly during the years. Sinton[2] in 1935 estimated that economic loss due to malaria at the time of Independence of India (1947) was about Rs. 7,500 million per annum. Starting with moderate attempt to control malaria in Lahore (now in Pakistan) during former half of 20th century, remarkable success was achieved through malaria eradication programme, when in 1964 about 1,00,000 cases were reported with no deaths[3]. The success of the programme was so pronounced that in 1960's it encouraged launching of disease control programmes against major communicable diseases like tuberculosis, leprosy, trachoma, filariasis etc.

2 MALARIA RESURGENCE AND THE MODIFIED PLAN OF OPERATION

The success achieved of the malaria eradication programme was shortlived, due to technical, administrative and financial flaws. The most important being sudden withdrawal of insecticide supplied by the United States Agency for International Development (USAID) in 1965 and hasty transfer of NMEP activities to general health services (maintenance phase), which were either nonexistent or poorly developed. Fig. 1 gives the malaria profile of India as reported by the NMEP. The resurgence of malaria after 1964, reached its peak in 1976, when about 6.47 million cases were recorded[4]. Malaria was seen as a definite impediment in development, and there was imminent risk of its adversely affecting the green revolution and the industrial growth of the country. The government was on alert to the seriousness of the situation and in 1977 reorganised the programme as MPO, which had 3 main objectives, (i) prevention of deaths due to malaria, (ii) reduction of morbidity due to malaria, and (iii) maintenance of industrial and green revolution due to freedom from malaria, as well as retention of achievements gained so far[5].

While laying down these objectives under the MPO, the government was fully conscious of the role of inter-sectoral

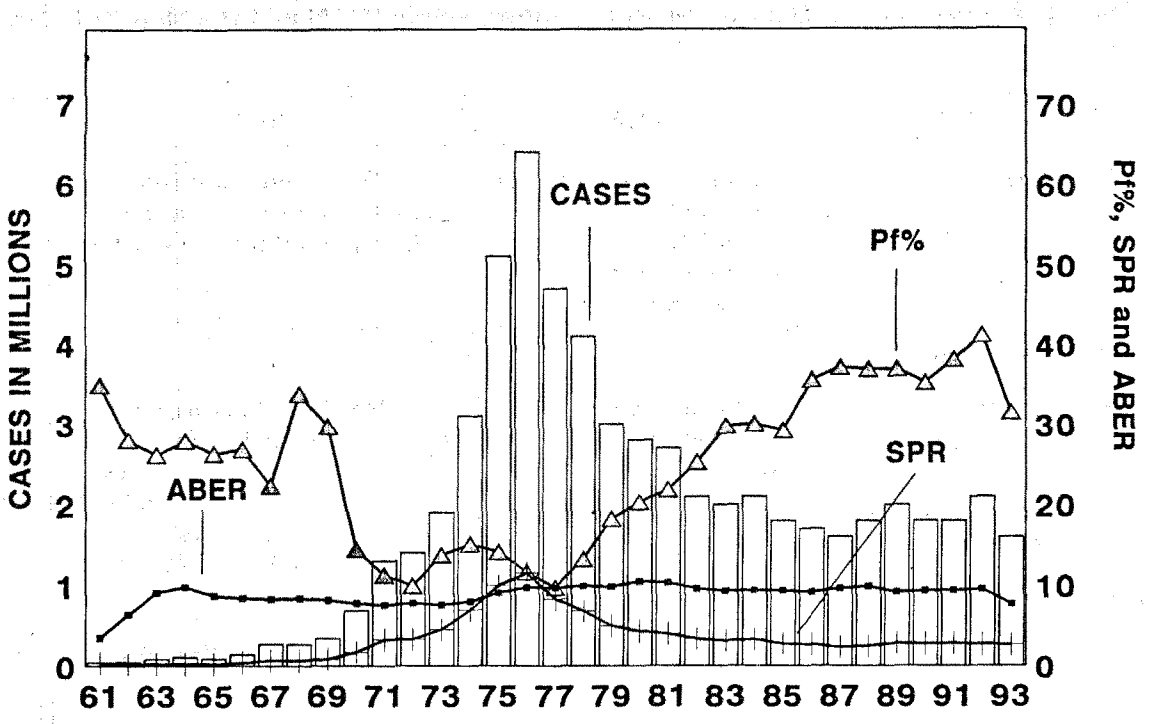

Fig. 1: Malaria profile of India

agencies in malaria control. This was a complete deviation from the practice under the malaria eradication programme which was a vertical programme, with no scope for intersectoral collaboration. Though not to the degree of perfection required, under the MPO there was scope for interaction and cooperation between the industrial and agricultural sector. The MPO was a 3-pronged strategic attack on malaria, namely government's effort, peoples' participation, and research and training. Table 1 gives the comparison of objectives and technical requirements in implementation between NMEP and MPO. A remarkable feature was the availability of drugs in almost all malarious villages in India by opening drug distribution centres (DDCs) and fever treatment depots (FTDs). DDCs were mainly targeted to prevent the mortality due to malaria by making drugs available, while FTDs collected blood slides to study the trend of the disease in addition to provide drugs. All DDCs and FTDs were voluntary, and only drugs, blood slides and register for recording the name and address of the beneficiaries were provided. All malarious villages in the country were covered under this project and in some villages there was more than one DDC/FTD to meet the demand. To counter any operational problem, a research component was provided under MPO.

Table 1. Comparison of Malaria Eradication Programme (MEP) and the Modified Plan of Operation (MPO)

Parameter	MEP	MPO
1. Objective	Ending of transmission and elimination of reservoir of infective cases in a time limited campaign	(i) To prevent mortality (ii) To prevent morbidity (iii) To maintain gains achieved
2. Implementation		
(i) Nature of the organization	Vertical organization, programme implementation through unit (1 million population)	Horizontal organization, implementation through general health services, boundaries of units to align with revenue districts irrespective of population
(ii) Functionaries	Malaria Unit Officer to organise all activities related to spray operations, surveillance, and treatment with centralised laboratory at PHC	Functions divided. DMO to organise spray operations as vertical and treatment decentralized to PHCs
(iii) Active case detection	Fortnightly household visit basis	Fortnightly household visits under MPW scheme
(iv) Inter-sectoral coordination	Not listed	Industrial projects made responsible for malaria control in their establishment with cost
(v) Community participation	Passive	Active through opening of DDCs/FTDs, i.e. in rural areas and free drug distribution by volunteers
(vi) Duration	Time bound	Open
3. Technical		
(i) Field operations	Based on well defined phasing, i.e. attack consolidation and maintenance	No phasing

contd...

Table 1. (*contd.*)

Parameter	MEP	MPO
(ii) Spraying	Restricted to attack phase	Spraying in areas with 2 API and above. Focal spray in areas below 2 API
(iii) Entomological component	At state level	At state and zonal level
(iv) Intervention methods	Non-flexible	Flexible
(v) Epidemiological parameters		
– Case findings	Essential, radical treatment required in maintenance phase	Important to implement. Chemotherapy and spray in *Pf* areas
– Vulnerable	–	Pregnant women, infants and children to receive priority treatment
– Imported cases	After withdrawal of spray	–
– Evalution of Results	Disapperance of malaria	By comparing the ABER/API, SfR of consecutive two years
– Entomological results	Monitor vector response to insecticides	Monitor vector behaviour(s), response to insecticide, study dynamics of transmission to evaluate changes in control strategy
– Research	Not necessary	Applied and operational research essential
– Training	Required	Required for further diversification and extension to non-health sectors
4. Financial	For the entire programme	Flexible from year to year as per epidemiological needs and availability of funds
– Cost sharing	100% centrally sponsored	50:50 centre and state sharing basis

On realising the role of micro-epidemiology in the transmission and control of malaria, training in malariology was geared-up.

MPO was the first amongst the disease control programmes to decentralise the programme delivery system. In contrast to NMEP, implementation of the programme was through district health system. A District Malaria Officer (DMO) was provided at each district under the administrative control of the Chief Medical Officer (CMO). Centralised laboratories were decentralised and were placed at the Primary Health Centres (now known as community health centres). Active and passive case detection were entrusted to health infrastructure. In view of the coordinated nature of activity for insecticidal spray, this activity had vertical set-up which was well-justified in approach, but lacked a strong inter-sectoral collaboration as envisaged in MPO[5]. This aspect was most pronounced in the preventive measures of malaria control, particularly incidental to engineering construction[6]. During the implementation of the Modified Plan of Operation, the emergence of *Plasmodium falciparum* in epidemic form in some areas, posed a serious challenge. The government acted wisely and in collaboration with the WHO and financial support from Swedish International Development Agency (SIDA) launched a *P. falciparum* Containment Programme (PfCP) within the ambit of MPO to arrest the rising trend and frequent epidemics of *P. falciparum*[7].

During eradication phase, urban malaria was not taken into consideration, as it was contemplated that the efforts of local bodies carrying out antilarval measures would be sufficient to curtail vector density in the urban areas. This was based on the experience mostly from Bombay[8] and Delhi[9] but in course of time it was proved that local bodies had failed to interrupt transmission resulting in large-scale outbreaks in some urban areas.

Considering the rise in incidence of malaria in the urban areas, UMS was formulated in 1971 and urban malaria units were established. During MPO, the scheme was extended initially to 47 urban areas and finally to a total of 131 towns[10].

UMS also in course of time was found deficient as it did not take *An. stephensi* factor into its reckoning. The whole approach was mainly directed towards *Culex* control, and partially *An. culicifacies* in fringe areas. *An. stephensi* control which required different strategy and staff deployment etc. did not receive adequate attention and this element was left untouched, hence impact on the transmission was found unsatisfactory[11].

Critics might say the programmes, the MPO and PfCP did not yield the desired results. A detailed analysis would indicate that the approach was correct and substantial progress was made. However, MPO was a contingency plan and required constant eval-

uation and modifications to match the emerging situation, but this did not happen; rather it was taken as the ultimate in malaria control.

The Government of India in 1986 gave priority to health programmes under 20 point programmes[12], but malaria lost its priority as it was clubbed under point 8 (health for all) which included Tuberculosis and Leprosy control programmes. This resulted in loss of leadership at the state level. Between 1978-86, six to seven programme directors changed in Andhra Pradesh, Assam, Karnataka, and Orissa. Bihar, Gujarat, Meghalaya and Tripura did not have programme directors during the period. Loss of expertise was the next cause due to frequent transfers and lack of training facilities of new recruits at Regional Coordinating Organization (RCO) now known as Regional Health and Family Welfare Organization (RH&FWO). During sixth plan NMEP expenditure was on 50:50 cost sharing basis as centrally sponsored category-II scheme. The cost of malathion which was provided on 100 per cent subsidy to states during the plan was also brought under 50:50 sharing in the 7th plan. As a result the insecticidal spray became a casualty, as State Governments gave credence to cost rather than technical requirements. States which required malathion opted for Diethyl-Diphenyl-Trichloroethane (DDT); as a result many areas reverted to original malaria endemicity (pre-DDT levels), and areas below 2 API experienced outbreaks. Introduction of multi-purpose worker scheme (MPW) though desirable but was implemented without taking into consideration the work load of the various programmes. At any given time 25-40% posts remained vacant and many areas particularly interiors remained as blackout areas[13]. Introduction of community health workers (CHWs), and the village health guide scheme with financial remuneration gradually eroded the voluntary institutions of DDCs and FTDs, and practically the scheme became defunct. A single instance of massive community participation purely on voluntary basis without any financial support which was well established, was completely destabilised.

3 PRESENT MALARIA SITUATION

The in-depth evaluation of the modified plan of operation of the NMEP in 1985 commented on the malaria situation that *the problem of malaria in India is grossly under estimated*[14]. This observation was based on several reports of under-reporting by the research organizations in the country.

As per the NMEP report, there has been a considerable reduction in total malaria cases, i.e. 6.47 million cases reported in 1976 declined to 2.099 million cases by 1992. However, *P. falciparum* cases increased from 0.75 million in 1976 to 0.879 million

by 1992. From 1983 till 1992, there has been stabilization of total malaria cases, although *P. falciparum* cases have been showing a gradual increase i.e. 21% in 1982 has almost doubled to that of 41% in 1992[15].

NMEP estimates on malaria morbidity could be cross-checked to some degree on the basis of the consumption of anti-malarials. Yearly production of chloroquine phosphate base in the country is 270 metric tonne (MT)[16,17]. Assuming the use of 70 MT for other therapeutic purposes and export to the neighbouring countries, atleast 200 MT is used within the country in the treatment of fever cases. One MT yields 4 million tablets of 250 mg, and therefore 800 million tablets of chloroquine are available. If 300 million tablets required by the NMEP are taken out, the balance of 500 million tablets are still available for the treatment of fever cases outside the NMEP. In the private sector on an average 7 tablets may be used in the treatment of one episode of malaria. Therefore 500 million tablets would treat 71.5 million fever cases. Since about 50% cases may be due to malaria, a rough estimate of morbidity due to malaria comes to 35.7 million episodes in addition to malaria cases treated by the NMEP. Therefore, it may be more realistic and safer to assume that at least 10-15 fold under-reporting of malaria cases or approximately 20-30 million malaria episodes occur every year. Therefore, there may be 10-15 million individuals suffering from malaria assuming an average of 2 episodes per person.

As far as malaria mortality is concerned, deaths due to malaria as reported by the NMEP started in 1974 and have fluctuated between 200 to 500 (Fig. 1) but these are grossly under-reported. In 1989 crude death rate (CDR) in the country was 10.8 per thousand. Of these deaths due to fever were 7.4%, and among the fever deaths, those due to malaria were 0.8%. Based on this information estimated deaths due to malaria have been calculated as 73,795. Vital statistics of India also reported similar death figures due to malaria i.e. 1,37,846 deaths in 1985[18] and 75,285 in 1987[19].

To measure the burden of the disease, World Development Report, 1993 uses a new measure expressed as disability adjusted life years (DALY)[20]. DALY is a measure that combines healthy life years lost because of premature mortality with those lost as a result of disability. DALY for malaria in India in 1990 was 0.47 million for women and 0.48 million for men (total DALY 0.95 million).

4 NEED FOR A CHANGE IN THE STRATEGY

MPO was a contingency plan to meet the deteriorating malaria situation prevailing in 1970's[5]. It was to be suitably strengthened to meet the changing needs. All plans need peri-

odical review to assess its efficacy to meet the prevailing situation, however MPO has been continued to be in its present form since 1977.

The present malaria situation demands a change in the strategy. The highlights inter alia, includes factors demanding a change in the strategy are:

(i) Although there is reduction in *P. vivax* cases, there is no dent in *P. falciparum* malaria which has extended to new areas covering almost the entire country. The earlier emergence of chloroquine resistance and now extending to sulpha-pyrimethamine combination and evidence of its gradual spread are a matter of serious concern requiring immediate and more effective control of transmission.

(ii) Insecticide resistance in vectors of malaria particularly *An. culicifacies* has made spraying practically ineffective in the containment of transmission. Spraying has also resulted in changes in vector behaviour viz. increased exophily and exophagy, thus questioning the strategy of residual spraying. Spraying of insecticides has also associated problems of refusals, mud-plastering of sprayed walls and unacceptability in economic zones of sericulture, honey bee rearing and tobacco cultivation. Entomological component did not get any direction to prove its usefulness, and this technical element was used for administrative and related works by the establishment.

(iii) Rapid urbanization, industrialization, irrigation, man-made changes and population migration have resulted in formation of new paradigms which require specific approaches for malaria control.

(iv) Deficient health infrastructure, management information system and health delivery at periphery requires to be reviewed and reorganized in view of control failures.

(v) Lack of information on sociological/behavioural attitudes, and reach of health services in difficult terrain systems particularly, in tribal populations has resulted in failure of malaria control operations.

(vi) Programme lacks the capacity to absorb new technologies and therefore requires additional technical man power.

(vii) So far intersectoral coordination with other sectors was restricted to sharing of expenditure rather than finding problem oriented solutions. Further flexibility of intervention granted to the programme officers were mere slogan, as any change required the approval by Technical Advisory Committee (TAC) of NMEP, which seldom met.

(viii) Different malaria situations required different approaches under the MPO. In the absence of emphasis on the study of microepidemiology, this was never practiced.

(ix) Active case detection (ACD) was functional in 40 to 50 per cent areas and this data, which was used to monitor the incidence, could only provide information on trends as millions of cases treated by DDCs, FTDs and treated in urban areas (both in the private and in hospital) did not find their enumeration in the malaria statistics. There was also the build-up of parasite reservoir in absence of timely radical treatment.

For the reasons mentioned above, NMEP field operations were weakened, impact was not perceptible, and in many places NMEP was seen as irrelevant.

The renewed attack on malaria based on epidemiological analysis, and as envisaged in this document will give immense benefit to the community and to the economic development of the country. Most important group of population, namely women, children and migrants are now the main victims of the malaria disease. Effective control of malaria will help the *Child Survival and Safe Motherhood Programme* as it would provide healthy mothers free from malaria infection and complication of anaemia. It will also reduce the mortality in pregnant women particularly those in the 3rd trimester.

The population living in forest, forest fringes, hilly and difficult areas are marginalised group. Malaria is a serious problem among them[21]. Meticulously planned malaria programme will reduce the problem in this group of population and will help in uplifting the health status of the marginalised group as enshrined in the constitution of India.

5 PREVALENT MAJOR MALARIA PARADIGMS

Based on existing malaria situation, the following malaria paradigms have been identified in the country.

5.1 Type I. Tribal Malaria

5.1.1 Tribal malaria of the deep forests and forest-fringes: Features of this malaria are stable and high malaria transmission with (i) predominance of *P. falciparum* moderately resistant to chloroquine and, focally, to sulpha-pyrimethamine drugs, (ii) *An. dirus*, *An. minimus* and *An. fluviatilis* as major vectors refractory to transmission control, (iii) predominant mobile tribal population and constant measurable mortality among pregnant women, children and mobile non-tribal population groups, (iv) inadequate health infrastructure, and (v) lack of treatment facilities at the village level. Control objectives should be prevention of mortality in high risk groups and reduction in morbidity.

5.1.2 Tribal malaria in proximity of forest-fringe areas and with disturbed ecology: The features of these areas are moderate to high endemicity with (i) periodic epidemics/outbreaks, (ii) predominance of *P. falciparum*, (iii) widespread low to moderate degree of resistance to chloroquine, (iv) *An. philippinensis* (= nivipes) as main vector amenable to transmission control, (v) aboriginal tribal migrated to these areas also recently established non-tribal populations, (vi) high mortality among non-tribal and moderate among tribal population during periodic epidemics, (vii) limited health infrastructure, and (viii) lack of drugs at the village-level. Control objectives should be: (a) prevention of mortality, (b) reduction of morbidity, (c) prevention and control of epidemics, and (d) reduction of *P. falciparum* in mono- and multi-drug-resistant areas.

5.2 Type II. Rural Malaria

5.2.1 Irrigated areas of arid and semi-arid plains: The features of this malaria include (i) moderate to low endemicity, (ii) *P. vivax* predominance during lean years, and *P. falciparum* during periodic exacerbation of malaria transmission, (iii) localized *P. falciparum* resistance to chloroquine, (iv) *An. culicifacies* as the main vector, (v) multiple vector resistance, (vi) moderately developed health infrastructure, and (vii) moderate impact on health and substantial mortality during epidemics. Control objectives should be: (a) reduction of morbidity, (b) prevention and control of epidemics, (c) reduction of *P. falciparum* and (d) elimination of mono- and multi-drug resistant *P. falciparum* foci.

5.2.2. Rural areas without irrigation: Important features of this malaria are: (i) low endemicity, with *P. vivax* predominance and periodic localized outbreaks, (ii) in desert areas with *An. stephensi* as major vector during interepidemic periods and *An. culicifacies* during epidemics, (iii) in other rural areas *An. culicifacies* as the major vector amenable to transmission control, and (iv) fairly well-developed health infrastructure and marginal impact of malaria on health. Control objectives should be maintenance of low incidence status and prevention and control of epidemic outbreaks.

5.3 Type III. Urban Malaria

5.3.1 Malaria in towns: Important features of malaria in towns include: (i) moderate to low endemicity, with *P. vivax* predominance and focal *P. falciparum* transmission, (ii) sporadic epidemics around construction projects, (iii) *An. stephensi* and *An. culicifacies* as the main vectors refractory to transmission control, (iv) limited impact on health, and (v) well developed health infrastructure.

5.3.2 Malaria in peri-urban areas: This malaria is mostly influenced by *An. culicifacies*, poor sanitary conditions with low socio-economic groups living in unplanned settlements, prone

to periodical epidemics. Control objectives should be: (a) prevention of mortality and duration of illness, (b) reduction of morbidity, and (c) reduction of *P. falciparum* incidence.

5.4 Type IV. Industrial Malaria

Malaria in development projects in various epidemiological strata with: (i) disturbed ecosystems and epidemic-prone areas, (ii) one or more major vectors involved, may be amenable or refractory to transmission control, (iii) substantial impact on health of labour force, (iv) limited health facilities for prompt treatment, invariably associated with chloroquine resistance, and (v) in the north-eastern states, with mono- and multi-drug resistant *P. falciparum*. Control objectives should be: (a) prevention of mortality, (b) reduction of morbidity, and (c) suppression of transmission.

5.5 Type V. Border Malaria

Malaria prevalent along high transmission belts, international borders and state boundaries. These areas have their own problems in regard to malaria control, e.g. frequent exchange and mixing of population, illegal activities and poor administrative control thus making malaria control problematical, and at times impractical. Control objectives should be the same as for the rest of the contiguous region, but selection of control tools would largely be based on local situation and quality of health delivery infrastructure present.

Malaria among migrant population moving from endemic to non-endemic areas and vice-versa often presents a serious malaria problem. Migration often brings localized epidemics and new parasite strains are disseminated. Migration malaria cuts across all the boundaries of epidemiological types of malaria, but it is more pronounced in projects and intensive agriculture areas. Control objectives should be: (a) prevention of mortality, (b) prevention of epidemics, and (c) suppression of mono- and multi-drug resistant *P. falciparum*.

In the major epidemiological types of malaria discussed above, one may find overlapping areas of mixed epidemiology and therefore the above classification should be seen in a broad perspective of malaria paradigms at the national level.

6 STRATEGY OF MALARIA CONTROL

India is one of the signatories of the Global Malaria Control Strategy signed in Amsterdam in October 1992. Keeping this international commitment in view, a revised malaria control strategy has been drafted. The main tenet of the strategy is based on the commitment of freedom from malaria as the basic right of the people of India.

Revised malaria control strategy requires:

- Political commitment;
- Intersectoral coordination;
- Legislative support; and
- Epidemiological approaches in malaria control.

The situation of malaria has deteriorated rapidly due to creation of mosquitogenic potential under the impact of developmental activities. In such situations where malaria is generated by human activity, the primary preventive responsibility of malaria control should lie with the sector(s) responsible for generating mosquitogenic conditions at their cost. Residual problem of malaria control should however, remain the responsibility of the general health services.

The main strategy of malaria control so far has been the control of malaria vectors at their resting sites by spraying residual insecticides. While this strategy would continue to be applied on selective basis, taking into account the magnitude of the malaria problem in India, existing technical, operational and administrative constraints, it is felt that there is no radical solution to the problem at present. Therefore, the major feature of the proposed malaria control strategy is the *Improved Management of Malaria* with the following general objectives:

(i) Management of serious and complicated malaria cases;

(ii) Prevention of mortality due to malaria particularly in high risk groups;

(iii) Control of malaria outbreaks/ epidemics;

(iv) Reduction of *P. falciparum* incidence;

(v) Containment of drug-resistant malaria;

(vi) Reduction of morbidity due to malaria; and

(vii) Maintenance of low malaria incidence status.

7 GENERAL APPROACHES TO MALARIA CONTROL

General approaches to the management of malaria are as follows:

7.1 Organizational

(i) Decentralization of malaria control; and

(ii) Enhanced support for the development of epidemiological approaches.

7.2 Disease Management

(i) Early case detection and prompt treatment (EDPT) even at the most peripheral level of health services.

(ii) Disease management through improved hospital infrastructure.

7.3 Transmission Control

(i) Selective and sustainable vector control;

(ii) Rural and urban sanitation;

(iii) Intersectoral coordination; and

(iv) Legislative support.

7.4 Strengthening of malaria control

(i) Prediction and early detection of epidemics;

(ii) Capability and capacity building at the periphery;

(iii) Health systems research (HSR);

(iv) Information, education and communication (IEC) approach;

(v) Knowledge, attitude, belief and practices (KABP) approach;

(vi) Community participation; and

(vii) Periodic programme reviews, e.g. drug policy, insecticide policy, drug resistance status, operational problems, inputs from research, social, political and economic determinants, training needs etc.

8 STRATEGIC MALARIA CONTROL APPROACH

Malaria control in areas under each paradigm described in section V requires specific approach for disease management and transmission control for the attainment of pre-set targets and goals. These are described below.

8.1 Tribal Malaria

Areas of the country under tribal malaria have been described under epidemiological Type I and so far this type of malaria has not responded adequately to control measures.

In seven peninsular states of India over 41.54 million tribal population of various ethnic origin resides under different eco-epidemiological forest belts. In addition, over 27.12 million rural population (including 7.38 million schedule tribes) in northeastern states are exposed to high risk of malaria (Table 2). While in the peninsular India tribal areas contribute around 33 per cent of the total malaria cases and 57 per cent of the total *P. falciparum* cases of the country, rural population including tribals of northeastern states contribute another six per cent of the total malaria cases and 11 per cent of the total *P. falciparum* cases (Table 3). Although in absolute numbers, total contribution of malaria by northeastern states is less but severity of malaria, i.e. *P. falciparum* preponderance and the associated mortality risks are the same in both the areas.

In tribal areas, a state of equilibrium has reached between the host and the malaria parasite[22]. This is evident from the fact that most of the adults have developed immunity whereas the children, in the absence of immunity to malaria, suffer and die. Pregnant women in particular are the worst sufferers due to endemic malaria in these areas.

There are various factors which hinder the undertaking of malaria control ac-

Table 2. Population of scheduled tribes in peninsular and northeastern states of India

Name of the state	No. of tribal districts		Total rural population (millions)	Total tribal population in rural area (millions)
	Entire	Partial		
a) *Peninsular states*				
Andhra Pradesh	–	16	53.55	3.17
Bihar	6	12	69.91	5.81
Gujarat	1	7	34.09	4.85
Madhya Pradesh	4	23	52.18	11.93
Maharashtra	–	18	62.70	5.77
Orissa	3	12	26.37	5.91
Rajasthan	2	14	34.26	4.10
Total	16	102	333.06	41.54
b) *Northeastern states*				
Arunachal Pradesh	11	–	0.75	0.75
Assam	23	–	19.9	19.9
Manipur	8	–	1.33	1.33
Meghalaya	5	–	1.44	1.44
Mizoram	3	–	0.37	0.37
Nagaland	7	–	1.00	1.00
Sikkim	4	–	2.33	2.33
Total	61		27.12	27.12
Grand total	77	102	360.18	68.66

Source: Census of India. 1991.

tivities in tribal areas. Some of these are as follows:

(i) No systematic study of knowledge, attitude, belief and practices (KABP) among tribals has been carried out to know their cultural, social and behavioural patterns. The tribals have their own beliefs regarding origin of the disease and have an inclination for local remedies rather than the modern therapy. A strong cultural factor that adversely affects the efficacy of insecticide sprayed is that the houses are mud-plastered at regular intervals. The movement habit of tribal population is a complicating factor as their movements into the forests are mostly nocturnal.

Table 3. Malaria in tribal population

Year	Total malaria cases (1,000)			*Pf* cases (1,000)		
	All India	Tribal	% of tribal cases to total	All India	Tribal	% of tribal cases to total
Peninsular states						
1986	1702	574	32.0	638	422	66.1
1987	1663	513	30.8	618	350	56.6
1988	1855	586	31.6	685	354	51.7
1989	2033	695	34.4	746	391	52.4
1990	1777	642	36.0	616	362	58.8
Av.	1806	602	32.96	660.6	375.8	57.12
Northeastern states						
1986	1702	163	9.6	638	113	17.7
1987	1663	104	6.2	618	63	10.1
1988	1855	79	4.2	685	57	8.3
1989	2033	101	4.9	746	59	7.9
1990	1777	96	5.4	616	56	9.1
Av.	1806	108.6	6.0	660.6	69.6	10.6

Source : Directorate of NMEP.

(ii) Most of the tribal areas are in difficult terrain, presenting logistic problems.

(iii) Literacy rate amongst the tribals is low which hinders the dissemination of knowledge.

(iv) Though limited studies have been carried out however the knowledge concerning exact transmission pattern of malaria in certain areas is yet to be generated. Vector bionomics and status of parasite susceptibility to drugs are serious lacunae.

(v) The tribal areas extending from northeast to west and from north to south are beset with ecological diversity. Therefore, the uniform methodology of malaria control may not be applicable.

(vi) Genetic variation in red cell polymorphism could create problems in chemotherapeutic approach in some cases[23].

8.1.1 Approaches for malaria control: Tribal populations are static communities and are generally located in foothill forested regions (2000 m altitude). The communities follow forest based economies which entail their visitation of forests for collection of for-

est produce as well as nearest markets for selling. At other times they work on forest lands either as "Jhum" or rainfed cultivators. Malaria control in these communities can be managed as follows:

(a) **Disease management:** (i) Infrastructure development, (ii) Establishment of link workers, (iii) Early Detection Prompt Treatment (EDPT), mobile van with diagnostic facility in problem areas, and (iv) Referral facilities and screening of migrant labour and radical treatment.

(b) **Transmission control:** (i) Selective vector control; (ii) Impregnated bednets and repellents, (iii) Ecological barrier around settlements, and (iv) KABP studies to involve communities for improved health delivery.

(c) **Development of control strategy:** Tribal malaria control would include phasing out of the project into preplanning, planning, and implementation phase.

(i) Pre-planning phase

This phase will be utilized to generate the following information:

Topography: Type of terrain, soil, altitude, and rain shadow phenomenon.

Forest types: Forest (arid/semi arid, deciduous, monsoon, evergreen). Trees of economic importance (timber, forest produce and others).

Mineral: Minerals and their types, locations and mining technology.

Meteorological data: Temperature, humidity, and rainfall for at least last 10 years.

Entomological data: Vectors, distribution, seasonal prevalence, breeding habitats, resting and feeding behaviour, flight range, and dynamics of malaria transmission.

Epidemiological data: Species of the malaria parasite, endemicity of the disease, morbidity and related information.

Human factors: Demography, occupation, type of housing, sleeping habits, social habits, migration pattern (annual/seasonal or any other movement related to occupational needs).

KABP studies: Knowledge, attitude, beliefs and practices related to housing, food habits/medical care and social aspects, disease control perceptions particularly malaria.

Research inputs: Feasibility studies on the use of impregnated bednets, repellents, susceptibility to insecticides, haemoglobinopathies, susceptibility of anti-malaria drugs to *P. falciparum.*

Identification of tribal community leaders and tribal *healers.*

Areas covered by different missionaries among tribal population.

Non-governmental organizations (NGO) working in the area.

Information on tribal development departments and their activities.

Status of malaria control programme, infrastructure, activities and other health related programmes.

Other organizations like tribal welfare, forest and education operating in the area.

(ii) ***Planning phase***

Data analysis: Careful analysis of data generated under the above and to microstratify according to the eco-epidemiological type and its elements. Staff requirements for the project including financial resources.

Action plan: Preparation of detailed action plan of operation of each stratified area for disease management and transmission control including intersectoral and NGO collaboration.

Staff recruitment: Initiation of recruitment of required staff and their training. Advance logistical planning for procurement of materials and equipments.

Supervision: Set up mechanism of supervision and evaluation.

(iii) Implementation phase

Implementation will be carried on as per the planned document. The following agencies may be involved: state and district health authorities under the technical supervision of Director, NMEP and other concerned agencies like tribal welfare, forest and irrigation department etc.

8.2 Rural Malaria

8.2.1 Irrigated areas of arid and semi-arid plains: Epidemiological characteristics of rural malaria have been described under type II (section V). Development of water resources optimally is crucial for the economic development of the country. India's overall water resources have been assessed at 1880 km^3. In addition ground water resources have been assessed as 452 km^3.

Irrigation potential has increased from 22.6 million ha during pre-plan period to 82.8 million ha at the end of 1990-91[24]. Against this, utilization potential at the end of 1990-91 was 74.2 million ha. A target for creation of 2.99 million ha and utilization of 2.7 million ha is envisaged during 1991-92. Planwise position of irrigation potential created and utilized under major medium and minor irrigation projects is given in Table 4. Out of a total of 264 major projects taken up, 81 have been completed by the end of the 7th plan (1985-90).

During the first four Five-years development plans there was no regulated development plans for the irrigated (command) areas[24]. Consequently,

there were heavy water losses and yields were poor. Besides this, irrigated areas became malarious because of untidy irrigation. To overcome these problems, command area development programme (CAD) was launched in the country at the beginning of the 5th plan to ensure faster and better utilization of water in the irrigation projects. The programme broadly covered, on-farm development works, construction of field channels and drains, land shaping and development of other ancillary facilities to ensure equitable distribution of water to all farmers. This programme is operational in 166 major/medium irrigation projects in 20 states and 2 union territories with local cultivable command areas of over 20.8 million ha through 5424 CAD authorities[24].

In India, among the vector-borne diseases malaria and Japanese encephalitis are of prime importance associated with irrigation potential both in short- and long-term. Malaria comes immediately in the epidemic form when irrigation gets established due to high breeding potential associated with seepages, water stagnation and drainage problems. Water logging due to over

Table 4. Development of irrigation in India

Five-year plan	Created (million ha)			Utilised (million ha)		
	Major-Medium	Minor	Total	Major-Medium	Minor	Total
First	12.2	14.0	26.2	11.0	14.0	25.0
Second	14.3	14.8	29.1	13.0	14.8	27.8
Third	16.6	17.0	33.6	15.2	17.0	32.2
1966–69	18.1	19.0	37.1	16.8	19.0	35.8
Fourth	20.7	23.5	44.2	18.7	23.5	42.2
Fifth	24.7	27.3	52.0	21.2	27.3	48.5
1978–80	26.6	30.0	56.6	22.6	30.0	52.6
Sixth	26.6	30.0	56.6	22.6	30.0	52.6
Estimated at the end of Seventh plan	32.91	46.83	79.74	27.89	43.53	71.42
Anticipated achievement during 1990–91	0.69	2.33	3.02	0.71	2.03	2.74
Target for 1991–1992	0.644	2.355	2.999	0.635	2.061	2.696

Source : India 1992, Publication Division, Ministry of Information and Broadcasting, New Delhi.

irrigation by surface water and poor drainage in command areas further compounds the malaria problems. High malaria endemicity, and increased incidence of malaria deaths in Pattukottai regions near Madras and Mandya district in Karnataka due to introduction of Cauvery-Mettur[25] irrigation projects and Visvesvarayya canals in the 1930s are well-known[26]. In recent times high incidence of malaria in Upper Krishna Irrigation Project[27] in Karnataka and Sardar Sarovar Dam[28] in Gujarat are the examples worth mentioning.

Japanese encephalitis is another vector-borne disease which has become endemic not only in areas of intense rice cultivation, but also has entrenched in water logged irrigation systems (Tungabhadra and Mandya in Karnataka) in arid zones[29]. In India between 1978 and 1987, 39,149 cases of JE with 14,246 deaths, a case fatality rate of 36.39 per cent was recorded[30].

However, on the contrary whenever irrigation projects are constructed with health safe guards, the problem remains minimal. From the experience gained in commissioning of Upper Ganga Canal where not only large fertile tracts got water logged and went out of cultivation in the absence of adequate cross drainage works across the canal, but also irrigation tracts became malarious. At the time of construction of Sarda Canal in 1920s, provision of health-safeguards received the top priority and the project was delayed by four years in order to collect the information on (i) number of cross drainage works required to prevent any obstruction to natural flow of water across the canal, and (ii) to determine the existing water logged and/or areas prone to water logging so as to avoid the alignment of canal through such areas. Besides that, at head-works at Banabasa, subsoil drainage system was incorporated to take care of "seepages" as "built in" component of the project is a classical example[31]. Malaria problem has virtually remained non-existent till the present time. Another good example of planned agriculture development is that of an irrigation project in the Al-Hassa Oasis, Saudi Arabia. This project was implemented in late 1960s to increase the area under cultivation, reduce wastage of water, improve irrigation practices, and provide adequate drinking water. Prior to project implementation malaria had been a problem, but since 1973 no indigenous case of malaria has been reported. This success was basically attributed to the lining of canals, efficient drainage and recovery of marshy and water logged lands by planned afforestation[32].

Approaches for malaria control

These are as follows:

Disease management: (i) Strengthening of existing health care services including referral; (ii) detection and treatment of malaria cases by state health institutions and private

sector; (iii) DDCs and FTDs in underserved areas, and (iv) screening of migrant labour for radical treatment.

Transmission control: (i) Engineering methods of vector control through intersectoral efforts for each component of project based upon microstratification, (ii) rational use of irrigation water, (iii) improved agronomic practices, and (iv) selective vector control.

Development of control strategy: For building-up control strategy for irrigation malaria, health impact analysis (vector breeding potential) would be required for the following elements of the irrigation project:

- Up stream effect
- Down stream effect
- Conveyance (canal system)
- Command area

Planning of environmental management methods have to be treated separately for new projects and completed projects (old project).

New Project

(a) ***Adverse health impact studies :*** It is imperative to carry out adverse health impact studies as per the guidelines[33] by health survey teams which should be multi-disciplinary in nature and comprise a malariologist, a medical entomologist public health workers and agricultural engineers. The findings of such studies should receive full considerations before finalizing a project.

(b) ***Environmental management methods (EMM)***[34]***:*** EMM for prevention of vector breeding should be incorporated as "built in" process of the project and should receive consideration under the following three phases.

Planning and design phase

(i) Dam : Location, storage capacity of the impoundment. High flood level and low flood level.

(ii) Extent of masonry and earthern dam.

(iii) Extent of likely seepages and their disposal.

(iv) Selection of energy dissipating technologies/structure to minimise the breeding potential of the vector mosquitoes.

(v) Selection of sites for borrowing earth/stone.

(vi) Clearing of forests and scrub jungle prior to impondage to ensure reduction of breeding potential, safety of dam and appurtenances, navigation and to avoid development of foul smell due to rotting of vegetation.

(vii) Siting of villages from submersion areas.

Construction phase

- Marginal drainage of shore line up to drawdown strip.
- Construction of seepage disposal system/sub-soil drainage system up to safe limits and/or up to natural drainage system.
- Selection of elevated and well drained sites for labour camps, officers' residence and offices.
- Concurrent antimalarial measures should be instituted both for disease management and transmission control.

Maintenance phase

Adequate funds should be made available for maintenance of head works, canals and drainage systems and antimalarial civil works in command areas.

Old Projects

Scientific investigations: Comprehensive studies should be carried out at the old irrigation schemes, (i) to define the vector breeding potential of each component of the irrigation project viz. upstream, reservoir, river downstream, canals and command area, (ii) define the dynamics of malaria transmission, and (iii) based on these to prepare an action plan for mitigating actions along with agencies responsible for undertaking remedial actions within the framework of intersectoral coordination. These works can be taken up in phased manner to tide over the financial constraints.

There is an urgent need for optimizing the use of following conservation technologies aimed at optimal utilization of water resources to prevent build-up of breeding potential of vectors.

(i) Extensive instead of intensive irrigation approach.
(ii) Volumetric measurement instead of flood irrigation.
(iii) Resorting to automatic remote control devices.
(iv) Conjunctive use of surface and ground water.
(v) Lining of canals, and their distributaries.
(vi) Development of effective regional and local drainage system.
(vii) Micro-irrigation systems, like sprinklers, drip and drop irrigation.
(viii) Crop varieties capable of growing with less water, saline water and short duration crops.
(ix) Maintenance of canal and distributaries.
(x) Farmer's cooperation to prevent canal damage.
(xi) Seepage control in the existing systems.

Awareness Programmes for Health Impacts Associated with Irrigation Projects

It is a common knowledge that irriga-

tion will improve nutritional status of the communities and, level of general sanitation. Improved economic status will make people health conscious and enable them to seek requisite health care facilities. Economic status will also raise living standards which will have better control on our health problems. However, the association of water-related diseases which may cause heavy morbidity and mortality and hinder development have been overseen by the planners.

Therefore, it is highly desirable that health concern should be viewed in totality and not in isolation. It is therefore essential that medical, engineering and agricultural professionals should perceive themselves as working together towards a common objective. Each needs to understand activities of the other sector and help in holistic development.

One way to achieve this objective is to introduce appropriate course curricula on malaria control in various training programme offered by Water and Land Management Institutes (WALMI) of the states for engineers, agricultural scientists, extension workers, farmers and other officials.

8.2.2 Rural malaria: Without irrigation is described under 5.2.2. Control approaches would be the following.

Disease management: (i) Strengthening of laboratory services at the PHC/ sub-centre level for passive case detection of suspected malaria cases, (ii) Private sector should be activated for correct diagnosis and treatment, and (iii) Case detection for early diagnosis.

Transmission control: Focal spray in areas with indigenous cases, particularly *P. falciparum.*

8.3 Urban Malaria

The characteristic features of urban malaria epidemiology have been described in type III (Section V). During eradication phase, it was expected that the local bodies will manage malaria control in their respective areas but due to various reasons this never happened.

To tackle the growing problem, urban malaria scheme (UMS) was launched in 1971-72. Following criteria were used to include a city/town in this scheme.

(i) Population more than 40,000.
(ii) Annual Parasite Incidence (API) 2 or more in the preceding 3 years.

As per census report of 1991, during 1971 there were 371 urban towns (population over 50,000) with a population of 72 millions. Out of these around 15 million population in 131 towns was protected against malaria under MPO[35]. By 1991, both the number of towns and population has nearly doubled. The number of town (over 50,000 pop.) have grown to over

600 with population of 160 million, yet the UMS remained static and was not extended to any new towns. This leaves about 150 million population residing in towns, out of the purview of urban malaria scheme.

Towns/cities under the purview of urban malaria scheme (131 towns) have also failed to bring any relief, because of deficient planning and inadequate infrastructure. Reasons for resurgence of malaria in urban areas are manifold.

(i) Absence of legislative measures, e.g. Bombay Corporation[8] is a good example where legislative measures helped in controlling malaria effectively.

(ii) Private practitioners do not give radical treatment to malaria patients and in turn keep the malaria parasite reservoir alive.

(iii) Though most of the Municipal Corporations have epidemiological services, these are generally not used for malaria control.

(iv) There is no entomological component in most of the urban areas.

(v) The control of malaria in urban areas are targeted for mosquito control with no specific activities to control *An. stephensi* and *An. culicifacies*, major vectors of malaria in urban and peri-urban areas.

(vi) Infrastructure for mosquito control is totally inadequate particularly in towns with high rise buildings. Supervisory tier is grossly inadequate.

(vii) The industrial and construction activities which have come up in the urban areas in a big way have neither any specific malaria control set-up nor do they actively cooperate with the malaria control organization of the local bodies.

(viii) In metros, there are various agencies carrying out mosquito control measures and there is no coordination for integrated approach of control. With a view to cover all urban areas of malaria control, erstwhile National Filaria Control Programme (NFCP) units were taken over in the administrative control of urban malaria but adequate studies were not taken up to streamline and standardize the activities of NFCP workers for malaria control.

(ix) In urban areas, mosquitogenic conditions are created by artificial accumulation of water and *An. stephensi* breeding is quite high in the overhead tanks. Proper education to the community on mosquito control is completely lacking.

(x) Most important aspect is the lack of finances. Because of the competing needs, the health department and local bodies barring a few, do not have adequate funds for mosquito control activities.

Development of Control Strategy Regulated Development

Health Impact Assessment (HIA) as a part of Environmental Impact Assessment (EIA): This can be achieved by the appointment of environmental screening committee in each town/city. It should be made mandatory that all development projects would need screening by this committee. Amongst other experts the committee should include "Public Health Expert" to examine each project for any adverse health impact and suggest mitigating measures to ensure sustainable urban development. Recommendations of the environmental committee should be binding and thus strictly implemented. The above committee should also take note of the existing problems and suggest remedial measures. The implementation of recommendations could be taken up in phases depending on the resources available.

Strengthening of epidemiological and entomological cell: These capabilities should be developed at local level in case of big towns (population 1,00,000), and at zonal level for smaller towns.

(a) Functions of Epidemiological Cell and Surveillance

(i) Active Case Detection (ACD) in peri-urban areas/construction sites.

(ii) Passive Case Detection (PCD) in all major hospitals/dispensaries. All dispensaries, hospitals under Government/private sector should act as "malaria clinics". Working of malaria clinics should be ensured on all week days including Sundays.

(iii) Sentinel diagnostic centres in selected dispensaries or malariometric surveys on sampling basis.

(iv) To suggest remedial actions to the control programme on the basis of epidemiological assessment.

(b) Entomological Cell

(i) To delimit the magnitude and diversity of mosquitogenic problems.

(ii) To undertake geographical reconnaissance and delimitation of species specific breeding sites.

(iii) To identify and classify all problem sites to bring to the notice of non-health sectors.

(iv) Selection of appropriate control strategy viz. chemical, biological and environmental in an integrated approach.

(v) Collection of longitudinal entomological data from sentinel locations for evaluation of control impact using entomological parameters.

(vi) Prediction of malaria outbreaks.

Control measures: In urban towns control measures should be species-specific as control strategies differ from vector-to-vector and species-to-species.

(a) Vectors of Malaria

(i) *An. culicifacies*: Remedial mea-

sures for eliminating breeding sites should be executed in the following order:

- Drainage.
- What can't be drained, should be filled.
- What can not be filled should be stocked with fish or expanded polystyrene beads.
- What can not be treated under above categories should be treated with biolarvicides and/or chemicals.

(ii) *An. stephensi:* By legislative measures[8]. Programme Officers should be delegated powers for implementation of bye-laws governing control of mosquito breeding.

(b) Vectors of Dengue

(i) *Aedes aegypti*[36]: By legislative measures in domestic situation, factories, cinema houses and places of worship.

(ii) By restricting the "Tyre trade" to designated conforming areas where stocking of tyres should be under "sheds" to prevent collection of rain water in tyres.

(iii) Popularising "Dry day" concept (emptying of all stored water containers, scrubbing and keeping all containers dry for one day) in the communities to prevent breeding of mosquitoes.

(iv) Enlisting the cooperation of communities particularly welfare and womens' associations for mosquito control[37].

(c) Vector of Filariasis

Cx. quinquefasciatus and other pest mosquitoes Mitigating measures would involve:

(i) Desilting of major drains in the month of October and April to prevent "autumn" and "spring" peaks of the pest mosquito population in north India and depending upon silt deposit in rest of the country[11].

(ii) Provision of "Cunette"[38] in drains for carrying sullage affluent during lean periods.

(iii) By providing outfalls to storm water and sullage drains to some natural drainage system.

(iv) By recycling waste water in mini-treatment plants, particularly in organised housing sectors to make treated affluent available for gardening purposes on low rates. Similar treatment plants could be set up on zonal basis in and around unauthorised/slum areas and make affluent available for vegetable growers in these areas. These measures will not only bring down the use of potable water for gardening, it will also make the surroundings more healthy.

Support facilities for the implementation of bioenvironmental control

Hatcheries for fish

Stock hatcheries for raising *Gambusia*

and guppy fish should be maintained in specially constructed hatcheries-temple tanks or by leasing out fish ponds from fisheries department. There is also a need for building up expertise in rearing fish, transportation etc. Zonal hatcheries can similarly be maintained in ornamental tanks.

Expanded polystyrene beads (EPS): Facilities for expanding polystyrene beads should be developed centrally. Ready to use material could then be transported to the required zones[39].

Facilities for equipment repairs: Since chemical control is still a major component of the whole control strategy, facilities for repair of larvicides/ insecticides dispensing equipments including those for fogging (for emergency control) should be developed centrally by the municipalities/corporations.

8.4. Industrial Malaria

The characteristic features of project malaria have been described as epidemiological type IV in section V.

Since independence, India made big strides through successive five-year plans to achieve self-sufficiency in industrial production. A large number of industrial complexes connected with the production of steel, aluminum, electronic goods, heavy machinery, fertilizers were promoted. Besides these, exploitation of oil and petroleum also got big impetus. All these activities require setting up of large industrial plants and townships. To meet the demands of raw material for these industries, extensive developmental efforts have been made in the mining sector[40]. Most of the industrial townships during the developmental stages and later on recorded high incidence of malaria e.g. Mirzapur Thermal Power Project, which during the construction phase showed a spurt of total malaria cases in district from 2421 cases in the 1979 to 11,455 cases in 1980 with high preponderance of *Pf*[41]. Mathura Oil Refinery, a vast petrochemical industrial complex registered a high incidence of malaria during the construction of refinery[42]. Malaria incidence continues to be very high even after the completion of the project. National Thermal Power Corporation unit in Dadri (U.P.), another project in the power sector, registered a high incidence of malaria both in the project and in the impact villages with high preponderance of *Pf* cases[43].

Steel plant at Vizag, Andhra Pradesh, during the construction phase employed 5000 to 30,000 workers. This plant accounted for 40 to 72% of the total malaria cases of the district between 1987-90[44]. A similar situation of malaria has been reported from two major iron-ore mines in Sundergarh district, Orissa[40].

Why Industrial Projects are Malarious?

Industrial projects are malarious because of the following reasons:

Location governed by the availability of raw material: Usually industries are located in forested and malarious areas, because of the availability of raw material viz. industries in the steel, mining, paper and pulp sectors.

Incentives for backward areas: Government gives incentive for establishing industries in backward areas with an objective of social and economic development of the area. These areas often have high receptivity and vulnerability to malaria, e.g. forested areas of district Mandla, Madhya Pradesh.

Tendency to save on the cost of land: Industries usually come up in unproductive/barren land resulting from water logging/salinity and alkalinity. Settlements in these areas have to face acute malaria problem, e.g. Thermal Power Project in Dadri, located on water logged land of Upper Ganga Canal.

Water-based industries: Water-based industries require enormous water for cooling and waste disposal. To reduce expenditure, location of industries are usually selected in the proximity of the river systems. Riverine belts being malarious, perpetuate high incidence of malaria, e.g. Mathura Refinery. While in some industries water management technologies are poor, and results in creation of high breeding potential, at intake and outfall points e.g. Thermal Power Plant at Indraprastha Road, Delhi and KRIBHCO Fertilizer Factory at Surat (Gujarat).

Construction of projects without incorporation of health safeguards: Since there is no linkage with health, industries often select unhealthy sites for labour camps, adopt poor engineering designs, follow "head carry on" technology for excavations within the project, lack adequate drainage, maintenance and all these together contribute to high prevalence of malaria.

Migratory labour: Contractors often import labour from poor socio-economic and backward regions of the country. These are poverty stricken malarious areas. They are often the reservoirs of infection, including new strains of malaria parasite. In presence of high build up of vector population, malaria outbreaks are often encountered in these areas due to tropical aggregation of labour.

Emphasis on curative rather than preventive measures: Although each project has 2-3% of the total outlay for health. Invariably these funds are used in establishing hospitals etc., i.e. curative services. No effort is made to build preventive services to reduce pressure on curative services.

Approaches for malaria control: The malaria control strategy will include:

Disease management: (i) screening of itinerant labour for radical treatment,

(ii) malaria clinic on site, (iii) strengthening of nearest hospital, and (iv) mass drug administration, whenever required.

Transmission control: (i) healthy settlement sites, (ii) efficient water management to prevent mosquitogenic conditions (iii) anti-larval operations and (iv) focal spray in areas with indigenous cases particularly *P. falciparum*.

Development of control strategy: Planning of control strategies based on environmental management methods (EMM) have to be carried out separately for new and old projects.

A. **New Projects**

Investigations of adverse health impact study: A multidisciplinary team comprising public health specialists, medical entomologist and an engineer will carry out an adverse health impact study both for short-term and long-term aspects of the project. Based on the findings, an action plan by incorporation of mitigating measures of adverse health impacts will be prepared for implementation.

The subject matter for such an exercise would be:

(i) Selection of the project site: (location).

(ii) Preparation of general mapping of the site with all topographical features.

(iii) Preparation of a general plan for each component of the industrial complex. Residential colonies and other infrastructural facilities.

(iv) Preparation of ground action plan for each of the contractor/sub-contractor involved in construction activity. Preparation of special clauses to be incorporated into the contract document to take care of structures/disposal of earth work from foundation, disposal of sub-soil water during construction phase which usually support breeding of vectors during construction.

(v) Pre-planned sites for excavation and their filling by earth work from foundations.

(vi) Selection of well-drained healthy site for construction of residential colonies with effective water management practices to handle delivery of water supplies in mosquito-proof overhead/ground level storage tanks. Effective plans for disposal of solid waste and storm water,

(vii) In case of water-based industries, selection of technologies which will prevent build-up of vector populations, both at intake and outfall points.

(viii) In case water storage becomes necessary, the stagnation of water may not be allowed for more than seven days. Should it be necessary to exceed this period (KRIBHCO Fertilizers, Surat) for

removal of suspension of solids, some appropriate chemical technology may be adopted to hasten this process within seven days.

(ix) Efficient drainage system for the entire project area.

B. **Completed Projects** (Old projects)

Investigations: In-depth epidemiological-cum-entomological studies should be carried out to establish dynamics of transmission, and mosquito breeding foci supporting the active transmission. Based on such study an appropriate action plan may be prepared for the implementation of integrated disease vector control strategy.

Environmental management being a permanent measure should be carried out in a phased manner and adequate financial provisions should be made for the maintenance.

Awareness programme for industrial engineers/technicians: Each industrial house should conduct a training programme for their engineers/technicians as part of continuing education in the respective fields of specialization. It will be highly desirable to introduce necessary course curricula on "Malaria Problem associated with Industry and its Control".

Health budget of the industrial houses: Industrial houses are insensitive to public health problems, as it is generally felt that these will be taken care by the State Government. Consequently, total health budget is spent to build-up curative services. It is high time that each industrial house gives priority to strengthen the preventive services so that load on curative services could be minimized.

8.5 Border Malaria

It may be highlighted that population migration is an important factor in the transmission and spread of new malaria parasite strains, and focal outbreaks. A variety of factors govern population migration. Some of these are related to agriculture, construction works, mining, grazing, fishing, and forestry. There are also substantial migrations due to militancy, conflicts, wars, natural calamities like drought and floods, movement of nomadic tribes and national and international tourism. In last 3-4 decades, expansion of railways and a network of roads has considerably increased the mobility of the population. As a result large population groups migrate on routine basis from the endemic states to non-endemic states and vice versa. This type of migration often brings serious episodes of malaria particularly in the non-immune population. The other problem associated with the migration of population is the rapid extension of *P. falciparum* resistance to different parts of the country. In a well studied example it has been shown that, when a group of labour population from Orissa had migrated to Assam for job opportunities, on their return they

brought resistant falciparum malaria to their native state. In another study NMEP (1986) reported that in a project in northeast India, of a total of 2,53,000 people employed, 11.1% had malaria and 7.1% had *P. falciparum*. It has been estimated that one-sixth of the country's population moves annually during the transmission season from non-malarious to malarious areas and vice versa[22].

India's tribal population mostly reside in forest and forest-fringe areas which are remote, difficult and inaccessible. A large number of epidemics have been linked to the population migration of the tribals. Tribals migrate in groups for employment, and because of their specialization in agriculture, they are in demand in Punjab, Uttar Pradesh, West Bengal, Assam etc. Migration due to marriage is also important and involves 25% females of the child bearing age[22].

Approaches of malaria control: The border malaria control would include the following:

Disease management

(i) Infrastructure development;
(ii) EDPT, DDCs and FTDs;
(iii) Referral hospitals; and
(iv) Alternate drugs in border areas for resistant *P. falciparum*.

Transmission control

(i) Information exchange on outbreaks;
(ii) Synchronization of malaria control activities; and
(iii) Selective vector control

9 RATIONAL USE OF MALARIA CONTROL TOOLS

In spite of vigorous research conducted globally, a universally effective tool is yet to be available for malaria control. The vaccine against malaria though on the horizon is yet to be established[45]. There are effective drugs but the problem of resistance of *P. falciparum* is increasing[46]. The insecticidal spray though effective but is beset with the problems of environmental pollution, vector resistance and poor acceptability by the population[13]. Bioenvironmental methods, wherever feasible have proved successful, but would require organizational changes and intersectoral cooperation on sustained basis[34,47]. Insecticide impregnated bednets are highly effective but its utility depends on vector bionomics and cannot be advocated for universal use. Thus, under the ecological changes, changes in the vector biology and parasite resistance to the drugs, the available malaria control tools have to be used in the most appropriate manner to achieve the best results. In the present context, case management and treatment are of primary importance followed by the control of transmission. The specific tools for malaria control are given below.

9.1 Drugs

Standard drugs like chloroquine, Sulpha-pyrimethamine, 8-aminoquinoline

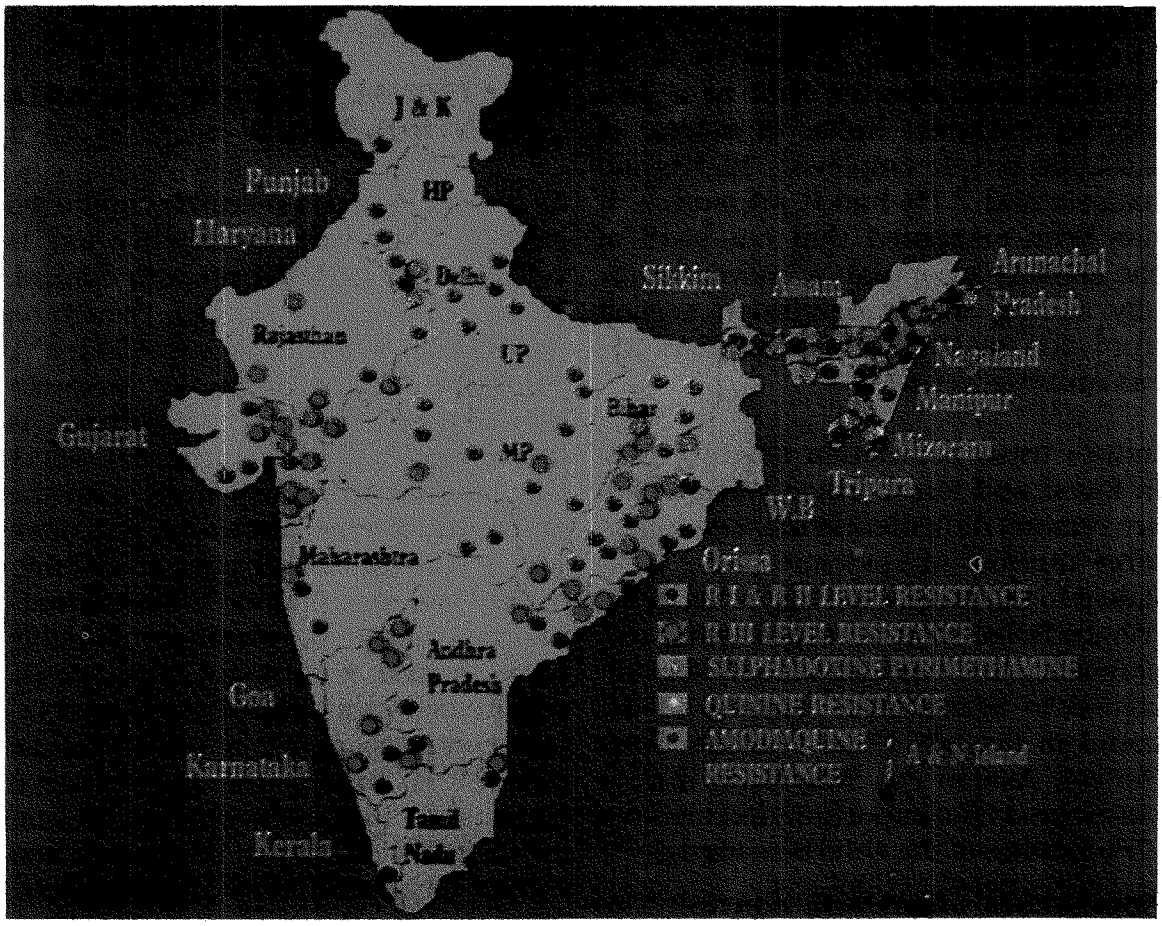

Fig. 2: Areas showing RIII level of chloroquine resistance to *P. falciparum*

are commonly used[48]. Fig. 2 gives the present status of chloroquine resistance in *P. falciparum*. The problem of drug resistance to commonly used drug "chloroquine" is increasing and there is evidence of resistance to sulphalene/ sulphadoxine pyrimeth-amine (SP) group of the drugs[46,48]. Fortunately India did not use drugs like mefloquine and halofantrine. As such, the problem of drug resistance to this group of drugs is not there. The newer drugs like artemisinin and its derivatives have proved its efficacy in the treatment of complicated malaria. Central Drug Research Institute, Lucknow, has already produced a derivative which is undergoing clinical trials. It is understood that the Government of India is already planning to take some policy decision on production of artemisinin group of drugs.

For rational use of drugs, detailed guidelines should be provided about managing malaria at different levels of treatment of complicated cases, and malaria chemoprophylaxis. The drug policy followed by NMEP was formulated way back in 1981 (Table 5). Since then radical changes have been observed in sensitivity of the *P. falciparum* to antimalarials. The presumptive treatment of 600 mg of chloroquine though effective for *P. vivax* has diminishing impact over the *P. falciparum* infection, consequently percentage of *P. falciparum* infection is on steady increase. It is therefore imperative to revise the drug policy developed in 1981 and till such time WHO guidelines on the treatment, management and prophylaxis against malaria infection with such modifications as warranted by any special epidemiological paradigm may be followed. In remote and inaccessible tribal areas with poor infrastructural facilities, and intense malaria, the strategy should be to collect blood slides from clinically suspected malaria cases, fever of unknown origin, and all fever of doubtful origin for giving prompt radical treatment. However, in areas without these facilities, full dose of chloroquine should be given. Monitoring of drug efficacy, its adverse reaction should carefully be studied particularly in tribal belts where considerable amount of haemoglobinopathies exist. The drug policy should also clearly guide regarding the procurement, quality control and distribution of antimalarials.

Table 5. Drug policy for rationale use of antimalaria drugs in NMEP

A. Areas with established chloroquine resistance in *P. falciparum.*

a) Presumptive treatment (All fever cases current or with history)

i. Active case detection (ACD)	–	Amodiaquine 600 mg base (adult)
ii. Passive case detection (PCD) and	–	(2 tablets i.e. 1000 mg dose of sulphalene 50 mg dose of pyrimethamine)
iii. DDC & FTD	–	Amodiaquine 600 mg base (adult)

b) Radical treatment (*Pf*)

The following combinations of drugs used for treatment in chloroquine resistant *P. falciparum* areas:

i. Sulphalene	–	1000 mg
ii. Pyrimethamine	–	50 mg
iii. Primaquine	–	45 mg

Children should be given proportionate lesser dosages. The above combinations are not given to infants. Pregnant women and infants are not given Primaquine.

contd...

Table 5. (*contd.*)

Radical treatment in such areas for *P. vivax, P. malariae* and mixed infection (*Pv+Pm*) is the same as in *P. vivax* predominant areas.

Chloroquine	–	600 mg - 1st day single dose (adult)
Primaquine	–	15 mg daily for 5 days.

B. Areas where *P. falciparum* is senstive to chlorquine

a. Presumptive treatment by ACD PCD & FTD/DDC

Use of chloroquine will be continued as per the dose already in use (i.e. 600 mg base for adult).

b. Radical treatment of *P. falciparum* cases

Adult	–	600 mg chloroquine + 45 mg Primaquine (single dose)

c. Radical treatment of *P. vivax/P. malariae* or mixed

Adult (1st day)	–	600 mg chloroquine + 15 mg primaquine
(2nd day)	–	Only 15 mg primaquine daily

C. Drug schedule for labour population in PfCP areas

a. Laburers before leaving PfCP area (Zone-I or any area with high incidence of *P.f.*)

i. Mass drug administration with 600 mg chloroquine and 45 mg Primaquine (adult) single dose

b. Labourers coming from Zone-I or on detention in Zone II & III, the regime will be as under:

Presumptive	*Radical*
i) Chloroquine 600 mg	A total of 1500 mg chloroquine phosphate is given in three consecutive days along with 45 mg Primaquine (single adult dose on the Ist day)
ii) Primaquine 45 mg	If there is no response to this regime within three days (72 hrs.), 1000 mg Sulphalene + 50 mg Pyrimethamine with 45 mg Primaquine (adult single dose)

PfCP — *Plasmodium falciparum* Containment Programme
PfCP zone I — Northeast India
PfCP zone II — Parts of Bihar, Orissa & West Bengal
PfCP zone III — Part of Andhra Pradesh, one district of Maharashtra, four districts of Karnataka and eastern Madhya Pradesh.

9.2 Insecticides

Residual insecticides and chemical larvicides have been the mainstay of malaria control. In rural areas DDT, HCH, or malathion are sprayed to interrupt transmission[49]. Malathion (5% in diesel oil) is used in thermal fogging in the urban and industrial areas[50]. Natural pyrethrums (diluted in 1:20 kerosene oil) are used as space spray for mosquito control in living rooms by the communities. The main consumer of natural pyrethrum among the organised sectors is defence. In recent years some new insecticides like fenitrothion, actellic and synthetic pyrethroids have been tried with encouraging results[51,52]. In urban areas MLO, fenthion and temephos are used as larvicides[41]. Development of insecticide resistance in insects of public health importance, harmful effects on beneficial fauna, environmental concern particularly bio-amplification and the food chain contamination are some of the concerns against the use of chemicals in vector control. In particular, there is general apprehension in the use of non-biodegradable insecticides belonging to chlorinated hydrocarbon group like dichloro-diphenyl trichloro-ethane (DDT), and hexachloro-cyclo-hexane (HCH). Replacement insecticides like malathion, fenitrothion etc. are cholinesterase inhibitors and therefore are hazardous and at least 5-6 times more expensive. Synthetic pyrethroids like deltamethrin, lambdacyhalothrin, cyfluthrin etc. are being considered for residual spraying but these insecticides, besides being expensive have excito-repellent action and already there is evidence of physiological resistance in disease vectors[53,54]. To control mosquitoes in urban areas biolarvicides (*B. thuringiensis* and *B. sphaericus*) are being encouraged, and trials in endemic areas have produced encouraging results[55].

There are six major vectors of malaria. Fig. 3 gives the natural occurrence of vectors influencing transmission in India. The problem of insecticide resistance is mainly affecting the control of *An. culicifacies*. Control of *An. stephensi* is carried out by anti-larval methods. Fig. 4 gives the status of insecticide resistance in *An. culicifacies*, the major vector of rural and peri-urban malaria in India. Because of the imminent technical problems in continuous use of insecticides in vector control, selective application should be the guiding force in the development of a rational vector control strategy. Selective application technique requires a proper mix of other vector control strategies, viz. engineering methods, biological control, legislative measures, minimum use of insecticides like spraying to tackle epidemic situations, spraying in houses and not cattlesheds, spraying only during the ascending phase of vectors with the possibility of transmission, and correct selection and application of insecticides which would produce cost-effective results. Spraying should also take into consideration the target spe-

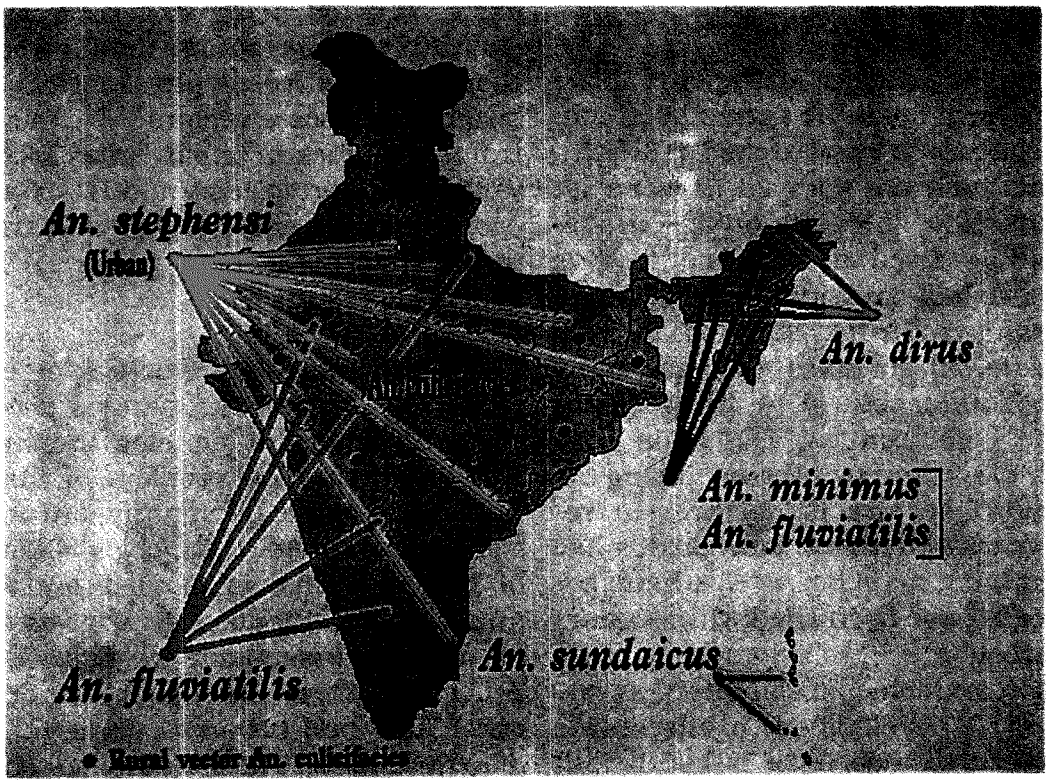

Fig. 3: Influence of major malaria vectors of India

cies, particularly the sibling species found in the area. In general spraying should be targeted against the susceptible and endophilic vector populations, and field operations should be economically viable and sustainable. This would require training of malaria control staff at the district level.

9.3 Bioenvironmental Methods

Environmental management and biological control (use of fishes, biolarvicides) leading to reduction in vector breeding assumes greater importance in the context of long-term malaria control. Source reduction leading to permanent decrease in vector population provides a basis for a sustainable control of malaria transmission and, therefore, should be resorted to in all situations wherever feasible and cost-effective. This is the area of malaria control activities where the effective intersectoral cooperation with irrigation, agriculture, flood control, public works, local administration is indispensable[56].

Vector ecology, particularly the extent of vector breeding places differ greatly under field conditions in India.

An. stephensi breed in limited and often in man-made breeding places in rural, urban and peri-urban areas where the malaria control programme should resort to species sanitation. Filling of borrow-pits, draining of seepages, cleaning of marginal vegetation, should be undertaken by the concerned local bodies with community participation in urban and localized areas to exclude *An. culicifacies*. Already success has been demonstrated in the control of rural[57], industrial[58] and urban malaria[59], and the strategy is now being implemented in Karnataka, Goa and Madras.

9.4 Personal Protection

Use of repellents is an excellent measure of personal protection from mosquito bites. Variety of repellents are marketed in India e.g. electrical devices evaporating synthetic pyrethroids in low concentrations, burning of plant derived products, DEET (N,N-diethyl-1, 3-methylbenzamide) based cream and oils etc. The age old method of

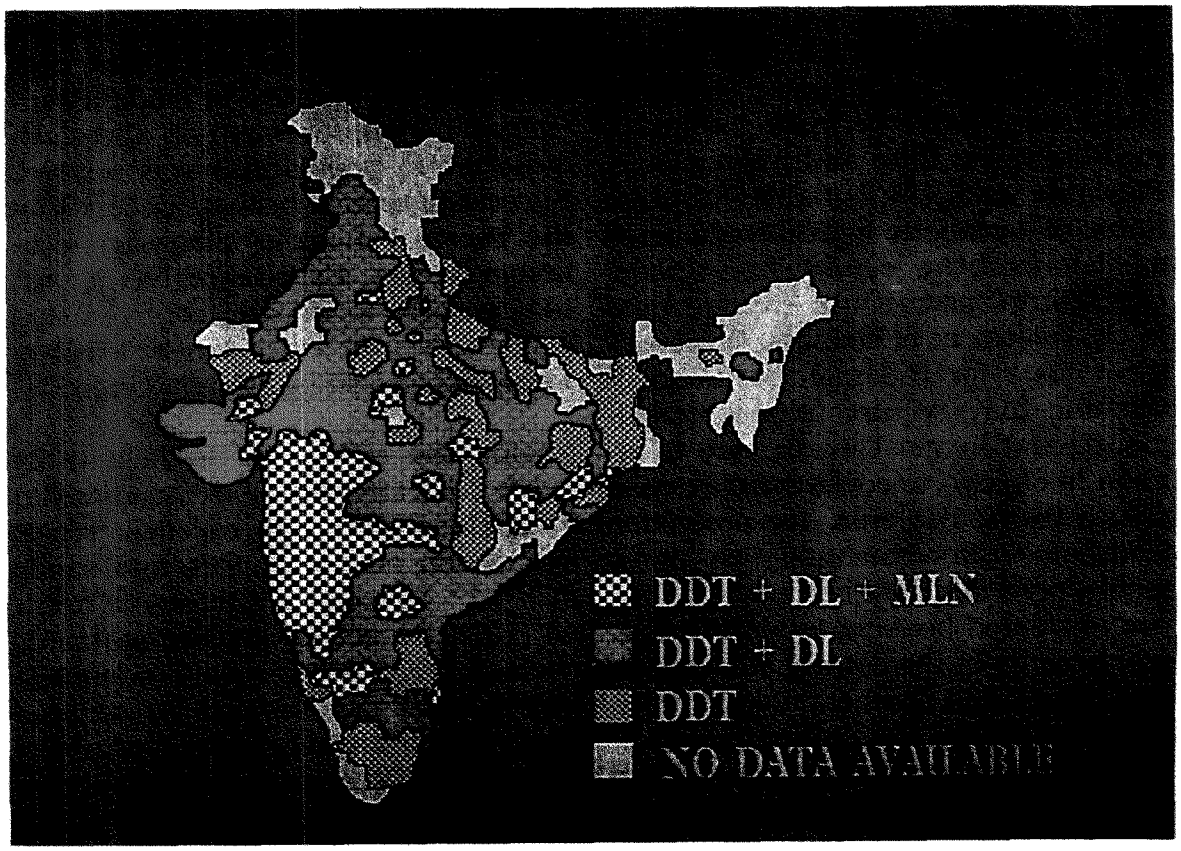

Fig. 4: Areas showing resistance of *An. culicifacies* to DDT, Dieldrin and malathion

using mosquito bednets is wide-spread in the country. Use of flit as space spray is also used to knock-off mosquitoes. All these methods provide some degree of protection from insect bites. Per cent protection will depend on a variety of factors such as the type of repellent used, appropriate dosage, timing, density of insects and sociological factors. In Defence services repellents are considered as an essential element of prevention as also in Paramilitary and Police forces, particularly staff deployed in endemic areas and for those engaged in patrolling.

A recent development has been the use of insecticide impregnated bednets. These are usual bednets preferably made of nylon fibre and impregnated. Flowable and emulsifiable formulations of synthetic pyrethroids such as deltamethrin, cyfluthrin, lambdacyhalothrin, permethrin etc. are used in the treatment of bednets. One treatment lasts for 6-8 months (frequent washing may require frequent treatment), and in most areas, one treatment is enough to cover the transmission season. However, for protection from mosquito nuisance two treatments per year may be required. The use of treated bednets produce collateral benefits of the control of bedbugs, head louse and domestic insect pests. Treated bednets are gaining popularity in the mining areas in Orissa and the northeastern states, particularly, in the tea gardens[60], industrial houses and in the remote tribal areas distributed by the Assam Government Tribal Welfare Department[61,62]. However, treated bednets may not be useful in malaria control universally. A feasibility study of the use of impregnated bednets in Mandla district (M.P.)[63] among the Gond tribe revealed that usage of impregnated bednets could never go beyond 20% in spite of intensive health education campaigns. Bednets were misused for fishing, for wrapping around the animals and used as pillows. After 3 years, 77% bednets were found completely damaged and were unfit for any use. In this area monitoring of entomological indices confirmed the observations that bednets were not effective in malaria control as no improvement in the mosquito vector populations was noticed. Success of treated bednets depends on the vector behaviour and socio-economic factors. Experience has shown that success in malaria control using bednets even in areas, where feasible, would depend on health education.

Among the repellents, in field trials neem oil (extracted from *Azadirachta indica*) has shown an excellent repellent action on mosquitoes and sandflies[64-66] Low concentrations of neem oil (1-5%) in edible oils like mustard, coconut or vanishing cream or emulsified in water can be used for application on exposed body parts. One application at dusk is enough for protection throughout the night. 1 to 1.5 ml of 5% neem oil diluted in kerosene or acetone could be applied on the used py-

rethroid treated mats, which provides good protection, when heated in the electric repellent devices.

10 IMPLEMENTATION OF THE STRATEGY

For effective implementation of the strategy, the following aspects are of importance:

10.1 Political Will and Commitment of Decision Makers

However good the action plan may be, yet without strong political commitment no meaningful results would be achieved. The expenditure incurred so far on malaria control has given proper dividend. Indian Institute of Management, Ahmedabad[67] in 1980 reported that net cost benefit from 1953-54 to 1976-77 at constant prices indicated that every Rupee spent on malaria control and eradication, since 1953-54 has brought in a benefit of Rs. 9.607. During the eradication period, the political will at the national level has been consistently encouraging. Concerned with massive resurgence of malaria in 70's, the national government provided Rs. 75 crores per year in 1977 for the modified plan of operation. At that time the existing budget for malaria control was Rs. 18 crores only. It was entirely a centre-sponsored scheme. Subsequently, budget was shared on 50:50 basis between the centre and the states. Even then the central share for 1994-95 remained as high as 110 crores. This clearly shows priority was given to malaria control by the national government. Never before were separate funds earmarked for research on malaria, but from 1977 onwards Rs. 2 crores have been provided for research activities on malaria. In 1977, the Government and SIDA entered in an agreement for *Plasmodium falciparum* Containment Programme with financial assistance of 13 million US dollars.

Though there has been a substantial improvement in the malaria situation as compared to 1976, the results obtained so far do not commensurate with the commitment of political will shown at the national level by providing huge financial inputs.

Independent appraisal of malaria programme has been carried out many times since 1977. Health being a state subject, the responsibility of implementation of the programme rests with the state. Poor implementation of the programme at state level is glaring, as evident from the reports of the independent appraisal teams[14].

No amount of strong political will at the centre or provision of funds at the central level will improve the situation, unless response from periphery is encouraging. The political will at the state level is lacking.

With acceptance of district health system, adequately developed health infrastructure is essential for effective

delivery of all promotive, preventive, curative/control and rehabilitation programmes. With large number of posts lying vacant, inadequate logistics, training of staff and immobility, the health infrastructure by and large is in an unsatisfactory stage. In such state of affairs, no health programmes could be effectively delivered. Unless a strong political support at the state level is available, neither the financial nor the inadequacy of health infrastructure would be improved. Undoubtedly, the states have many pressing problems and within the state health departments there are competing demands from other health programmes. How to deliver the malaria programme effectively within the competing demands from other health programmes should be a political decision. The present plan will also meet the fate of earlier plans if not backed-up with strong political commitment. Apart from provision of adequate funds, political commitment is indispensable for disciplined delivery of the programme. Review by the state health ministries in every quarter will go a long way in the progress of all health programmes including malaria.

10.2 Organization

Fig. 5 gives organogram of malaria control activities under the central and state governments. When one considers malaria control in the present context, first and foremost item is the organizational set-up which includes periphery, district, state, zonal and the national level. Unless the organization is toned-up, the desired result will not be obtained even if heavy financial input and provision of sufficient logistics is provided.

10.2.1 National Malaria Eradication Programme (NMEP): At present, malaria control all over the country barring Defence, Railways and few special agencies rests with the NMEP. It seems quite irrational to entrust the entire responsibility of the programme to NMEP, when certain agencies (if trained properly) have the competence to carry out the control programme themselves. Some of these organizations have adequate finances also at their disposal to undertake such control measures, viz.: (a) industrial sector, (b) tea and coffee industry, (c) military and paramilitary and police organizations, (d) Border Road Organization,.(e) River Valley Projects for irrigation of more than 10,000 ha, (f) mining projects, (g) rehabilitation project like DNK, (h) airports and seaports, and (i) roads and buildings. If these sectors are taken out of the purview of NMEP, it will relieve NMEP to enable them to concentrate more on certain special areas: (a) peri-urban, (b) tribal, (c) forest-fringes, (d) *P. falciparum* areas, particularly having the parasite resistance problem, (e) areas having multiple resistance of the vectors to insecticide, (f) mortality prone, (g) epidemic prone, (h) irrigation, (i) migration, (j) disturbed both political and

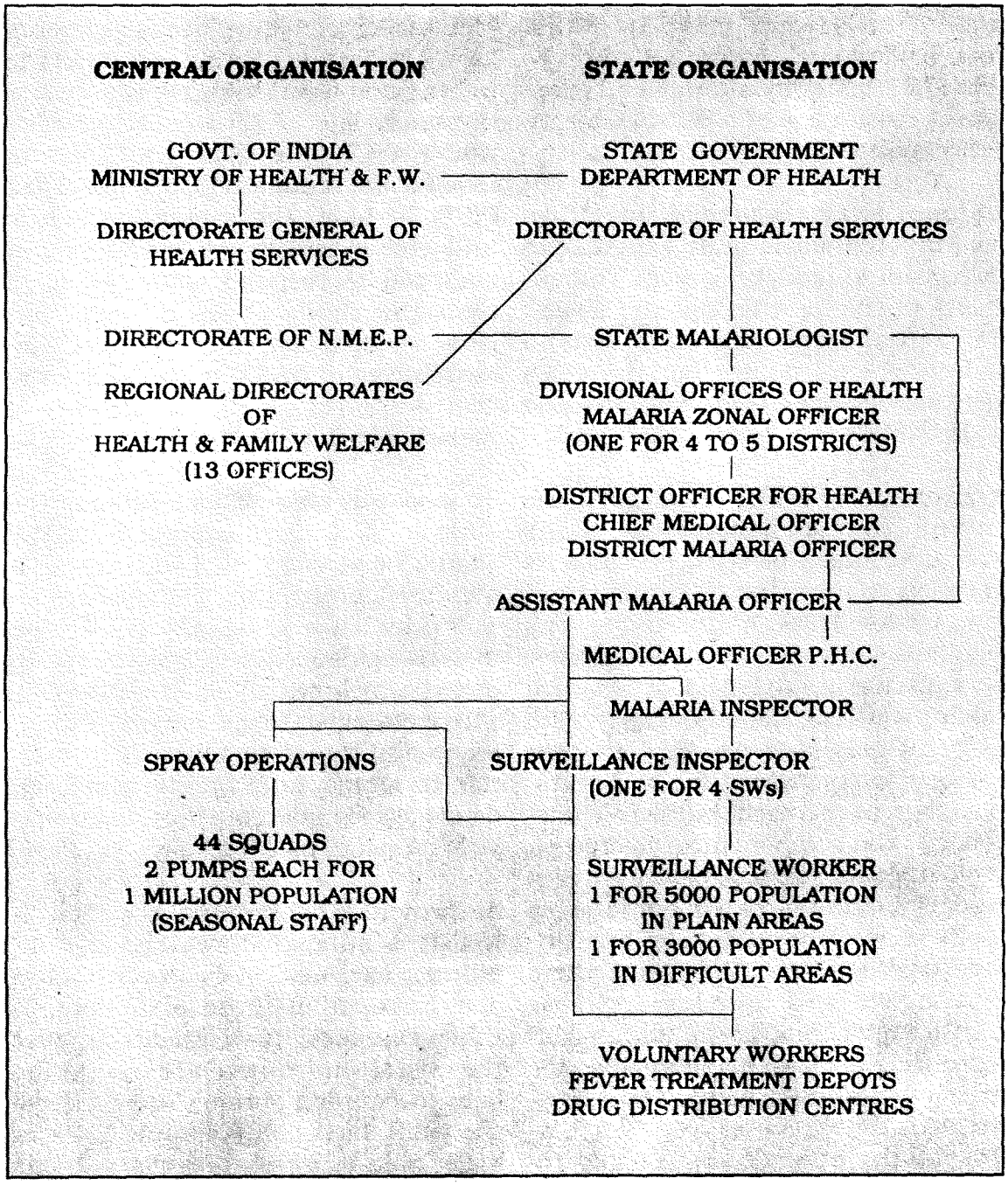

Fig. 5: Organizational chart of the National Malaria Eradication Programme, India

natural, (k) silk worm industry, (l) honey culture, and (m) tobacco cultivation. The savings made by NMEP while having such a support could be utilised for better monitoring and adoption of research methodologies for effective malaria control.

Areas of joint responsibility: Urban malaria situation is quite serious and its control should be a joint responsibility of the local bodies and NMEP. The actual implementation should be by the local bodies but the cross checking activities could be entrusted to the NMEP.

Directorate of NMEP: Basically, the structure and specialization of NMEP Directorate has not changed since its inception to meet the changing situation. Under MPO, a rethinking was done and steps were taken to improve the expertise in the field of research training and medical entomology. Still sufficient emphasis was not given to develop the expertise in the field of epidemiology particularly in micro-epidemiology. The component of micro-epidemiology was envisaged to be covered under the training component targeted mostly at workers at district and primary health centres. Similarly, there is an urgent need to induct expertise in civil engineering and public health engineering to develop and improve the environmental management and engineering technologies for control of malaria. In the absence of a strong research and development component, NMEP didn't get success in guiding the states to respond to changing needs. Monitoring activities at the national level has been of routine nature as the information from states are scanty and invariably late. Additionality provided under PfCP was mostly utilized to monitor the routine activities under the PfCP. In brief, the present structure and the expertise of NMEP is not equipped to respond satisfactorily to meet the changing needs under adverse epidemiological situations. Restructuring of NMEP is one of the urgent needs for an effective delivery of malaria control.

To meet this changing situation at the state level, the Directorate of NMEP should be strengthened with research and development (R&D) component on a priority basis. A special division on malaria epidemiology should be established which will have a networking with existing state epidemiological bureaus and the state malaria organization to promote the knowledge of epidemiology for malaria control, particularly on micro-epidemiology.

At present, the training activities at NMEP is supported by its sister institutes like Malaria Research Centre and National Institute of Communicable Diseases. It is creditable that the sister institutes are rendering help in training various categories of the staff but NMEP should have a major role in developing the syllabus for different categories of staff as they

are in better position to evaluate the felt needs of training of staff in the states.

The monitoring and evaluation could be entrusted with the epidemiology division for collection, analysis and dissemination of the information. The medical entomology division also needs strengthening. They should take frequent visits to the states and zonal organizations to observe the existing vector behaviour, its susceptibility status and guide the Directorate of NMEP on the rational use of anti-mosquito measures.

Most of the NMEP Directorate's time is consumed on logistics for the programme. Now the question is whether the logistic component could be taken out from NMEP and entrusted to the purchase wing of the Directorate General of Health Services (DGHS). There are positive as well as negative aspects in shifting the responsibility for provision of logistics away from NMEP. The requirements by the NMEP may receive routine attention by the centralised purchase wing which may not realise the seriousness, as is perceived by the NMEP Directorate which will hamper the availability of the drugs, insecticides and other supplies and equipments (S&E) in time to the state sector. The advantages are that the NMEP would be relieved from this routine duty of providing logistics which nearly takes 50% of their time. NMEP should be responsible to intimate the purchase wing of DGHS on the district-wise requirement of S&E, the delivery schedule, monitor the availability of S&E at the district level in due time, and ensure quality control of insecticides and equipments.

Regional office for health: The concept of Regional Offices of Health and Family Welfare (ROH&FW) was developed on the pattern of the Regional Coordination Organization (RCO) established under NMEP and continued under MPO. These RCOs were responsible for coordinating, supervising, training and monitoring the programme performance for one or more states under the administrative control of the Directorate of NMEP. These were the major links between NMEP and the States. Subsequently, these RCOs have been re-designated as ROH&FW and are responsible for all major health activities supported by Government of India (GOI) and are directly under the administrative control of DGHS. The concept is excellent, as it serves the focal point at the state level for liaison between GOI and the state governments. They are supposed to carry out the responsibilities like coordination, supervision, training, and monitoring the programme performance including malaria control, but in practise, their assistance in the implementation of the programme at the state level has been diluted, and the impact is not perceptible. They appear to be overloaded with activities and much of their time goes in correspondence. This link between the GOI and the states needs revitalisation. They should be actively involved in planning,

training and monitoring of NMEP in their respective states.

State level organization: The Programme Officer for malaria at state level should have a cell consisting of an epidemiologist, an entomologist and supporting staff. It should liaison with the state epidemiological bureaus to strengthen epidemiological support to the district level. The state malaria cell should be responsible for training, supply of S&E, timely receipt of reports and feedback, develop/strengthen the management information system which should include monitoring and evaluation. The state malaria cell should be in the position to forewarn the impending epidemics following natural disaster and plan for implementation for epidemic prevention through the district health organization. The cell should also liaise with the medical care cell at the district level to develop a system for management and treatment of malaria cases at district, sub-district, community health centre and PHC level. The state malaria cell should carry out periodic ad-hoc surveys in different areas to evaluate the status of the malaria control programme. The communication from state to national level and vice versa should be streamlined, and that will facilitate monitoring of the programme at the national level. At present, for all practical purposes, the planning is done at the national level and implementation is by the states. This needs reversal. The state malaria cell should plan in consultation with the district and finally with the national authorities.

District level: With the acceptance of district health system where all health programmes are to be integrated for its effective delivery, care should be taken to prioritise the activities. The existing district malaria officers stationed where malaria is not a serious problem should be converted to the district epidemiologist to assist in the epidemiological approach to solve the problem of communicable diseases including malaria. This district epidemiological bureau should be able to support epidemiological investigation including that of entomology at the sub-district and health infrastructure level. In course of time, with the reduction of malaria in other districts, the district medical officer's post in these districts should be converted to district epidemiologist. The district epidemiologist should also be responsible for the training of staff working in the district for malaria control in close collaboration with other concerned disciplines particularly medical care. As the emphasis is now on the management and treatment of malaria cases, cooperation among the district medical care cell is highly essential.

The same philosophy should also flow to the sub-district community health centres (PHCs). The most peripheral workers are the multi-purpose workers, at the sub-centre level. Thus being the first contact point, proper ori-

entation to this group of workers is of vital importance. The quality of training should be such that it would be absorbed by them depending on their educational qualifications.

Zonal set-up: Under NMEP, 72 zonal organisations were created to coordinate the activities between districts of a state[5]. These zonal units comprised an epidemiologist and entomologist and they were supposed to provide epidemiological back-up to the districts, particularly in monitoring of the changing pattern in the behaviour of vectors and resistance of parasites to antimalarials. They were supposed to assist in epidemic containment, but these zonal offices have not contributed as expected. These set-ups are still present and they should be strengthened by providing training on present day concept of malaria control. In course of time, these should be designated as zonal epidemiological units and are expected to have excellent technical ability to guide the epidemiological set-up at the district level.

10.3 Training

Training in malariology is essential for the successful control of malaria in the country[6]. Training has become extremely essential because of the following reasons:

- Malaria is a focal disease and its control demands decision making at the local level.
- The concept of malaria control is changing from an umbrella approach of spraying residual insecticides to that of integrated vector control.
- Introduction of new technologies in the programme requires training, e.g. insecticide impregnated bednets, new drugs, diagnostics, vector control methods etc.
- Objectives of malaria control have been revised as per the global malaria control strategy.
- Malaria transmission is a dynamic process and changing epidemiological features of the disease demand re-training.
- Responsibility of malaria control, if delegated to other sectors, e.g. industries, railways, tea, coffee and rubber plantations etc. a large manpower training programme would have to be mounted for the staff of these sectors.
- Training for intersectoral cooperation to staff belonging to non-health sectors, e.g. engineers, architects, town planners, administrators, agriculturists etc.
- Training of staff due to frequent transfers and recruitment.
- Specialized training in certain new and emerging areas of malariology.
- Training of the staff of the neighbouring countries working in the field of malaria.

Training facilities would have to be developed at various levels in the coun-

try, like: (i) central level, (ii) state level, (iii) zonal level, (iv) district level, and (v) PHC level. At the central level, the primary requirements of establishing a training centre would be: (i) availability of infrastructural facilities, (ii) a strong research base in the host institution, (iii) close linkages with the NMEP Directorate, and (iv) scope of field exercises in various endemic areas of the country.

10.4 Management Information System (MIS)

During the eradication era, the information obtained from periphery to central level was exhaustive, through unipurpose workers at all levels. The information received was not only stored, every bit of it was fully utilised to achieve the target of malaria eradication. For estimating insecticide and drug requirement every year, in a fixed time, census was being carried out on the population, existing and new structures and any addition to the existing structures. In many instances, NMEP census figures were more accurate than the national census figures.

This was a unique situation when there were no other health programmes to compete for collection of information except for the National Filaria Control Programme which was mostly confined to urban areas.

With the realisation that vertical programme was not cost-effective, the concept of integrated health services was developed but by then many vertical programmes were in force.

MPO was fully integrated with the health infrastructure with other vertical health programmes except leprosy control programme.

The health infrastructure is not evenly developed all over the country. There are wide variations in the development from PHC to PHC. It is the tendency of all programmes to obtain maximum information from the periphery. In many instances, the information collected are only stored and feedback is inadequate.

While discussing about MIS, one has to consider that there is a cost attached to each information collected from periphery. Further, work load of peripheral staff is also to be considered and information of maximum utility should be the criterion for collection.

It has been stated earlier that main emphasis of the proposed strategy is to improve the management of the programme as it is strongly believed that potent technologies are available which could be delivered for malaria control at affordable cost with improved management of the programme.

This involves a strong coordination with other programmes. Certain information could be useful for all health programmes which could be collected centrally and shared by all. Coordina-

tion with sectors other than health is also necessary, for example district information system of national informatics centre (DISNIC) which collects various information from district level, will be a useful source for obtaining needful information in a cost-effective manner. It has provision for collection of information from periphery to district, state and the central levels.

Similarly, Health Information System (version 2.0) developed by Directorate General of Health Services is also very useful for MIS for malaria programme. Problem remains as to how these channels can be utilized instead of the existing channel. Not much cost will be involved to follow DISNIC or HMIS. It requires motivation at all levels.Whatever system is followed, the effective information system should provide the information for planning, implementation and evaluation of NMEP. It should provide information on:

(a) Existing malaria status for forecasting,

(b) High risk group of population and area based malaria load,

(c) Developing strategies,

(d) Estimate outputs of the programme, and

(e) Identifying problems, issues and gaps in programme implementation.

The primary source of data collection could be:

(1) The registers and records maintained by the programme managers,

(2) Special studies carried out from time-to-time,

(3) Periodic and adhoc evaluation, and

(4) Data from other departments on demography, environmental and developmental material.

The MIS should be designed carefully to meet the specific requirement of each activity at each level.

10.5 Intersectoral Collaboration

Malaria paradigms in India include man-made malaria such as irrigation malaria, project malaria, urban and peri-urban malaria, accelerated transmission of malaria in border areas, migration, disturbed areas due to militancy, conflict and malaria caused by natural calamities, e.g. floods and drought etc. Mostly malaria transmission could be reduced or eliminated by incorporating safe guards in man-made developmental activities, e.g. seepage control, tidy irrigation, siting of tropical aggregation of labour in healthy areas, screening of itinerant labour, incorporation of engineering methods of malaria control etc. However, there would be certain situations which may require selective vector control interventions. In the former case, much of the malaria problem could be mitigated by incorporating mosquito breeding safeguards at the planning and execution stage with provision of

monitoring and control during the maintenance phase. Implementation of these engineering methods and safeguards are outside the purview of the health departments and must be ensured through intersectoral collaboration. Therefore, involving other sectors in the control of malaria is not only desirable but an essential pre-requisite for rational vector control. Some key sectors responsible for creating malariogenic potential are, irrigation department, construction agencies, water supply, drainage, sewage and flood control, mining, forestry etc. Since malaria is a focal disease, core data may be collected before undertaking any major human activity to elicit intersectoral collaboration of the concerned agencies. This may require active participatory action. Eliciting intersectoral collaboration on routine basis may require legal support, and provisions should be made through appropriate amendments, extension of the existing laws or by framing new laws.

10.6 Community Participation including Non-Government Organizations (NGOs)

It has already been mentioned earlier in this paper that the erstwhile DDCs and FTDs have become almost defunct with the introduction of community health workers and village health guides. Subsequently, it has also been noticed that the performance of community health workers and village health guides is not up to the expected level. The role of volunteers is indispensable as they are the first to know about the occurrence of fever cases in the community and should have knowledge to treat fever cases or refer the cases to the nearest health centre, in case of complicated malaria. Efforts should be made to involve the communities from the very beginning in all activities to share responsibility. It will be difficult to revive the DDCs and FTDs who are completely voluntary without any financial support. If they are to be revived with financial support then it is likely that they will meet the same fate as witnessed in case of community health volunteers and village health guides. In view of this, other agencies with drug to treat mild and moderate cases of malaria and refer complicated malaria cases to nearest health facilities are to be explored. These agencies could be:

(a) In the pre-independence era, every post office in India had quinine tablets which were available free of cost. It is worth exploring, if this channel could be available for free administration of chloroquine to suspected malaria cases.

(b With the extension of *panchayat* system to every corner of the country, involvement of the *panchayat* would be another important source for treating fever cases in the villages.

(c) Another source would be the involvement of *anganwadi* workers as they are mostly devoted to the health of women and children.

This will be beneficial as they are the largest victims of malaria in many situations.

(d) The government is taking keen interest in the welfare of women and children and in many instances, the village *Mahila Samiti* is doing an excellent job. It may be explored if, this agency could be of help in this regard. Administration of the drug to suspected malaria cases is of vital importance as it will prevent mortality and reduce morbidity. It is essential that these voluntary agencies apart from being supplied with chloroquine should be supplied with paracetamol tablets. This will enhance their credibility with immediate remission of fever.

(e) Community has potential to play a greater role in source reduction. It was observed in past that such participations were excellent in initial phase and declined during the course of time. Source reduction is not a one time measure and has to be sustained for a very long period. The community is interested in economic gains if that could be accrued through such activities. MRC from time-to-time has tried prawn and fish culture as an economic benefit to the community, while doing source reduction[68]. It requires an exhaustive study on the social and cultural behaviour of the community to determine a suitable entry point for enlisting community involvement which could be sustained. Health education with appropriate message would be of considerable value[47]. NGOs like missionaries are of considerable help in tribal areas.

10.7 Health Education

Health education is an important component for effective delivery of malaria control programme. Since malaria eradication era, health education component has been involved but the impact was of limited value. The conventional manner of conducting health education may not be suitable particularly in the tribal belt. "Peer" education will be of great value in such areas. Essentially, malaria is a disease of human behaviour. Lot of inputs and technology had been used to change human behaviour for the interruption of human immunodeficiency virus (HIV) transmission. Though the primary objective in AIDS control programme is to change the human sexual and injecting behaviour but these techniques could suitably be modified to change the human behaviour against malaria transmission. This ranges from source reduction, timely seeking of medical advice and undertake self-protection measures. Every health programme tries to maintain its own health education cell but pooling these resources at the district level will be cost-effective.

11 RESEARCH AND DEVELOPMENT

In India research on malaria was organically linked to the field operations

in malaria control. Beginning from the days of Sir Ronald Ross, when he demonstrated malaria transmission by mosquitoes till the period of malaria eradication, India's contribution in malariology has had significant impact on the success of malaria control in the tropics. The euphoria of success in malaria control filled malariologists with the hope of eradication which at that time seemed imminent, so that even much before eradication, planning for post-eradication period had started[69]. In the early 1960s when malaria was almost eradicated, investments on malaria research was curtailed and diverted to other health priorities, as a result, research on malaria started dwindling towards extinction.

At the other end the response to malaria control during eradication era varied from area-to-area. Some endemic areas became free of malaria, while in others the problem persisted and defied all control attempts. Problems of vector resistance to available insecticides and drug resistance in *P. falciparum* further eroded the effectiveness of the programme. Large-scale developmental activities undertaken in the country brought in radical ecological changes affecting the ecosystems and in turn malaria systems. This highlighted the need for applied and field research in malaria on continuing basis to enhance the capabilities and effectiveness of the programme and basic research for evolving new tools which are cost-effective and eco-friendly.

11.1 Research Capabilities in the Country

Research on malaria was revived under the auspices of Indian Council of Medical Research (ICMR) and field research under MPO and PfCP[70-72]. ICMR established permanent research centres, viz. Malaria Research Centre, Vector Control Research Centre and Centre for Research in Medical Entomology, exclusively for research on malaria and other mosquito-borne diseases. In addition, ICMR has set up a chain of Regional Medical Research Centres to tackle regional problems. Malaria Research Centre established 13 malaria field research stations primarily to investigate regional malaria problems and test the effectiveness of new tools developed by it in different geographic areas.

Besides, inputs have been provided by other research organizations, viz. National Institute of Communicable Diseases (NICD), Council of Scientific and Industrial Research (CSIR), Department of Biotechnology (DBT), Bhabha Atomic Research Centre (BARC), International Centre for Genetic Engineering and Biotechnology (ICGEB) in malaria. However, research output was either not inducted or utilized by the NMEP (as in the case of MRC) or research was open ended, and of academic nature. Thus there is obvious need to

establish linkages for coordination between the programme and the research organizations.

11.2 Establishment of Malaria Advisory Board

Coordination between the implementing organization and the research bodies can best be achieved by constituting a high level Malaria Advisory Board. This Board should comprise Directors of research institutes of Indian Council of Medical Research (ICMR) and a few select and eminent malariologists of the country under the Chairmanship of DG (ICMR) with Director NMEP as Member Secretary. The Board should be mandated to review the annual performance of the programme, identify problems affecting the progress of the campaign, and formulate need based research programmes which could be taken up by ICMR and other research institutions and final output inducted into the programme.

11.3 Priority Areas of Operational and Field Research

Priority areas of applied and field research having relevance to the programme include, (i) efficacy and cost-effectiveness of specific interventions and related areas that influence them and other components of the programme and management activities, (ii) effective, entomological and epidemiological response, (iii) community perception of malaria and treatment practices, (iv) effectiveness of referral systems, (v) efficacy of antimalarial drugs, (vi) changing ecological ecosystems and their impact on transmission, (vii) KABP studies on socio-cultural practices of tribal communities with regard to their perception to modern treatment and other health related matters, (viii) malaria control as health care management issue, (ix) stratification as an epidemiological tool to determine control priorities, (x) community participation, and (xi) ways and means of intersectoral coordination.

11.4 Role of WHO

World Health Organization has a promotional role in the control of malaria. The Tropical Diseases Programme (TDR) of the WHO has been promoting strategic and applied research on malaria in the area of vaccine development, *P. falciparum* genome mapping, diagnostics, new chemotherapeutic agents, applied field research for cost-effective and sustasinable malaria control, and socio-economic research. WHO also helps in man power development by organizing training workshops, providing research grants, fellowships, supporting courses in malariology and medical entomology, and procurement of supplies to facilitate field operations and research on malaria. In addition WHO helps to mobilize funds and supplies from other UN agencies, bilateral support, and from the donors. WHO also organizes independent appraisals of the program-

mes, makes recommendations for improvement and monitors the progress. World experience on malaria is mobilized to develop malaria control strategy which is reviewed and updated to tackle the new and emerging challenges. In 1992, WHO convened an series of meetings and drafted a global malaria control strategy which was signed by malaria endemic countries of the world to which Government of India is also a signatory. This strategy is now being implemented in the country through the NMEP.

12 ROLE OF BILATERAL AGENCIES

Bilateral agreements for funding of malaria control programmes has had significant impact in the control of malaria in the tropics. Notable donations to control malaria in India were made by the USAIDS programme in the initial stages and two decades later by SIDA for the containment of *P. falciparum*. Currently there is a proposal under consideration with the World Bank for assistance to control malaria in the tribal populations of the peninsular India. With the recognition of the need to incorporate health safeguards in the development projects PEEM (Panel of Experts on Environmental Management in Vector Control) of the WHO has been playing an important promotional role in the prevention and control of malaria, and the development of indigenous and appropriate technologies in vector control.

13 CONCLUSION

Freedom from malaria is the basic right of the Indian people. The government of India is therefore, providing major funding for malaria control along with its integration with other national health programmes. Unfortunately, transmission of malaria in many ecological settings of the country has become refractory or partially refractory and requires new approaches, targets and tools for its control. In this paper we have reviewed the various phases of malaria control in the country bringing out the present epidemiological types of malaria, situation analysis of each type and the need for a revised malaria control strategy superseding the modified plan of operation. In order to control malaria below economic threshold so as to allow optimum socio-economic development of the country and provide malaria control to the neglected regions and high risk groups, the paper describes the approaches for each paradigm, attainable targets and malaria control interventions giving details on implementation of the strategy. There are inter alia some policy issues that should receive attention of the government to enable the field operations to proceed uninterruptedly. These are:

13.1 Drug Policy

Drug policy should be reviewed in the background of new epidemiological paradigms and emerging problem of

drug-resistance as also the emphasis on protection to high risk population.

13.2 Insecticide Policy

Blanket spraying of residual insecticides is under criticism from various quarters. Therefore, insecticide policy should be restricted to selective spraying against indoor resting susceptible populations only in a cost-effective manner keeping in view the sustainability of spraying programme.

13.3 New Technologies

Introduction of new intervention technologies in malaria control should be emphasized, wherever possible and efforts should be made to apply multi prong approaches using various tools.

13.4 Reorganization of NMEP

NMEP Directorate should be reorganized at the national, regional, zonal and state level in tune with the revised strategy of malaria control. As far as possible trained manpower should not be lost by transfer and malaria training should be made compulsory for all staff working in the programme.

13.5 Control Approaches

Approaches for all malaria control should be based upon epidemiological reasoning through MIS. MIS should be interfaced with other sectors to provide holistic account of malaria ecology in the area for planning of malaria control at the periphery.

13.6 Research

Basic and applied research in malaria is done at various research institutions in the country. However in order to absorb the new developed technology, an epidemiology division should be created within NMEP. This would also help in taking up some important operational research programmes jointly with the research organizations, monitoring of routine activities of drug-resistance and vector-resistance, and eliciting intersectoral coordination by establishing linkages.

Strategic research should be directed towards transgenic mosquitoes to develop vector strains refractory to infection, susceptible to insecticides, preferentially biting animals etc.

Basic research should be directed towards the development of malaria vaccine, diagnostics, methods of immunomonitoring, evolution of resistance in the vectors and the malarial parasites, new methods of vector control, screening of drugs for their anti-malarial activity, methods to reverse drug-resistance, host-parasite interactions etc. There are several areas of applied and operational research which will accelerate malaria control. Research needs

of the programme should be identified and prioritized in consultation with the field officers and programme directors in the states. However, some priority areas of applied research were identified which may be taken up depending on the availability of resources and expertise.

(i) Biology and ecology of the vectors (including at sibling species level).

(ii) Site of acquiring malaria infection in problem areas.

(iii) Demonstration of selective vector control in management of endemic malaria.

(iv) Biology and ecology of the immature stages of vector mosquitoes.

(v) Strategies of malaria control for arid zones particularly development of anti-larval methods to control *An. stephensi.*

(vi) Trials with new insecticides and determination of criteria for sustaining or withdrawal of house spraying.

(vii) Detection and evaluation of insecticide resistance, especially pyrethroid resistance.

(viii) Role of impregnated bednets in malaria control under various epidemiological situations.

(ix) Global warming and its impact on the trends in vector proliferation.

(x) Drug-resistance in *P. falciparum* and methods of containment.

(xi) Studies on *P. falciparum* and *P. vivax* transmission dynamics in different ecotypes under the pressure of various interventions.

(xii) Field trials with new drugs and drug combinations.

(xiii) Adverse reactions of anti-malarial drugs.

(xiv) Research on management of Clinical and complicated malaria.

(xv) Development of early warning system to detect and contain epidemics.

(xvi) Geographical Information Systems to define malaria receptivity and vulnerability at macro- and micro-level.

(xvii) Development of a model to study malaria transmission dynamics related to meteorological parameters.

(xviii) Epidemiological investigations of malaria in endemic areas.

(xix) Pattern of migration and its impact on malaria transmission.

(xx) Problems of border malaria and methods of its containment with particular reference to drug-resistant malaria.

(xxi) IEC and KAPB studies in relation to people's perception about malaria and its control including traditional practices.

(xxii) Environment and malaria transmission.

(xxiii) *P. vivax* relapse and molecular approaches for its identification.

(xxiv) Health systems research to manage malaria control at the periphery.

(xxv) Health impact assessment parameters and their validation.

(xxvi) Economic loss due to malaria in various development projects.

13.7 Urban Malaria

Problem of urban malaria is becoming serious mainly because of unplanned expansion and migration of people from rural to urban areas. In-depth situation analysis of urban and peri-urban areas should be taken up and in these areas the emphasis should be given to species sanitation, and field operations supported by appropriate legislative measures.

13.8 Training

Present training programme are not only limited in scope but also follow "chemical era" theme. The training programme needs to be strengthened to cover workers at each echlon by strengthening institutions at national and state level, and should be diversified to include scientists/engineers/ technologists of other sectors.

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Instructions to Authors

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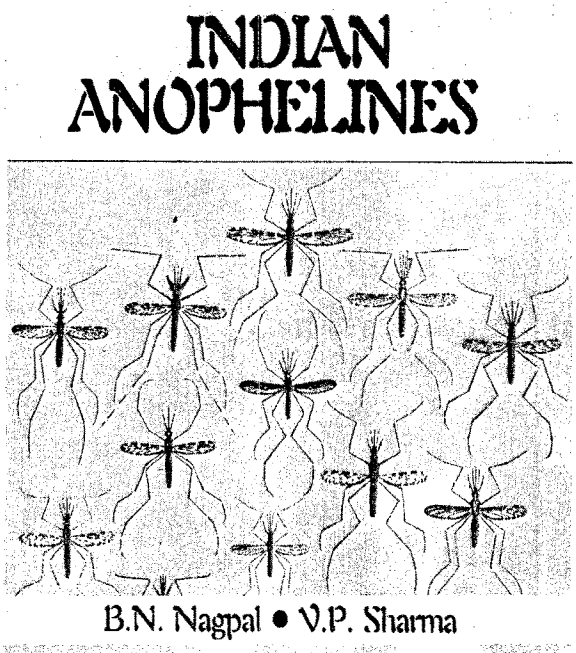

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