OVERVIEW

MALARIA: COST TO INDIA AND FUTURE TRENDS

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Abstract. A study of the economic loss due to malaria and its future trends revealed that malaria in India was responsible for economic loss between US$ 0.5 to 1.0 billion annually. The study also brought out that malariogenic potential of the country is increasing, and new malaria paradigms have been established requiring new approaches for its control. Unless this trend is checked losses due to malaria will increase in the coming decades. Effective malaria control requires immediate remedial measures to prevent environmental degradation conducive to vector proliferation; and renewed attack on malaria based on local epidemiological, entomological and social determinants. The first requirement for such an action is a reliable data base, both on the malariometric indices and the causative factors. Research therefore should be intensified to fill the gaps, generate new knowledge, disseminate malaria information as widely as possible and provide training for success in malaria control by the implementation of the global malaria control strategy.

INTRODUCTION

Economic studies on malaria and its control are important to bring planning of malaria control into the correct perspective of national development. These studies also bring to the forefront the importance and need of adequate resources so that the impact of the disease is mitigated, both in terms of economic loss and also the human suffering. The first in-depth study on what malaria costs India was made by Sinton (1935). He estimated that at least 100 million individuals suffered from malaria yearly in British India alone, and this he felt was probably a moderate estimate. He also pointed out that there was indirect morbidity predisposed to by *Plasmodium* infections which may at that time have been between 25 to 75 million cases. Sinton further stated that as a minimum estimate at least 1 million (m) persons died each year in British India as the direct result of endemic malaria, and very probably such an estimate was below the true figure. A break up of economic loss due to malaria was estimated by Sinton in pounds sterling as: (i) cost of medical attendance 15 m. (ii) loss of time, efficiency and employment 10 m. (iii) post malaria inefficiency 22 m. (iv) wastage of capital due to value of lives lost and funerals etc. 68 m. (v) miscellaneous expenses to the family 80 m. (vi) financial loss to the communities 26 m. In addition to these losses, there were enormous losses in agriculture, industry, mining, railways, sea borne commerce and shipping etc, besides serious setback to growth and development: physical, physiological and mental of the population. Sinton summed up by stating that "the problem of existence in very many parts of India is the problem of malaria. There is no aspect of life in this country which is not affected, either directly or indirectly, by this disease. It constitutes one of the most important causes of economic misfortune, engendering poverty, diminishing the quantity and quality of food supply, lowering the physical and intellectual standard of the nation, and hampering increased prosperity and economic progress in every way."

The malaria situation in India remained unchanged until the 1940s. Soon after world war II, DDT was released for use in public health in India and this changed the outlook of malaria control in the country. Initial experiments on the residual spraying of DDT produced spectacular results in terms of malaria control. This success brought a feeling of euphoria among the malariologists and the planners. Wherever DDT was sprayed as residual insecticide, malaria was wiped out. Therefore, the Government of India in 1953 launched the National Malaria Control Program (NMCP). By 1957-58, under the NMCP, 165.15 million population was protected from malaria. At that time resistance in the vectors of malaria started to surface. In consultation with the World Health Organization (WHO) it was decided to eradicate malaria before the onset of widespread resistance in the malaria vectors. With this background, in 1958 NMCP was converted to the National Malaria Eradication Program (NMEP). The entire country was brought under the NMEP, and by the early 1960s malaria was nearly uprooted. In 1965 there were about 0.1 million parasite positive malaria cases, and deaths due to malaria had been completely eliminated. At that time malaria was seen to be on its way out as a public health problem from the entire country. Therefore to optimize the use of health resources, in 1963 the Malaria Institute of India (MII) was re-designated as the National Institute of Communicable Diseases (NICD). Also the publication of the Indian Journal of Malariology was terminated, as there were neither the readers nor the contributors to the journal. Malaria was no longer perceived as a problem, and all work on malaria was considered unnecessary and consequently de-emphasized. While malaria was raising its ugly head in almost all previously endemic areas, malaria eradication and support structures was wound up in the euphoria of success. It is often satirically said that DDT successfully eradicated the malariologists but not malaria.

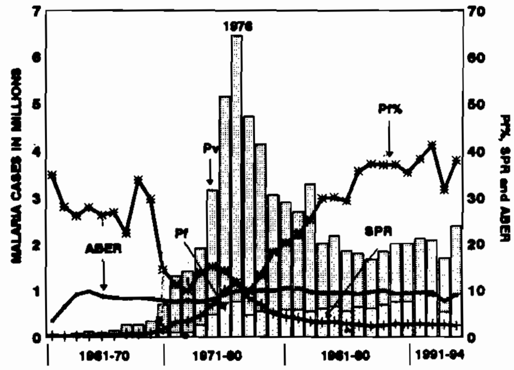

Fig 1–Epidemiological indices of malaria in India. Malaria was effectively controlled in the early 1960s but started to multiply in the successive years. Malaria cases peaked to 6.46 million in 1976. The modified plan of operation was implemented in 1977 and its impact was seen in reduction of total malaria cases but there was no impact on *P. falciparum* cases (see the lower portion of the bar). ABER remained at about 10 and SPR between 2 to 3. In 1994 there were 2.4 million cases out of which 0.9 million cases were *P. falciparum*. ABER 8.88; SPR 3.06; SfR 1.16; API 2.71; AfI 1.03; Pf% 37.91%; deaths 1,160.

When the case incidence was low there was need to justify expenditure on malaria, as during this period, per capita cost of a case protected from malaria was visibly very high. A study by Ramaiah (1980) showed that each Rupee spent on malaria control brought a gain of Rs 9.27, and therefore malaria control made economic sense. Economic studies on methods to improve the control of tropical diseases are becoming an important and integral part of field operations (Mills, 1994). Epidemiological records of NMEP updated annually show that in the last decade or so malaria situation in the country has stabilized at around 1.6 to 2.1 million parasite positive cases each year, 35-38% of these constitute *P. falciparum* (Fig 1). Is this the real situation? This is an important question which must be addressed to estimate economics of malaria control. We know the rapidity with which receptivity to malaria has changed in the country in the last 3-4 decades, mostly man made environmental degradation favorable for vector breeding. Areas hitherto free from malaria are facing renewed threat from the disease. New malaria paradigms have appeared within the unstable malaria such as irrigation malaria (Sharma, 1990), urban malaria (Pattanayak *et al*, 1981), peri-urban malaria (Sharma *et al*, 1985) project malaria (Dua *et al*, 1988). This situation is becoming a formidable problem as the available vector control methods are not producing the desired impact in terms of malaria control, and this is being witnessed in all malaria endemic areas (Arata, 1994). Therefore malaria upsurge is posing a renewed threat and becoming more complex with the spread of drug resistant *P. falciparum*, and the high cost of malaria control with diminishing returns. With this background it is time again that we address the same question of what malaria costs India, as was addressed by Sinton about half a century ago *ie* the economics of various losses and expenditure associated with malaria in context of the prevailing malaria situation in the country.

INCIDENCE OF MALARIA IN INDIA

In India malaria cases are recorded by the state health departments through a mechanism of active case detection (ACD) and passive case detection (PCD). In rural areas a multipurpose worker (MPW) is expected to visit each and every house at fortnightly intervals, find a case of fever from the time he last visited, and collect a blood smear. He then gives presumptive treatment and makes appropriate entries in the register. Blood smears collected during the domiciliary visits are delivered to the laboratory technician at the primary health center (PHC) or the sub-center. Under PCD fever cases report directly to the malaria clinics, sub-centers, PHCs, etc. Blood smears are examined by the laboratory technician and results of ACD slide examination are communicated to the MPW, who is expected to go back to malaria cases and give them radical treatment. In urban areas there is no active case detection except under special circumstances, but there are malaria clinics attached to the hospitals and in certain specified areas. Fever cases come to these clinics for malaria tests, and those found positive for malaria are given anti-malarial drugs.

Widespread return of malaria in the late 1960s was a major setback to the NMEP, and it was apparent that the eradication strategy was unlikely to be helpful even in reducing or containing morbidity and mortality due to malaria. Therefore in 1977 the government of India reorganized malaria eradication as Modified Plan of Operation (Pattanayak and Roy, 1980). Under the MPO one objective was to reduce morbidity and mortality due to malaria. In order to achieve this objective, drug distribution center (DDCs) and fever treatment depots (FTDs) were opened throughout the country. As of June 1992 there were 132,382 DDCs and 64,372 FTDs (NMEP, 1991). DDCs provide drug to any fever case on asking but FTDs also collect blood smears for malaria tests at the PHC for radical treatment. Results of malaria positive cases based on blood smear examination by the PHCs, sub-centers and malaria clinics are collated at the state level for epidemiological analysis of data and forwarded to the NMEP HQ for analysis at the national level. It may be noted that the analysis of the malaria situation in the country is complicated by the (i) problem of widespread drug resistance in *P. falciparum* resulting in drug failure; (ii) shortage of anti-malarials in some places *eg* there are reports of chloroquine in short supply and primaquine is not available in the private sector. The life saving drug quinine is not supplied by the NMEP. It is in short supply and often not available in the open market, and artimisinin or its derivatives are not marketed still, to treat serious and complicated malaria cases; (iii) mis-diagnosis of cases often on the clinical basis, and also due to poor blood examination; (iv) inadequate treatment as a result of poor compliance, and also wrong treatment in some cases; (v) a large number of people prefer indigenous systems of medicine which have questionable remedial action; (vi) treatment by private medical practioners who do not prescribe radical treatment thus allowing the build up of reservoir of infection; and (vii) backlog of slides resulting in delayed treatment and the spread of malaria.

In as far as the incidence of malaria is concerned, the method of case detection through the ACD and PCD suffers from the following problems resulting in the under-reporting of malaria cases:

1. There are 40-50% vacancies among the multipurpose workers (MPWs), and to that extent there are "black out areas" which later on report epidemics of malaria.

2. MPW has to look after 8 programs; among these family planning takes priority, and therefore malaria surveillance is neglected. There are incentives for the family planning work and there is no accountability for poor malaria surveillance.

3. There is no provision of staff for leave reserve either at the MPW or at the technician level.

4. During the peak transmission season there is back log of slides and it takes 6-8 weeks before this back log is cleared. Unexamined slides are not counted in calculating the incidence of malaria.

5. DDCs distribute drugs without taking a blood smear and therefore malaria cases taking drug from the DDCs are not counted in the incidence.

6. Malaria cases of private clinics and even some government hospitals like the All India Institute of Medical Sciences, Ram Manohar Lohia Hospital etc are not included in the collation of NMEP data. In rural areas people with fever often visit Ayurvedic, Unani, and homeopathic doctors.

7. In urban areas there is no ACD and a large number of patients go to private practioners. General practioners treat patients on a clinical basis and slides are never examined. These cases and those found to be positive in the pathological laboratories are not included in the collation of malaria incidence data.

8. Incidence data do not include morbidity and mortality figures of defence, paramilitary forces, border road organization, police organizations, autonomous institutions, tea gardens, coffee planta-

tions, and private hospitals.

In this context it may be noted that in 1985 the in-depth evaluation team of experts reviewed the modified plan of operations of the NMEP and commented on the malaria situation that "the problem of malaria in India is grossly under-estimated". Studies carried out by research organizations in some areas of the country also bring out under-reporting and strongly support the conclusions of the review committee. It may be pointed out that the surveillance system developed under NMEP was not established to monitor the disease incidence. The primary purpose of surveillance was to provide treatment to all citizens of India in howsoever remote areas they may be living. However this information is often used to project the disease incidence. Based on various epidemiological data analysis done over the last decade, field visits to the endemic districts, participation in various evaluations of the NMEP, and discussions with a large number of health officials, it may be more realistic and safer to assume at least 10-15 fold under-reporting of the cases, or say about 20-35 million malaria cases.

Another method of malaria assessment could be the consumption of chloroquine. Yearly production of chloroquine phosphate base in the private sector is 600 metric tonnes, of which 150 mt is exported to the neighboring countries. One metric tonne yields 4 million tablets of 150 mg, and therefore 2,400 million tablets are available. If we take out 300 million tablets required by the NMEP, the balance of 2,100 million tablets are available for the treatment of fever cases in the private sector. Since in the private sector 10 tablets are used to treat a case of fever/malaria, and taking into account the children, low dosages required due to a combination of drugs used by the doctors, poor compliance, wastage; it may be realistic to assume that 7 tablets may be used in the treatment of malaria. Therefore 2,100 million tablets will treat 300 million fever cases. As stated before, incidence of malaria is grossly under reported. This is also substantiated by very high SPR reported by various investigations. Some examples of SPR are : 46.72, Sharma *et al* (1982); 25.47, Sharma and Uprety (1982); 54.35, 45.5, Uprety *et al* (1982); 67.5, Choudhury *et al* (1983); 54.05, Chandrahas and Sharma (1983); 39.6 and 46.1 Sharma *et al* (1985); Malhotra *et al* (1985); 52.4, Shukla *et al* (1985); 17.45, Singh *et al* (1985); 33.2, Ansari *et al* (1986); 57.6, Singh and Sharma (1989); 47.7, Prasad and Sharma (1990); 34.38, Yadav *et al* (1991) 51,57, Prasad *et al* (1992); 7.56, Khan and Kareem (1992); 61.0, Mathur *et al* (1992); 53.3, Yadav *et al* (1993). In some studies it was also compared with PHC data and the comparative SPR was 21.2 *vs* 4.7, Sharma *et al* (1983); 43.2 *vs* 12.6, Sharma *et al* (1983); 58.66 *vs* 5.27, Malhotra *et al* (1985); 26.3 *vs* 7.6, Ghosh *et al* (1989); 5.47 *vs* 1.46, Choudhury *et al* (1987). Since the data base on the case incidence is weak and unreliable, we have estimated indirectly low and high figures of malaria. In estimating low incidence figures, calculatiions were based on 2.82 SPR reported by the NMEP in 1991. This gives 8.46 million cases out of 300 million fever cases treated outside NMEP. In addition 2.11 million cases are reported by the NMEP and therefore total cases come to 10.57 million. To this figure if we ad 50% more cases not recorded on account of inadequate surveillance and drug distribution without taking a blood smear, the round figure comes to 15 million malaria cases. To estimate higher incidence based on reports of various research organizations a four fold greater SPR based on 1991 figure will give 11.28 SPR: or say 11. This will give 33.84 million cases out of 300 million fever cases treated outside the NMEP. To this if we add 2 million cases of malaria recorded by the NMEP a final figure of 35.84 million or say 35 million cases may be the minimum on the higher side in one year. Therefore in calculating the economic loss due to malaria we have taken lower and higher estimates of 15 and 35 million malaria cases occurring in the country. Also the malaria and *P. falciparum* cases in rural and urban areas have been calculated on the proportional basis as recorded by the NMEP (1991). Table 1 gives malaria cases reported by NMEP in the rural and urban areas and also the guesstimated cases of malaria in the country.

ESTIMATED LOSSES DUE TO MALARIA

Table 2 gives the economics of various losses and expenditure being incurred on malaria by the country and the communities. Committed spending on malaria control by the NMEP both by the central and state governments in 1991 was Rs 1,800 million (S No. 1). In India because of the deteriorating malaria situation in the urban areas NMEP launched the Urban Malaria Scheme (UMS) in 1971 (Pattanayak *et al*, 1981). Under the UMS, towns

Table 1

Malaria cases in India in 1991.

Malaria cases	Total cases	Pv cases	Pf cases
Reported cases (NMEP)			
Rural	1,905,570	1,010,228	895,342
Urban	211,890	188,744	23,146
Total	2,117,460	1,198,972	918,488
Guestimate (low)			
Rural	13,498,980	7,156,414	6,342,566
Urban	1,501,020	1,337,055	163,965
Total	15,000,000	8,493,469	6,506,531
Guestimate (high)			
Rural	31,497,620	16,698,299	14,799,321
Urban	3,502,380	3,119,794	382,586
Total	35,000,000	19,818,093	15,181,907

with 40,000 or more population and malaria API 2 or more with 10% annual blood examination rate for 3 year period were taken up for malaria control. Initially 133 towns were identified under this category and the scheme was implemented in phases. So far the scheme has been implemented in 128 towns with 76.4 million population (NMEP, 1991). In the last 2 decades, urban areas in the country have registered a phenomenal increase both in terms of their number and also the geographical spread. As per the 1991 census, there were 645 towns with 50,000 or more population.

In urban areas outside the UMS there is provision of mosquito and malaria control by the local bodies. Expenditure on malaria control in urban areas is based on the information collected from some urban local governments and extrapolated for the rest of the country. In calculating this expenditure NMEP's contribution of 50% cost sharing of the supplies has been taken out. In 1991-92 malaria control budget in all urban areas of Tamil Nadu is Rs 20.94 m, 14 towns in UP is Rs 21.0 m, Chandigarh Rs 94.2 m, Surat Rs 11.9 m, Bhavnagar Rs 2.74 m, Delhi Rs 51.2 m, Bombay Rs 47.5 m, etc. We estimate Rs 10 per capita cost and the total budget for malaria control in towns of India outside the NMEP funding would be of the order of Rs 1,000-1,500 million (S No. 2).

Defence, railways and other government organizations outside the purview of the NMEP have their own malaria control program and Indian Railways also contribute towards labor and some supplies. An estimated Rs 80-120 million is spent by these organizations (S No. 3).

Projects, industrial houses and public sector undertakings are responsible for malaria control in their own establishments *eg*, expenditure by 8 units of the Bharat Heavy Electrical Ltd, is Rs 13.46 m. Upper Krishna Project in Karnataka is Rs 6.0 m and there are hundreds of such projects in the country. Krishna Brahaman (1991) reported Rs 23-25 lakh loss due to malaria at the Visakhapatnam steel plant (AP). He also estimated that 11% of the total man days are lost in construction due to malaria and the project cost escalates by 2.5 to 3.5% on account of malaria. This does not account for economic loss due to malaria in the impact villages. Yadav *et al* (1991) reported economic loss due to malaria from the mining settlements in Sundargarh district, Orissa. It was estimated that for protecting a population of 13,748 residents in two mining settlements the annual expenditure/loss due to malaria stood at Rs 1.1 million *ie*, Rs 80 per capita. Per capita expenditure to individuals was Rs 178 to labour, Rs 78 to regular employees and Rs 228 to businessman and others. A study on monetary loss due to malaria in Haldwani (UP) found loss per episode of malaria from Rs 43-283 at 1985 rates and Rs 5-10 lakh at the Khribeo, fertilizer, Surat (Gujarat). (MRC, unpublished results). Based on the results of various studies and discussions the cost of malaria control in projects may be around Rs 700-1,100 m (S No. 4). Similarly, autonomous organizations have their own malaria control arrangements, so also tea gardens, coffee plantations etc. Expenditure by these organizations would be about Rs 100-180 m (S No. 5). Estimated expenditure on malaria research in India by national and international organizations is Rs 100-120 million (S No. 6).

Nursing of the sick would also require better nourishment. It is estimated that one attack of malaria causes the loss of 5,000 calories. To replenish this loss about Rs 5/- per day for 7 days would be required by way of improved diet. This will cost Rs 525 m and Rs 1,225 m (S No. 7). Transportation of the patient to the hospital or the private clinic may cost on average of Rs 10/- per patient. The total amount of money in transporting malaria patients comes to Rs 15 m and Rs 35 m (S No. 8). In India there is a market of Rs 1,600 m of various personal protection methods which includes oils, creams, pyrethroid impregnated mats, DEET, DEPA, etc. Mostly these methods are used to repel

Table 2

Economic loss due to malaria in India in 1991.

S.No.	Items of expenditure and economic loss		Amount in Indian rupees in millions for 1 year Low	High
1	Malaria control budget of NMEP for the year 1991		1,800	1,800
2	Expenditure on malaria control in urban areas by local Govts		1,000	1,500
3	Expenditure by defence, railways and other Govt organizations outside the purview of the NMEP		80	120
4	Expenditure by public sector undertakings, projects, industry etc.		700	1,100
5	Autonomous organizations, tea gardens, coffee plantations etc		100	180
6	Expenditure on Research and development by the national and international organizations		100	120
7	Improved diet @ Rs 5/-day for 7 days		525	1,225
8	Transportation @ Rs 10/- per case of malaria		15	35
9	Use of personal protection methods 25% (low) and 45% (high) for malaria prevention. Current Indian market of Rs 1,600 million annually.		400	720
10	Cost of malaria treatment to the patient and to the public funded hospitals not covered by the NMEP			
	a) *P. vivax* cases		241.52	563.25
	b) *P. falciparum* cases		1,128.11	2,632.25
Sub-total (I)			6,089.63	9,995.50
		US$	(193.32)	(317.32)
11	Los of wages for 7 days			
	i) rural areas @ Rs 30/-		2,834.78	6,614.50
	ii) urban areas @ Rs 40/-		420.29	980.67
	iii) Loss due to attendance/care @ 2.5 days for each case of malaria @ Rs 30/-day		1,125.00	2,625.00
12	Deaths due to malaria Cost of deaths discounted @ 12% for 30 years is 8.058 years (250 days/year) each for 75,285 low and 137,846 high deaths @ Rs 35 average of rural\ and urban labour cost.		5,308.15	9,719.18
Sub-toal (II)			9,688.22	19,939.35
		US$	307.56	633.00
Grand total	Indian Rs		15,777.85	29,934.85
		US$	500.88	950.31

Note: Conversion US$ @ Rs 31.5

mosquitos to prevent nuisance bites etc, but it is estimated that 25-45% of expenses on these methods may be incurred for the protection from malaria. Therefore this expenditure comes to Rs 400 m and Rs 720 m (S No. 9).

Treatment cost of malaria has been calculated for *P. vivax* and *P. falciparum* separately (S No. 10). In calculating the cost of *P. vivax* treatment, of the 7,156,414 (low) and 16,698,299 (high) estimated cases occurring in rural areas, at least 25% of cases will go to the private sector because of poor surveillance and backlog of slide examination. The remaining 75% cases will receive free treatment and this cost of treatment has already been included in the NMEP budget. Treatment cost of 25% vivax malaria cases *ie* 1,789,104 (low) and 4,174,575 (high) in the rural areas will cost the patient Rs 50 per case amounting to Rs 89,455,200 (low) and Rs 208,728,750 (high). However in urban areas because of the lack of ACD the proportion of vivax cases going to the private sector would be about 90%, and this will cost the patient Rs 100 each. The remaining 10% will receive free treatment at the government hospitals and clinics. We have calculated the cost of treatment for the 90% cases *ie*, 1,203,350 (low) and 2,807,815 (high) cases occurring in urban areas. The estimated treatment cost would be Rs 120,335,000 (low) and Rs 280,781,500 (high). It was also estimated that out of the total Pv cases, 1% Pv cases in rural and urban areas will be serious and require hospitalization. It may be noted that all patients with malaria are compulsorily hospitalized in the defence and in some industrial sectors. Since there are no data available on the pattern of hospitalization in rural and urban areas we have based our calculations on the estimated cases occurring in the rural and urban areas, which are 71,564 (low) and 166,983 (high) cases in rural areas. It was assumed that cases in rural areas will be hospitalized for 3 days in the PHCs. This will cost the PHC Rs 300 and to the patient Rs 50 amounting to a total of Rs 25,047,400 (low) Rs 58,444,050 (high). In urban areas 13,370 (low) and 31,198 (high) cases would be hospitalized for 3 days. This will cost Rs 400 to the hospital and Rs 100 to the patient amounting to Rs 6,685,000 (low) and Rs 15,599,000 (high). Total expenditure on the treatment of *P. vivax* cases both in rural and urban areas (S No. 10a) comes to Rs 241,522,600 (low) and Rs 563, 553,300 (high).

It is estimated that in rural areas, of the 6,342,566 (low) and 14,799,321 (high) *P. falciparum* cases, 25% cases will go to the private sector *ie*, 1,585,641 (low) and 3,699,830 (high). The treatment cost to the patient will be Rs 75 per case amounting to Rs 118,923,075 (low) and Rs 277,487,250 (high). Remaining 75% will receive free treatment at the PHC level and this cost has already been included under the NMEP. In urban areas 10% cases will receive free treatment at the government hospitals and the malaria clinics but the cost of remaining 90% will have to be paid for by the patient. Of the 163,965 (low) and 382,586 (high) falciparum cases 147,568 (low) and 344,327 (high) cases would normally be treated at the private clinics and cost on an average of Rs 125 per case. This expenditure comes to Rs 18,446,000 (low) and Rs 43,040,875 (high). In *P. falciparum* infections at least 15% cases will become serious and complicated. These cases will require hospitalization. Each case will be hospitalized for an average of 4 days. Cost of hospitalization would be Rs 400 to the PHC and Rs 100 to the paient. In rural areas treatment costs for 951,385 (low) and 2,219,898 (high) cases would be Rs 475,692,500 (low) and Rs 1,109,949,000 (high). In urban areas 4 day hospitalization would cost the hospital and the individuals Rs 600 and Rs 200 respectively. Treatment costs in urban areas for 15% cases *ie*, 24,595 (low) and 57,388 (high) cases would be Rs 19,676,000 (low) and Rs 45,910,400 (high). In addition to this average expenditure on management of 10% serious cases would be at least 10 times more, both in the urban and rural areas. This amount comes to Rs 475,692,500 (low) and Rs 1,109,949,000 (high) for the rural areas and Rs 19,676,000 (low) and Rs 45,910,400 (high) for the urban areas. Total expenditure in the treatment of *P. falciparum* cases (S No. 10b) comes to Rs 1,128,106,075 (low) and Rs 2,632,246,925 (high).

Most studies on cost analysis concentrate on the treatment and days of work lost. The duration of morbidity, due to malaria has been estimated between 5 to 20 days (Russell and Menon, 1942; Conly, 1975; San Pedro, 1967), but a common convention is to use 7 days of work lost per bout of malaria (Sinton, 1935; Najera *et al*, 1992). Therefore we have followed the 7 days work lost norm, and the prevailing wages in the rural and urban areas @ Rs 30/- and Rs 40/-per day respectively. This comes to Rs 2,834.78 m and Rs 6,614.50 m in the rural areas and Rs 420.29 m and Rs 980.67 m in the urban areas. There would be loss of labor of a person who will attend the patient, particularly on the days of malaria attacks. This loss of time by a person for care of the sick would be on an average of 2.5 days @ Rs 30/-per day. Loss of wages on this account would be Rs 1,125 m and Rs 2,625 m (S No. 11).

Deaths due to malaria are recorded by the NMEP of cases where the malaria parasite has been demonstrated in the peripheral blood. This requirement is difficult to be fulfilled in most cases because (i) largely malaria deaths occur in remote and inaccessible areas with almost non-existent health infrastructure; (ii) generally an event preceded by death is recorded as the cause of death; (iii) *P. falciparum* may bring on a sudden crisis resulting in death, if proper medical attention is not given in time; and

(iv) in many patients parasitemia may be so scanty that it is often missed even in best of the hospitals. The program therefore has been recording very few deaths. In 1990, 353 deaths due to malaria were recorded. Considering the widespread resurgence of malaria and particularly the increasing trend of *P. falciparum*, deaths from malaria should be large in number and quite alarming. NMEP's records show no deaths due to malaria in a four year period (1988-1991) in 7 states and 6 union territories (Haryana, Himachal Pradesh, Jammu and Kashmir, Meghalaya, Nagaland, Sikkim, Uttar Pradesh, Chandigarh, D and N Haveli, Daman and Diu, Delhi, Lakshdweep, and Pondicherry with a population of 182.67 million (1991 census), and during the 4 year period there were 840,204 malaria cases and 73,787 *P. falciparum* cases. The Economic and Statistics Directorate of Rajasthan mentioned that of over 0.1 million deaths registered with the registrar of births and deaths, malaria was recorded as cause of death in 4,434 cases in 1990 and 3,674 in 1991 as against 10 and 65 deaths reported by the NMEP respectively.

Lastest records are not available but the vital statistics of India reports 137,846 deaths in 1985 and 75,285 deaths in 1987 due to malaria in India. These deaths have been reported from 15 states and UTs *ie* from 143.25 million population under spray was not included (GOI, 1985, 1987). Since data for other years on deaths due to malaria are not available and the fact that malaria incidence has remained at about the same level in the last decade or so, deaths due to malaria in 1991 or in the later years would also be around the figures in 1985 and 1987. We have therefore taken figures of 1985 (high) and 1987 (low) instead of extrapolation. In calculating the cost of death we have taken the life expectancy at birth for 1990 as 61.7 years and the average of infection in India in 1990 was 30 years. Death due to malaria is therefore resulting in loss of 31.7 years of productive life. We have taken discounted life @ 12% for 30 years and it comes to 8.025 years using the table provided by Phillips *et al* (1993). The year has been taken to comprise 250 working days leaving 115 days for the week ends and national holidays etc. Monetary loss has been calculated @ Rs 35 per day (average daily wage rate in the rural and urban areas). Cost of deaths due to malaria comes to 75,285 deaths × 8.058 years × 250 days × Rs 35 = Rs 5,308.15 m for 1987 and 137,846 deaths × 8.058 years × 250 days × Rs 35 = Rs 9,719.18 m for 1985.

DISCUSSION

Future control of malaria in India would follow the Global Malaria Control Strategy of the World Health Organization to which India is a signatory (World Declaration on the Control of Malaria, Amesterdam, 26-27, October 1992) (WHO, 1993). The four basic technical elements of the global malaria control strategy are:

(i) To provide early diagnosis and prompt treatment (EDPT); (ii) To plan and implement selective and sustainable preventive measures, including vector control; (iii) To detect early, contain or prevent epidemics; (iv) To strengthen local capacities in basic and applied research to permit and promote the regular assessment of a country's malaria situation, in particular the ecological, social, and economic determinants of the disease.

Implementation of the above strategy envisages high skills at all the levels. EDPT emphasizes clinical diagnosis instead of blood smear collection from fever cases. At times malaria diagnosis may be quite difficult even in the best hands. This particular parameter requires intensive training of the peripheral health workers. Although in some cases it is obvious that blood smear collection is a waste of resources *P. falciparum* infection can be particularly misleading, threatening life. Obviously there should be a good health delivery system to take care of these cases, and that would require strengthening of health services at the periphery.

The second technical element suggests preventive malaria control by sustainable methods. Preventive interventions require a sound knowledge of the malaria epidemiology of the local transmission determinants. An approach to achieve sustainable interventions also requires intersectoral approaches and active involvement of the communities, a key element for success in rural or urban areas. Such an approach must be supported by strong political commitment and bureaucratic will. In India the experience so far has been that these are rather unattainable, sensitive and difficult issues, although results can be highly satisfying and rewarding.

The third element of early detection, containment and prevention of epidemics is particularly difficult in the existing set up. This requires capacity to forecast malaria epidemics and react with speed to manage the situation. Skills of the kind required at the periphery are missing even in the urban areas. There are no examples of successful forecasting anywhere in the country. In contrast let me bring out events during wide spread resurgence of malaria in the country in the 1970s. Malaria continued to rise unabated until it hit the 6.46 million mark in 1976. Action by the Government was initiated only in 1977. During that year, the modified plan of operation to contain malaria was launched. Simultaneously a high power board on malaria was set up in the Ministry of Health, GOI, a *P. falciparum* containment program was launched, a Malaria Research Center was established, and research on malaria was encouraged by funding a large number of projects at various research institutions. Administratively accomplishment of the technical elements seems to an uphill task with a large number of key posts remaining vacant for years, transfers, appointments of untrained staff, and lack of training facilities.

Success in the global malaria control strategy may demand the creation of a separate cadre of malariologists and a major training effort. Further new technologies should be rapidly developed for the forecasting and sustainable interventions, and these therefore demand serious research efforts by endemic countries. If the first 3 elements have been fulfilled, the 4th technical element may be easy to accomplish. Seen in the background of a deteriorating malaria situation, and given the rigid rules and regulations, service conditions, financial inputs and perceptions about malaria and its control at various levels, the global malaria control strategy would be helpful in reaching the unreached, provide treatment to people suffering from endemic malaria, but the implementation of the strategy is unlikely to halt the marching trend of malaria in the foreseeable future.

Estimates of economic loss in public health programs are problematical and at times notoriously difficult. The main problem lies with the data base which is often unreliable, insufficient and any extrapolation is fraught with dangers of under or over estimates. Therefore there are very few studies bringing out the economic losses due to various diseases. Because of the importance of this subject in prospective planning and resource mobilization Phillips *et al* (1993) have prepared detailed guidelines for cost effectiveness analysis of vector control under the auspices of Panel of Experts on Environmental Management for Vector Control (PEEM).

It has been estimated that in sub-Saharan Africa as a whole the annual economic burden of malaria was $0.8 billion in 1987 (0.6% of gross domestic product); by 1995 it is expected to be $1.7 billion (1.0% of gross domestic product), (Aseno-Okyere, 1994; Shepard *et al*, 1991). Economic loss has a tendency to rise along with national income and improved socioeconomic conditions. In estimating total expenditure on malaria control and related activities plus the direct and indirect losses due to malaria we have tried to rely on the available data. Unfortunately the data base for most of the items required in estimating losses is either faulty or simply not available. Sometimes the data are highly contradictory like the deaths due to malaria in India. We have therefore tried to limit our guesstimates to the lower side of (low and high) scales of the estimates. Based on the calculations shown in Table 2 the total economic loss due to malaria comes to US$513.58 to 963.01. This estimate is basically the direct loss due to malaria and does not take into account the enormous losses in agriculture, industry, mining, railways and a large number of other productive sectors in the country. It is rather difficult and risky to estimate these losses in absence of any reliable data base. To this may also be added the serious setbacks to growth and development- physical, physiological and mental of the population living in endemic areas, as was observed by Sinton (1935).

We also checked the World Bank estimates of morbidity and mortality due to malaria in India expressed as disability adjusted life years (DALYs). DALYs for 1990 in India due to malaria were reported as 0.95 million and per capita gross national product (GNP) for the same year was US$330. Based on the World Bank 1993 report loss to GNP due to malaria in 1990 was US$313.50 million. If to this if we add expenditure on items 1 to 10 of Table 2 (Rs 6,089.63 m or $193.32 m low and Rs 9,995.50 m or $317.32 m) then the economic loss due to malaria comes in the range of US$506.82 m to 630.82 m. These estimates are valid for the static malaria situation of about 2 million cases as recorded by the NMEP. However as pointed out in this paper, man-made malaria is increasing and therefore malaria will rise in the coming few decades unless some new technologies change the disease scenario, as in the 1950s. When suddenly DDT was made available for malaria control and wherever DDT was sprayed malaria was seen to be on its way out. There is, however, scope in the reduction of economic losses due to malaria by adopting the following strategies:

i) Incorporating results of economic studies in selecting the intervention strategy to make malaria control economically viable and sustainable.

ii) Health impact assessment in the environment impact assessment particularly from the vector breeding point of view with emphasis on the maintenance.

iii) Application of biological and environmental management methods wherever feasible and cost effective

iv) Malariogenic stratification in planning malaria control and use of remote sensing and geographical information system in developing control strategies

v) Application of the new knowledge and technologies on the biology of vectors, diagnostics, vector control, use of personal protection methods like repellents, screened houses etc., impregnated bed nets; treatment and epidemiological skills

vi) Selective and sustainable vector control, community participation; intersectoral coordination; appropriate health education, and by establishing close linkages with the developmental agencies

vii) Human resource development and decentralization of malaria control and decision making at the district and lower levels.

viii) Integrating vector control with income generating schemes, and the rural development program utilizing existing resources and manpower, and involving the communities

ix) Promoting health education and establishing close linkages with the communities and the developmental agencies.

The resurgence of malaria has the characteristic features of the (i) refractory nature of the anopheline vectors of malaria due to resistance independent or in combination with the exophilic and or exophagic vector behavior, (ii) increase in *P. falciparum* and decline in *P. vivax* incidence, (iii) *P. falciparum* resistance to anti-malarial drugs, (iv) refusals to accept residual insecticides for spraying the houses, (v) invasion of new vectors in some areas, (vi) ecological succession of malaria vectors, and (vii) ignoring malaria as a seasonal problem.

Unfortunately the transmission of malaria is aided and abetted by the a) high cost of insecticides, equipment, drugs, and operational costs with persistent upward trends resulting in financial problems and cuts in the operational commitments; b) man–made environmental degradation conducive for vector proliferation; c) establishment of new malaria padigms; d) population increase and its impact on the settlements and socio-economic development; e) back-and-forth population movement and migration; f) lack of awareness about the disease and poor inter-sectoral coordination; and f) failure to incorporate new technologies in the control of malaria. These factors along with the resilient nature of malaria, the problem of malaria in the coming few decades will remain a major concern of the health ministries and malaria will continue to cause enormous losses and suffering to human kind.

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