Malaria control in India: has sub-optimal rationing of effective interventions compromised programme efficiency?

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Despite more than five decades of intensive control efforts, malaria is still a challenge to the Indian health system.[1] 1.6 million cases and around 1000 deaths were reported in 2010 as per National Malaria programme.[2] These estimates of malaria burden, however, are uncertain. Incidence gaps have been identified.[3,4] Lack of accurate estimates for population at risk is one of the elementary problems in defining intervention strategies against malaria. The Government of India has recognized these facts while updating operational guidelines for malaria control.[5] There is evidence of the decreasing trend in cases over the past few years. However, recent estimates of malaria deaths made by independent researchers have raised questions on progress of the malaria control programme.[3] Increasing the pace of malaria control in India requires a meticulous assessment of malaria control interventions in terms of operational feasibility, cost-effectiveness, net-effectiveness and rationing of various interventions.

Epidemiologically, malaria is extremely complex; it is a focal disease the distribution of which is influenced by a multitude of factors related to human, mosquito and parasite population, as well as to the environment. The emergence, transmission and sustainability of malaria depends largely upon the interaction between and among these factors. Epidemiological reasoning and mathematical modelling has shown that the key to malaria control lies in reservoir reduction and vector control. As per the classic Ross–Macdonald mathematical model, the efficiency with which an arthropod vector transmits a pathogen, known as vectorial capacity, depends on the density of the vector species, number of susceptible host species, the probability that a vector, having acquired the pathogen, will live long enough to transmit the pathogen, which is a combination of its daily survival probability and the extrinsic incubation period.[6] Thus, the interventions that reduce the host-vector contact (e.g. bed nets) target reduction of host species. Those that target adult vectors [e.g. the application of dichlorodiphenyltrichloroethane (DDT) to the walls of dwellings] influence the probability of vector survival. Finally, vectoral capacity is also affected by vector competence, which is the chance that when a vector feeds on an infected host it will actually acquire the pathogen and support its development to the infectious stage. This is affected by

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intrinsic properties of the vector and by the density of the pathogen in the infected host. Interventions like mass drug treatment and schemes for the genetic modification of vectors target vector competence.

Control strategies for vector-borne infectious diseases can target the reservoir, the pathogenic microorganism, the vector, the human host, or combinations of these elements.[6] Traditionally, reservoir reduction has been achieved through early case detection and prompt treatment (EDPT) and vector control through indoor residual insecticide spray (IRS) with insecticides that reduce the daily survival rate of the mosquito whereas the insecticide-treated mosquito nets (ITN) reduce the human biting rate of the mosquito and its daily survival rate. However, critical prerequisites to have positive effects of IRS would depend on walls of dwellings being sprayable, mosquitoes resting indoors and sensitvity to insecticide. Similarly, the ITNs require a consistent use by humans whenever there is a chance of a human-mosquito contact. The adoption of newer methods of malaria diagnosis (rapid diagnostic kits) and treatment (artemisin-based combination therapy) as well as preventive instruments like long-lasting insecticidal nets (LLIN)/insecticide-treated bednets (ITNs) have improved the efficiency of malaria control programmes. All these present-day antimalarial interventions help in reducing the endemicity by reducing the human infectivity through early and effective treatment and reduction in vectorial capacity through mosquito control measures.[7] However, operationalization of these strategies has been a story of success and failures during different phases of malaria control in India.

The cost of scaling up and maintaining of the existing level of coverage of essential interventions has been a challenge. Despite a considerable increase in the past few years, global funding for malaria control still falls short of the estimated requirements to provide complete intervention coverage to those at risk in endemic regions.[8] The current international funding for malaria control represents approximately 20% of the estimated total need for a gradual scale-up of interventions for controlling malaria.[8] National government spending also falls short in many countries including India.[9] Thus, there is a need for effective and efficient utilization of all available resources. There is a growing body of evidence on best practices and cost-effectiveness of malaria control interventions across the globe, which can serve as guidance for financial decision-making.[10] It is important to ask whether interventions currently in practice are being appropriately used and what is the most cost-effective way to scale up activities to the levels needed? In particular, which prevention or treatment strategies, and what combination, are most effective and where?

An analysis of the budget documents of National Vector-borne Disease Control Programme (NVBDCP) in India has shown that financial allocations have been scaled up from Indian Rupees (INR) 1370 million during the Tenth Five Year Plan (2002-2007) to INR 3190.2 million for the Eleventh Five Year Plan (2007-2012).[11] The actual expenditure has also increased. However, the allocative efficiency of the programme is compromised as a result of inappropriate financing at geographical, operational and technical levels. In terms of geographical distribution, five states (Orissa, Chhattisgarh, Madhya Pradesh, Jharkhand and West Bengal) accounted for 60% malaria cases and 75% *falciparum* malaria cases in 2002-2003. However, the financial allocations represented only 41.5% of the total funds. Micro-stratification of risk areas for better targeting of interventions is very poor in India. Also, it is found that malaria is most common in areas where reliable data are least available so exact numbers are not easy to determine.[3] This in turn affects the optimum allocative efficiency. The estimated number of cases used for policy planning are basically generated from routine reporting of malaria data. However, independent researchers have reported that 86% deaths due to malaria are not recorded in any formal government health system, indicating that deaths from malaria are predominantly unnoticed by the existing health-reporting system.[3] Besides this, the health management information system in India has not been found fit for the recording of malaria morbidity and mortality.[12]

Some malaria control intervention are technically more efficient than others; for instance, it has been argued that early diagnosis and treatment through rapid diagnostic kits and artemisin-based combination therapies offer much higher net effectiveness over residual insecticidal sprays on the basis of operational feasibility. Estimates have revealed that during the Eleventh Five Year Plan the contribution for drugs and diagnostics has increased from 8.3% to 15.5% and from 0.7% to 6.3% respectively. Similarly, allocation for LLINs has been increased from 0% to 7.5%, highlighting the fact that programme is moving in the direction of improved technical efficiency. However, there is slight reduction in the budgetary allocation for bednets (ITN) from 5.2% to 3.4%. Also, it has been argued that the production and availability of LLNs is compromised in the country. It was also observed that the insecticide spraying budget has reduced from 52.5% to 28.1%. Such reduction may result in poor efficiency as it is well recognized that incremental cost-effectiveness of preventive measures are a good bargain.

In the context of operational efficiency and programme management, increasing the investment in training, and monitoring and evaluation to 3.2% and 3.5% respectively, offers positive synergies with intervention efficiencies. However, the financial allocation for behaviour change communication at 8.46% may result in reduced programme efficiency as it has poor net effectiveness and is prone to potential leakages. Similarly, the operational cost at 39.1% of total budget also raises concerns on efficiency. The programme does not conform to evidence-based recommendations on financial allocation for drugs, diagnostics, LLINs, ITNs and spraying, etc.

Allocative efficiency of funding can be enhanced by prioritizing financial allocation to key interventions on the basis of their net effectiveness and operational feasibility. This will ensure enhanced technical efficiency of the programme along with reduced operational costs. Financial allocation for interventions based on early diagnosis and treatment should be prioritized over IRS and ITNs/LLIN. With 85% of Indian population residing in high and low malaria-risk areas, the coverage scale of preventive intervention appears to be limited to less than 30% of population at risk.[13] Evidence suggests that both interventions are effective in reducing malaria, as compared with active case detection and treatment. However, ITNs are effective than IRS in averting malaria cases. However, in terms of efficiency of interventions the evidence from African countries has shown that in a very low-income country, the cost-effectiveness per DALY averted ranges from US$ 19 to US$ 85 for ITNs (nets plus insecticide), US$ 32 to US$ 58 for residual spraying (two rounds per year) and US$ 1 to US$ 8 for case-management improvements.[14] The health outcome measured in a randomized cluster trial in India has shown that the mean cost per case averted for ITNs was statistically significantly lower (US$ 52) than IRS (US$ 87).[15] High coverage with artemisinin-based combination treatments was found to be the most cost-effective strategy for control of malaria recently.[16] However, it has been argued that treatment alone can achieve less than half the total benefit obtainable through a combination of interventions, hence, scaling up the use of ITNs or IRS with insecticides is also critical. An assessment of cost-effectivenss and cost-benefit implications of increasing the coverage of all interventions (comprehensive), prevention (bednets and indoor spraying) and improved case management, found that increasing the coverage of improved case management is the most economically attractive strategy for the Asia-Pacific region. The cost per DALY averted in malaria case management strategies is US$ 88 as compared with US$ 1722 and US$ 1567 through strategies like spraying and bednets, and comprehensive strategies involving all interventions respectively (Personal Communication: Swarup Sarkar, GFATM and Ross Mcloed, Asian Development Bank). There are very limited cost-effective analysis studies available on environment-friendly antimalarial measures, i.e. biolarvicide, *Gambusia* fish and *Bacillus thuriengesis var israelis* etc. in the Indian context. Hence, more effort should be made to find out the feasibility of these interventions to enable decisions on whether to advocate these environment-friendly initiatives on long-term basis on a large scale. There is also the need for conducting a cost-effective analysis of various control measures initiated under the national malaria control programme.

The choice of intervention should not be one over another, rather it should be a rational mix that can offer a comprehensive control strategy inclusive of all interventions, and is focussed on regional programme requirements based on disease epidemiology. A decade ago the way to decide on interventions was to look for disease burden and its epidemiological manifestations in terms of mortality, morbidity and DALYs lost.[17] However in the current senario different malario-metric indices like the *Plasmodium falciparum* parasite rate (PfPR), entomological inoculation rate (EIR) within the limits of Plasmodium falciparum transmission (PfEIR), Pf annual parasite incidence (PfAPI), basic reproductive number for malaria under malaria control (PfRc) should be taken under consideration while allocating resources. The Malaria Atlas Project (MAP) could be of great help while considering the above matrices.[18] Information obtained from the National Anti-Malaria Management Information System (NAMMIS) could be of important, provided the validity of the reporting system is justified. Evidence from developing countries on best practices and cost-effectiveness of malaria control interventions can serve as guidance for financial decision-making. However, care must be taken when comparing the cost-effectiveness of prevention and treatment-based interventions, as the denominator populations at risk may not be directly comparable due to differences in age, location or exposure to malaria.[10] Similarly, valuable insights from economic analysis, mathematic models such as decision-tree models and probabilistic sensitivity analysis models can be considered for rational resource allocation by donors and domestic health budgets and for the selection of optimal packages of interventions by malaria control programmes. The model described by Ross and Macdonald can be a good starting point for identifying the epidemiological rationale and the utility of various interventions across different situations, and it should be complemented by a cost-effectiveness analysis and financial analysis to serve as guidance for policy decisions.

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