This paper discusses the experience of India and its anti-malaria campaign since 1953 and subjects it to economic analysis. Errors in the prevailing method of comparing the cost of alternative programs are pointed out. Findings are presented and discussed, including the demographic and production implications.

Assessing the Costs and Benefits of Anti-Malaria Programs: The Indian Experience

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Introduction

Programs launched since World War II have been notably successful in reducing mortality and morbidity from malaria, especially in the developing countries, many of which were previously highly malarious. Malaria, formerly the scourge of tropical and sub-tropical regions and noted by many writers over the centuries as a major obstacle to human well-being and a prime cause of depressed levels of economic, cultural, and political activity, has been so effectively attacked in the post-war years that in many once malarious countries it is no longer a significant cause of illness and death. This gross decline in the incidence of malaria has had important economic and demographic consequences. Reliable data on mortality and morbidity is unfortunately lacking; on the basis of the available data, however, it appears that the campaign against malaria has contributed heavily to the population explosion of the past two decades. This article is concerned with the experience of India, which since 1953 has supported the largest and one of the most successful anti-malaria campaigns in the world. The method of analysis and many of the conclusions, however, are probably applicable to other regions.

This article is based on the writer's experience as the economist member of an international team which, at the request of the Government of India, conducted an evaluation of the Indian National Malaria Eradication Program in September and October, 1970. In its present form it is a revised version of Chapter X, "Economic Aspects of the Malaria Control and Eradication Programs in India," of the team's report entitled *Evaluation In-Depth of the National Malaria Eradication Programme of India*. Certain additions and modifications have been made in order to provide background for readers unfamiliar with the Indian malaria program and to suggest implications for other countries and other types of health programs. The writer is an econimist on the staff of the Agency for International Development, but the views expressed are his own.

The Introduction of DDT Spraying

The development which made possible the world-wide attack on malaria was the synthesis in 1939 of a cheap insecticide, DDT, which can easily be sprayed on walls and retains for a long period the capacity to kill mosquitoes which touch it. The female anopheles mosquito, the vector of malaria, frequently rests upon a vertical surface immediately after ingesting the meal of human blood which she requires to carry on her reproductive function. Since this blood feeding occurs at night when most people are indoors, spraying the interior walls of dwellings provides an effective means of bringing the mosquito into contact with the insecticide. The mosquito's chance of escaping lethal contact with a DDT-sprayed surface is greatly reduced by her need to repeat the blood meal approximately every 48 hours. Malaria parasites contained in human blood ingested by the mosquito cannot be transmitted immediately to another human; they must first undergo a transformation process in the mosquito, which generally requires about twelve days. Mosquitoes repeatedly exposed to DDT are unlikely, therefore, to survive long enough to transmit malaria; transmission is interrupted and no new infections occur.

Residual spraying with DDT thus provided for the first time a technique which was cheap enough to permit wide-spread application in the rural areas, where malaria has been especially prevalent. Previous attempts to protect populations against malaria had been based on larviciding, drainage of mosquito breeding areas, protection of individuals by house-screening and bed-netting, and the use of prophylactic drugs, all of which were expensive. Such efforts were therefore confined to urban areas and to points of important activity, such as military installations, mining camps,

and centers of plantation agriculture and industrial production.

Control vs. Eradication

When residual spraying with DDT was introduced in the late 1940s it was conceived of as an operation which would be repeated annually. This type of program, to which the term "control" is generally applied, involved a gross reduction in the incidence of malaria but not the elimination of the disease. Two developments in the early 1950s, however, focused attention on the total interruption of transmission and elimination of all cases, i.e., the eradication of malaria. One of these was the accidental discovery made in Crete and the Peloponnesus that once transmission had been fully interrupted for a few years spraying could be withdrawn without the reappearance of malaria. The other was the appearance of mosquitoes resistant to DDT. These two discoveries led to the concept of eradication of indigenous cases of malaria.

The strategy for eradication, as evolved by the WHO in the mid 1950s, consists of four phases: 1) preparation or planning; 2) attack, during which all the dwellings in malarious areas are sprayed periodically for at least three years; 3) consolidation, during which comprehensive spraying is withdrawn and replaced by a system of case detection and treatment combined with selective (focal) spraying at points of outbreak to prevent the re-emergence of transmission; and 4) maintenance, or preserving the state of eradication achieved as a result of the previous phases by surveillance to detect and deal with any new cases imported from outside the area.

Background and Organization of the Anti-Malaria Programs in India

In 1953 the Government of India embarked on a national malaria control program which was gradually extended to encompass most of the malarious regions within the national territory. In 1958 the control program was converted into an eradication program which covered the entire country except for 15 million people living in tracts above 5,000 feet. The program was pursued as a joint effort of the central government and the states; the National Malaria Control Program (NMCP) and, beginning in 1958, the successor National Malaria Eradication Program (NMEP) provided leadership and technical and organizational guidance and the state health departments performed the implementation. When the eradication program was established the territory covered was organized into units each of which corresponded to about one million persons. The original time-phasing called for the achievement of eradication, with all units in maintenance, by 1968.

In 1952, just prior to the inception of NMCP, the number of cases of malaria in India was estimated at 75 million, or about 20% of the national population, and the number of deaths at 1.5 million, of which about half were attributed directly and half indirectly to malaria. By 1969 the number of cases had fallen below half a million, or the equivalent of less than 0.1% of the population, and there were no recorded deaths. Malaria has disappeared entirely from large areas, especially in the South. This sharp decline in morbidity and mortality represents a significant achievement. The objective of total interruption of transmission and elimination of all indigenous cases, however, has not yet been realized.

Table 1—Expenditure by Years and Plan Periods for Malaria Control and Eradication (Rs. Crores)

		Expenditure	
First Plan	1951/52	—	
	1952/53	0.27	
	1953/54	3.31	
	1954/55	4.10	
	1955/56	3.89	Control phase: 23.7
		11.57	
Second Plan	1956/57	5.38	
	1957/58	6.76	
	1958/59	9.96	
	1959/60	14.47	
	1960/61	17.69	
		54.26	
Third Plan	1961/62	19.92	
	1962/63	18.50	
	1963/64	16.53	
	1964/65	16.29	
	1965/66	15.60	Eradication phase: 202.5
		86.84	
Annual Plan Period	1966/67	13.88	
	1967/68	11.55	
	1968/69	16.88	
		41.31	
Fourth Plan	1969/70	17.57	
	1970/71	17.59	
		35.16	
Total		229.15	

Source: NMEP

Inputs: Resources Devoted to the Malaria Control and Eradication Programs

Since the inception of the control program in 1953 a total of 229.2 crores of rupees* (including both internal and external resources and resources of both the Center and the States) have been devoted to anti-malaria programs. This sum consists of Rs 23.7 crores for the control program (1952/53-1957/58) and Rs 205.5 crores for the eradication program (1957/58-1970/71), as shown in Table 1.

Over the entire period these expenditures represent one-third of the outlays for health (excluding family planning,

*All expenditure figures refer to the Indian fiscal year, which runs from April 1 to March 31. One crore equals ten million. The par value of the Indian rupee is $0.13, or 7.6 to the dollar. One crore of rupees (Rs) is therefore $1.3 million.

Table 2—Estimated Average Annual Cost of a Unit in Attack Phase (in Rs. Lakhs)

Material and equipment	1958/59 (1958/59 Prices) Col. 1	1958/59 (1970/71 Prices) Col. 2	1970/71 (1970/71 Prices) Col. 3
DDT	1.70 *	3.00 *	4.67 †
Contingencies	0.30	1.00	1.00
Drugs	0.20	0.20	0.20
Total	2.20	4.20	5.87
Operational cost (personnel)			
Nucleus staff	0.63	1.30	1.50
Surveillance staff	1.25	2.45	3.20
Spray component	0.92	1.90	2.10
Total	2.80	5.65	6.80
Total	5.00	9.85	12.67

**71 tons*
†110 tons

Notes: In order to make 1958/59 and 1970/71 comparable two adjustments were made in constructing the above table: 1) the initial purchase of vehicles and spray equipment at a cost of Rs. 0.39 lakhs was omitted since it is a non-recurring expense, and 2) surveillance staff, which was actually not introduced until 1961/62, was added at a cost of Rs. 1.25 lakhs. Actual 1958/59 unit cost was therefore Rs. 9.86 (1.25-0.39) lakhs less, or Rs. 4.14 lakhs in total.

In order to make these expenditure figures reflect the real cost to the Indian economy, and not merely the money cost to the NMEP budget, two adjustments should be made: 1) imported items, notably DDT, should be priced at border costs and converted into rupees at a shadow foreign exchange rate, and 2) unskilled labor should be priced not at the market wage but at a shadow rate reflecting the marginal product of labor in its alternative occupation.

Source: NMEP

water supply, and sanitation) and 0.8% of total public sector outlays under the successive five-year plans. In relative terms these expenditures reached their peak (41.3% and 1.3%, respectively) during the last three years of the Second Five Year Plan (1958/59-1960/61), which corresponded to the first three years of the eradication program, and declined to 29.4% and 0.7%, respectively, by 1969/70-1970/71.

Cost per Unit in Attack and Consolidation

The average cost of a unit in the attack phase is shown in Table 2 to be Rs.5 lakhs* for the initial year (1958/59) of the eradication program (column 1), and Rs 12.67 lakhs for 1970/71 (column 3). In column 2 the physical inputs of the 1958/59 programs are converted to 1970/71 prices. This reveals that the 153% increase in unit cost is composed of a 97% rise in prices and a 29% increase in physical inputs, which happens to equal the increase in population which took place over the twelve-year period. In other worlds, there was no increase in physical inputs *per capita*.

The average cost of a unit in consolidation phase, Rs 6.32 lakhs in 1970/71 as shown in Table 3 (column 3), is almost exactly half of the Rs 12.67 lakhs required to support an average unit in attack phase.

An analysis of the average cost of a unit in consolidation phase for the initial year of consolidation activities (1962/63) and for 1970/71 presented in Table 3 shows that the 123% rise in the unit cost over the eight-year period is explained by a 90% rise in prices and an 18% increase in physical inputs (as against a population increase of 19% during the period).

These estimates of average unit cost can be checked by multiplying the unit cost by the number of units in each phase and then comparing the total with actual expenditures. Thus the 230 units in attack phase in 1958/59 at an average unit cost of Rs 4.14 lakhs (including initial outlay for vehicles and spray equipment but excluding surveillance cost as explained in the footnote to Table 2) would result in a total expenditure of Rs 9.55 crores; similarly, the 105 units in attack and the 68 units in consolidation in 1970/71 at respective unit costs of Rs 12.67 and Rs 6.32 lakhs would result in attack phase costs of Rs 13.4 crores (105 x Rs 12.67 lakhs) and consolidation phase costs of Rs 4.3 crores (68 x Rs 6.32 lakhs) or a total cost of Rs 17.7 crores. Comparison with actual expenditures of Rs 9.96 crores in 1958/59 and Rs 17.6

*One lakh equals one hundred thousand. One lakh of rupees is the equivalent, therefore, of $13,000.

Table 3—Estimated Average Annual Cost of a Unit in Consolidation Phase (in Rs. Lakhs)

	1962/63		1970/71
	In 1962/63 Prices	In 1970/71 Prices	In 1970/71 Prices
	Col. 1	Col. 2	Col. 3
Material and equipment			
DDT (5 tons)	0.13	0.21	0.21
Contingencies	0.30	1.00	1.00
Drugs	0.20	0.20	0.20
Total	0.63	1.41	1.41
Operational cost (personnel)			
Nucleus staff	0.67	1.30	1.50
Surveillance staff	1.42	2.45	3.20
Spray component	0.08	0.19	0.21
Total	2.17	3.94	4.91
Total	2.80	5.35	6.32

Note: In order to make these expenditure figures reflect the real cost to the Indian economy, and not merely the money cost to the NMEP budget, two adjustments should be made: 1) imported items, notably DDT, should be priced at border cost and converted into rupees at a shadow foreign exchange rate, and 2) unskilled labor should be priced not at the market wage but at a shadow rate reflecting the marginal product of labor in its alternative occupation.

Source: NMEP

Table 4—NMEP Expenditures Expressed in Constant (1958/59) Prices

	NMEP expenditures (Rs. crores at current prices Col. 1	Wholesale price index (1958/59-100) Col. 2	Price deflator implicit in NNP at factor cost (1958/59-100) Col. 3	NMEP expenditures in Rs. crores at 1958/59 prices deflated by Wholesale price index Col. 4	NNP deflator Col. 5
1958/59	9.96	100	100	9.96	9.96
1959/60	14.47	102	101	14.1	14.3
1960/61	17.69	113	103	15.6	17.1
1961/62	19.92	115	104	17.3	19.1
1962/63	18.50	120	109	15.4	17.0
1963/64	16.53	127	118	13.0	14.0
1964/65	16.29	141	129	11.6	12.7
1965/66	15.60	152	140	10.3	11.1
1966/67	13.88	173	160	8.1	8.7
1967/68	11.55	193	173	6.0	6.7
1968/69	16.88	191	176	8.8	9.6
1969/70*	17.57	198	181	8.9	9.7
1970/71*	17.59	207	185	8.5	9.5
Total	205.5			147.6	159.5

**Estimated*

Sources: NMEP.
Statistical Abstract of India, adjusted to 1958/59 base.
Central Statistical Office, White Paper on National Income, March 1969; 1968/69 to date are estimates by AID.

crores for 1970/71 suggests that these estimates of unit cost are reasonably accurate.

These increases in unit costs closely parallel the general rise in prices which has taken place in India since 1958. Over this period the wholesale price index has risen by 107% and the price deflator implicit in Net National Product at factor cost by 85%, as shown in Table 4 (columns 2 and 3). Deflating NMEP expenditures (column 1), which of course are expressed in current prices, by these two indices shows that in real terms (constant prices) 1970/71 expenditures are slightly below the 1958/59 level, and about half of the 1961/62 peak expenditure level.

In this connection it might be well to point out that when the 1957/58 level of expenditure on control (Rs 6.76 crores) is projected to the present with corrections for price change (i.e., about 100% increase) and for population growth (32% increase over the 13-year period) it comes to Rs 17.8 crores, or slightly more than the Rs 17.6 crores being spent on the eradication program in 1970/71.

Comparative Cost of Control and Eradication

The decision taken by the Government of India in 1958 to adopt an eradication program was based to a considerable extent on the argument that an intensified and more expensive program carried on in a few years would rid India permanently of malaria; thereafter there would be only minor maintenance costs. This was in line with the proposition advanced on a world-wide basis by WHO that eradication would be cheaper in the long run than a control program which continued indefinitely.

The following analysis of the economic costs of the two strategies is only intended to illustrate the need for performing this type of evaluation in similar situations in the future in weighing alternative courses of action for dealing with the malaria which remains in India. It should also be relevant for other countries considering alternative anti-malaria strategies.

The annual cost of the control program was Rs. 5.38 crores in 1956/57 and Rs. 6.76 crores in 1957/58; expenditures at about this level, rising gradually with population growth, could be expected to continue for the indefinite future. The cost of an eradication program was considered to be of the order of Rs. 80 crores. Table 5 shows the phasing of the eradication program and its costing according to Tables 2 and 3 above. A simple comparison of Rs. 80 crores over ten years with a Rs. 6 or 7 crore annual level of expenditure continuing indefinitely at first sight suggests that in the long run the former is cheaper. But this assumes that money today and ten or twenty years hence are of equal value, which of course is not the case. The only way to compare two expenditure (or income) flows is to reduce them to a common base. This is standard practice in all types of benefit-cost analysis. Discounting for present value gives the value today of an expenditure (or receipt) ten, twenty or thirty years in the future; or, to put it the other way, it tells how much one would have to put aside today to yield a fixed sum, say one hundred rupees, at different compound interest rates at some fixed point in the future. The discount concept is the reverse of compound interest; numerically, the former is the reciprocal of the latter.

There can be differences of opinion about the appropriate discount rate to apply under any particular set of circumstances, but there can be no doubt as to the applicability of the principle of discounting for present value in comparing the cost of two alternative courses of action, each with its own expenditure flow, which are designed to achieve essentially the same economic objective. A continued control program might, of course, have been at a level of effort (and cost) higher than that for 1957/58; actual 1957/58 expenditures on control are used here only for illustrative purposes.

Table 6 gives the present (1957/58) discounted value of control programs at the 1957/58 expenditure level (column 2) and at the average of the 1956/57 and 1957/58 levels (column 3) at various discount rates. These values are for 30 years, beyond which the present discounted value at any appropriate interest rate is so small that for all practical purposes it can be ignored.

Table 7 discounts the expenditure flow on eradication obtained from Table 5 (column 11) to present (1957/58) value for the same set of discount rates and sums them up for the ten-year period within which eradication was to have been completed.

Once both expenditure flows have been reduced to a common base (1957/58) it is possible to compare them and see which is cheaper. This is done in Table 8 in which two levels of spending on control (columns 1 and 2) are set beside the expenditure on eradication (column 3) at various discount rates. From this comparison it emerges that the difference in cost between control and eradication when both are converted to present value is not nearly as great as one would have supposed from looking at the unconverted figures; discounting places the alternative expenditure flows in a quite different light.

At a 10% discount rate control at the 1956/58 level costs about the same as eradication; at a 12% discount rate control at the 1957/58 level and eradication would have cost about the same.

Allowance should, of course, be made for the population growth which would raise the cost of both control and eradication. Such an adjustment does not significantly affect the outcome, however. The effect of a two per cent yearly increase in population is to offset the impact of the discount rate by 2 points on both expenditure flows. Thus the effect of a 12% discount rate adjusted for a 2% annual population growth rate would be equivalent to that of a 10% discount rate with constant population. (The average annual rate of population growth over the 1951-61 period was 1.9% and rose to 2.2% during 1961-71, according to the provisional results of the 1971 Census of India. 2% is thus close enough to the actual rate of increase to take the effect of population growth into account at least approximately).

Table 9 presents the same two levels of spending on control programs and that inherent in eradication as originally planned adjusted, for illustrative purposes, for a 2% annual growth in population. From this sensitivity analysis it emerges that at a 12% discount rate (10% net of population growth) control at the 1956/58 level is marginally cheaper than eradication; at a 14% discount rate (12% net of population growth) control at the 1957/58 level is almost as cheap as eradication, so that at any discount rate above about 14.5% control would be cheaper. The higher the discount rate, the cheaper control becomes relative to eradication. It is important to note that the figures used for eradication 1) relate to the originally planned phasing of that program, not to the actual expenditures, which are substantially higher, and 2) exclude the maintenance cost required in an eradication program but not required in a control program.

Table 5—Original Phasing of Eradication Program Contemplated During the Third Plan (1958/59 prices)

	Attack						Total	Consolidation			
	Spray only			Spray and surveillance							Total cost
	No. of units	Cost per unit (lakhs)	Cost (crores)	No. of units	Cost per unit (lakhs)	Cost (crores)	Attack cost	No. of units	Cost per unit (lakhs)	Cost (crores)	Rs. Crores
Column Nos.	1	2	3	4	5	6	7	8	9	10	11
			(1)x(2)			(4)x(5)	(3)+(6)			(8)x(9)	(7)+(10)
1958/59	230	4.14	9.6	—		—	9.6				9.6
1959/60	390		15.2	—		—	15.2				15.2
New Units	160	4.14	(6.6)								
Old Units	230	3.75	(8.6)								
1960/61	390	3.75	14.7	—		—	14.7				14.7
1961/62	25	3.75	0.9	225	5.0	11.2	12.1	140	2.8	3.9	16.0
1962/63	25	3.75	0.9	105	5.0	5.3	6.2	140	2.8	3.9	10.1
1963/64	25	3.75	0.9	50	5.0	2.5	3.4	155	2.8	4.3	7.7
1964/65	25	3.75	0.9	—		—	0.9	155	2.8	4.3	5.2
1965/66	—							25	2.8	0.7	.7
1966/67	—							25	2.8	0.7	.7
1967/68	—							25	2.8	0.7	.7
Total											80.6

Source: Report of the Special Committee (Madhok Committee) to Review the Working of the National Malaria Eradication Programme and to Recommend Measures for Improvement. New Delhi, 1969, page 23; costing according to data provided by NMEP and summarized in Tables 2 and 3.

It is difficult to say what the appropriate discount rate for India is. That it is higher in low-income countries than in affluent ones is generally recognized, just as it is generally recognized that poor people with low capacity to save tend to discount the future more heavily than affluent people. Ten per cent would seem a minimum discount rate and 12% to 15% a more appropriate range under present conditions. For the purposes of this illustrative exercise, it is not necessary to settle the question. It does seem worth pointing out, however, that the use of too low (or too high) a discount rate leads to the misallocation of resources and therefore retards the development process.

At a 12 to 15% discount rate there is not a great cost difference between control and eradication under the Indian conditions reviewed here; previous comparisons of control and eradication have not taken this factor into account. The practice of discounting for present value can and should be applied to future decision-making in India and elsewhere where there is a choice between alternative courses of action to achieve an objective with essentially similar benefits when these courses have different expenditure flows.

Outputs: The Economic and Social Consequences of the Malaria Control and Eradication Program

The malaria control and eradication programs have had three direct outputs: 1) reduced mortality, 2) increased fertility, and 3) reduced morbidity. Each of these has had a whole series of economic and social consequences which are difficult if not impossible to quantify but which can be identified conceptually.

Reduced Mortality

Over the past quarter century the mortality rate in India has fallen sharply from 27.4 per thousand estimated to have prevailed in the 1940s to 22.8 per thousand in the 1950s. In 1964 the Expert Committee appointed by the Government of India placed the crude death rate for 1966-70 at 14 per thousand. A number of experts on Indian demography now believe that the present crude death rate is more probably in the 16-18 per thousand range.* That malaria was an important killer before 1953 but is a negligible cause of death today is generally acknowledged. There seems to be no reliable data which would make it possible to apportion the rapid decline in the crude death rate over the past twenty-five years among the many factors which contributed to it. These include: 1) the control of communicable diseases such as smallpox, cholera, and tuberculosis as well as malaria; 2) the decline of dysentery, diarrhea and other water-borne diseases as a consequence of improved water supply; 3) improvements in environmental sanitation; 4) the wide availa-

*This view is supported by the provisional results of the 1971 Census of India which placed the 1971 population at 547 million, or considerably below the Expert Committee's medium projection of 561 million. (It is also possible, of course, that the birth rate dropped more than had been anticipated, but this seems less likely.)

bility of antibiotics; 5) the expansion of health services; 6) the absence of famine in time of crop failure as a result of externally available grain supplies and improved internal transport and organization; and 7) the existence of parliamentary democracy which obliges government to be responsive to conditions of distress. It is impossible to disentangle the role of each of these elements in the decline of the crude death rate, the more so since death was often caused by the interaction of two or more factors, as when a malarious person caught pneumonia or an undernourished person became ill with malaria.

It is possible, however, to test the assertion that 750,000 people died directly from malaria and an equal number indirectly prior to the inception of the control program and to see how these magnitudes relate to the decline in the death rate since 1952.

If there were 1.5 million deaths due directly and indirectly to malaria in a 1952 population of 370 million then malaria accounted in all for 4 deaths per thousand of population at a time when the crude death rate was 25 per 1,000 (the average of 27.4 for 1941-51 and 22.8 for 1951-61) or perhaps only 24 per 1,000.

In Table 10 a rough attempt is made to get at the impact on the crude death rate of the virtual elimination of death from malaria by 1961. The drop in the crude death rate between 1952 and 1961 would be between 4 and 6 per 1,000, depending on: (a) whether the 1952 crude death rate was 25 or 24; and (b) whether the 1961 crude death rate was 20 or 19. Of this 4 to 6 point drop in the crude death rate, the virtual elimination of malaria as a cause of death would account for 4 points, or from two-thirds to all of the decline in the crude death rate. Similarly, the containment of malaria would account for between 44% and 67% of the decline of the crude death rate between 1952 and 1970 if the current crude death rate is of the order of 16 to 18 per 1,000 as noted above. It should be emphasized that the above analysis is posited on the assumption that, directly or indirectly, malaria was responsible for 1.5 million deaths annually immediately prior to 1953. This estimate may or may not be correct and there seems to be no way of verifying it. In this connection, however, it is interesting to note that Coale and Hoover[1] in their analysis of the dynamics of Indian population point out that if the death rate due to malaria in India prior to 1953 was comparable to that in Ceylon prior to the inception of DDT spraying in 1946 there would have been about two million deaths per year. The same analysis goes on to suggest that elimination of malaria as a cause of death would then cause a drop in the crude death rate of 11 per 1,000 among the 200 million people officially classified as living in malarious areas in 1951, which is equivalent to a 6 point drop in the crude death rate for India as a whole. If the annual number of deaths due to malaria prior to 1953 was 1.5 million instead of 2 million then elimination of malaria as a cause of death would reduce the crude death rate by 4.5 points instead of 6 points. 4.5 is very close to the 4 points mentioned above.

The purpose of the unscientific model presented in Table 10 is mainly to show that if annual deaths from malaria

Table 6—Present (1957/58) Cost of Control Program for 30 Years

Discount rate (%)	Present value of 1 per year for 30 years	30 years of control at 1957/58 level of Rs. 6.76 crores	30 years of control at 1956/58 level of Rs. 6.07 crores
	Col. 1	Col. 2	Col. 3
6	13.765	93.0	83.5
8	11.256	76.1	68.5
10	9.427	63.6	57.2
12	8.058	54.5	49.0
14	7.006	47.3	42.5
16	6.175	41.7	37.5
18	5.517	38.2	33.6

Table 7—Present (1957/58) Cost of Eradication Program

			Discounted value in crores of rupees						
	Year	Anticipated annual cost (Rs. crores)	6	8	10	12	14	16	18
1958/59	1	9.6	9.1	8.9	8.8	8.6	8.4	8.3	8.1
1959/60	2	15.2	13.6	13.0	12.6	12.1	11.6	11.1	10.9
1960/61	3	14.7	12.3	11.7	11.0	10.5	9.9	9.4	9.0
1961/62	4	16.0	12.7	11.8	10.9	10.2	9.5	8.8	8.3
1962/63	5	10.1	7.5	6.8	6.2	5.7	5.2	4.8	4.4
1963/64	6	7.7	5.5	4.9	4.3	3.9	3.5	3.1	2.9
1964/65	7	5.2	3.5	3.1	2.7	2.4	2.1	1.8	1.6
1965/66	8	.7	.4	.4	.3	.3	.2	.2	.2
1966/67	9	.7	.4	.4	.3	.3	.2	.2	.2
1967/68	10	.7	.4	.3	.3	.2	.2	.2	.1
Total		80.6	65.4	61.3	57.4	54.2	50.8	47.9	45.7

Source: Time phasing from Madhok Committee Report, page 23; costed according to tables 2 and 3.

Table 8—Comparison of Control Program and Eradication Program at Present (1957/58) Value in Crores Rs.

Column nos.	30 years of control at 1957/58 level (Rs. 6.76 crores)	30 years of control at 1956/58 level (Rs. 6.07 crores)	Eradication* program (original phasing)
	1	2	3
6	93.0	83.5	65.4
8	76.1	68.5	61.3
10	63.6	57.2	57.4
12	54.5	49.0	54.2
14	47.3	42.5	50.8
16	41.7	37.5	47.9
18	38.2	33.6	45.7

Excluding maintenance.

Table 9—Comparison of Control and Eradication Programs at Present (1957/58) Value (in crores rupees) Adjusted for 2% Annual Growth in Population

Discount rate	Discount rate net of 2% population growth	30 years control at 1957/58 level Rs. 6.76 crores	30 years control at 1956/58 level of Rs. 6.07 crores	Eradication program* (original phasing)
8	6	93.0	83.5	65.4
10	8	76.1	68.5	61.3
12	10	63.6	57.2	57.4
14	12	54.5	49.0	54.2
16	14	47.3	42.5	50.8
18	16	41.7	37.5	47.9

Excluding maintenance.

prior to 1953 were of the order of 1.5 million and that such deaths were virtually eliminated by 1961 then the anti-malaria campaign was the major factor in the acceleration of population growth after 1951. Newman, in his analysis of the role of malaria control in Ceylon,[2] concluded that one-half to two-thirds, and most probably 60%, of the rise in the rate of population growth between 1945 and 1960 was attributable to the campaign against malaria. The effect in India on population growth between 1952 and 1970 would seem to be of the same order of magnitude.

Apparently the profound effect on the population growth rate was not anticipated by the Indian development planning authorities. Although the Second Five Year Plan, which was adopted in 1956, recognized that measures which raised the survival rate would accelerate population growth the magnitude of the increase was gravely underestimated. It was then assumed that the population growth for the decade 1951-61 would remain at the 1941-51 level, which was 13.1% (but wrongly stated in the Plan to be 12.5%), and for 1961-71 would rise to 13.3%.[3] The actual rate for 1951-61 turned out to be 21.6%, and for 1961-71, 24.6%. So gross a discrepancy between projected and actual rates of population growth indicates a lack of awareness on the part of the Planning Commission and the Government of India of the demographic consequences of economic and social programs, including public health, and the implications for overall development.

The economic consequences of a population explosion in retarding economic development are well-known. There are, however, some special circumstances in the case of malaria which may be worth mentioning. In the past, deaths from malaria are said to have been especially high in the age group between three months (when any immunity acquired from the mother lapsed) and ten years or so, when those who survived a bout of malaria had acquired some immunity of their own. As a consequence of this reduction in the death rate in the under ten bracket, the age structure of the population is changed and the dependency ratio is raised. This in turn raises marginal consumption and depresses marginal savings and investment rates. It also alters the pattern of investment in the sense that demand for housing, schools, medical facilities and other less directly productive forms of investment grows especially rapidly. Another consequence is that demand for employment opportunities is raised at a later stage.

In sum, then, on the basis of the evidence at hand, the reduction of mortality brought about by the anti-malaria program may be said to have brought substantial social or welfare beneifts, but to have exerted a decelerating effect on economic development. It has greatly intensified the need for family planning as a method of keeping births and deaths in balance at low levels, which is more humane than the equilibrium of the past achieved through a high level of births and a high level of deaths caused by disease and famine. The urgency of a major effort to reduce the birth rate is reflected in the geometric increase in the funds allotted for family planning in successive Five Year Plans from 0.15 crores of rupees in the First Plan to 2.16 in the Second, 24.9 in the Third, and 315.0 in the current (Fourth) plan. This rapid increase in the allotment of resources to Family Planning may be said to have been necessitated in large measure by the success of the campaign against malaria.

It is argued by some that until parents perceive that death rates are declining, and that it is no longer necessary to produce eight infants in order to have reasonable assurance that three offspring will survive to the parents' old age, there will be little motivation for family planning. If this is so (which is not confirmed by presently available evidence) it can be argued that the virtual elimination of death from malaria must be contributing to the reappraisal by parents of desirable family size, but whether this is in fact so, or whether India can afford to wait until this revised parental perception is widespread, is difficult to say.

Increased Fertility

The second output of the campaign against malaria is increased fertility, which has come about in several ways. First, a number of people who escaped death from malaria produced children who would not otherwise have been born. Second, the miscarriage rate was reduced, since pregnant women who carry malaria parasites (not just those suffering an attack of fever) are known to have an abnormally high (but unquantified) propensity to spontaneous abortion. The

incidence of malaria per year prior to 1953 has been estimated at 75 million cases; the equivalent of 20% of the population suffered an attack of fever and chills and a considerably higher proportion must have carried malaria parasites in their blood. The 75 million cases may well be a considerable exaggeration since many other types of fever were apparently classified as malaria, but clearly there was a lot of malaria then and there is very little today. The 350,000 cases recorded in 1969 correspond to less than one-tenth of one per cent of the population. Third, the reduction of the sexual abstinence caused when husband or wife was suffering from fever may have caused at least some minor increase in fertility. Data on the basis of which to quantify the effect of these three factors on raising the fertility rate, however, are lacking.

The economic consequences of increased fertility are approximately the same as for reduced mortality, except that in the former case all the additions to population are infants and therefore exert an even more pronounced influence on the dependency ratio. The unfavorable economic consequences noted above in connection with the decline in mortality would also apply in intensified form of course, to the increase in fertility. In this connection again, then, the gross reduction in the incidence of malaria underscores the crucial need for family planning to rectify the imbalance brought about by the successful campaign against malaria.

Reduced Morbidity

The third output, the dramatic decline in morbidity and its implications for production, is the aspect of anti-malaria campaigns on which health officials and malariologists in India and elsewhere have focused their attention in attempting to demonstrate that substantial economic benefits have been achieved.

Sizeable economic gains have undoubtedly resulted from the reduction of morbidity, but the methodology employed by many writers on the subject (most of them non-economists) to "prove" those gains are unsound and unconvincing. Three approaches, of about equal untenability, have been particularly popular. The first approach is to calculate man-days "lost" due to malaria, and then multiply this figure by some hypothetical output or wage. In such calculations no evidence is presented to show that the "lost" time would have been productively employed. In fact the opposite assumption is much more likely, except in special cases of seasonal labor constraint which will be discussed below, since malarious countries are also countries with large amounts of surplus labor, especially in rural areas where the incidence of malaria is particularly high.

The second approach is to take the increase in agricultural (or even total) output since the inception of the malaria campaign and arbitrarily credit a certain portion, say 10%, to the containment of malaria. Although the containment of malaria may well have played a role in the increase in production no evidence is presented to justify the selection of 10% rather than 2%—or 20%—and no attempt is made to measure the role of malaria vis-à-vis other variables.

A third approach is to look at an area which had previously been virtually uninhabitable, and therefore uncultivatable, because of being infested by malaria, and attribute all the production gains since the beginning of the malaria campaign to this one factor. Whereas the containment of malaria was a necessary condition of the reclamation of such potentially productive areas as the Terai, an extensive region north of the Ganges stretching to the foothills of the Himalayas (and similar tracts in other countries), it was not a sufficient condition; investment which would not otherwise have been undertaken was then made in land clearance, road construction, the laying on of irrigation, farm equipment, dwellings, etc. Resources used for these purposes (with some exceptions) are not free; they could have been used elsewhere and must be assigned a cost consistent with their most productive alternative use, or opportunity cost.

Table 10—Decline in Crude Death Rate

	(1) Decline in crude death rate since 1952		(2) Per 1,000 drop in crude death rate due to anti-malaria activity	(3) % of drop in crude death rate due to anti-malaria activity	
	25	24		25	24
1961 crude death rate					
20 per 1,000	5	4	4	80	100
19 per 1,000	6	5	4	67	80
1970 crude death rate					
18 per 1,000	7	6	4	57	67
16 per 1,000	9	8	4	44	50
14 per 1,000	11	10	4	36	40

The overlooking of this important consideration in many previous discussions of the economic gains of land reclamation made possible by the conquest of malaria invalidates the measurement of benefits. This is not to deny that important economic beneifts have been realized from land reclamation—surely they have—but merely to demonstrate that the method for assessing these benefits has been faulty.

It should be possible to undertake methodologically sounder studies of the impact of malaria containment on output in agriculture and on other economic activities such as forestry, mining and some types of construction (hydroelectric plants, irrigation works, etc.) which are carried on in rural areas and where the labor force in the past was especially vulnerable to malaria.

Conceptually, there are two categories of production benefit. The first is the case of potentially productive land which remained virtually uncultivatable until rid of malaria, as exemplified by the Terai. It should be possible to measure, district by district, the increase in area under cultivation since malaria was brought under control and to ascertain increases in production. Resources devoted to the creation of infrastructure and other investment would have to be taken into account at their opportunity cost and increases in yield, especially in recent years, attributable to improved technology and increased physical inputs (fertilizers, better seeds, etc.) factored out. It would not be easy, but it seems feasible; whether it is worth doing will be discussed below.

The second, and much more difficult, aspect is to quantify the increase in production which has taken place on land which has been cultivated all along but where the past prevalance of malaria depressed labor productivity and thus reduced output. Both inability to work at the time of

fever and chills and subsequent debility (mental as well as physical) exert a depressing effect on output *provided* these attacks coincide with a peak season of agricultural activity, either planting or harvesting. For instance, twenty years ago in the Punjab, the coincidence of the September-October peak of malaria with the overlapping harvesting of *kharif* (monsoon crop) and the planting of *rabi* (post-monsoon crop) is said to have resulted in a real labor constraint from which harvesting and/or planting suffered, with obvious implications for output. Such an analysis could not be done on an aggregate basis, since there is considerable variation between different parts of India in the seasonal pattern of agricultural activity, in the availability of labor (i.e. whether there is surplus), and in the customs, relationships, and sets of obligations which determine whether, even in an area with so-called surplus labor, the land of a man suffering from malaria would in fact be planted or harvested by another member of the community. To reconstruct this situation as of twenty years ago in order to assess the then effect of malaria on production, and thus the benefits from its virtual elimination, would be a stupendous task and the results could hardly be very reliable.

In the case of forestry, mining, construction, plantation agriculture and other activities carried on by organizations the effects of malaria were probably less to reduce output than to raise production costs because of the necessity of employing extra workers to take the place of the ill.

The difficulties of quantifying the effect of malaria on these other rural activities in the past as a base for assessing the economic benefit of its containment are almost as formidable as for agriculture. A proper study would require a sizeable interdisciplinary team and at least three or four years, and even then the results might not be very reliable or complete. Although academically challenging, it would be of purely historical interest and of no practical value whatsoever for improved decision-making in the present or future. Moreover, the kind of scarce talents required for such a study could be much more productively employed on other types of research and analysis. To expend scarce resources on attempting to quantify past economic benefits of the anti-malaria campaign would be wasteful and of little utility. It seems sufficient to acknowledge that substantial (and essentially unquantifiable) production gains have been achieved from the containment of malaria and to focus analysis on the future, about which something can be done, rather than on the past.

In addition to production gains, sizeable savings have been realized in the outlays for treatment of malaria as a consequence of the decline in its incidence. These include the freeing of medical personnel and hospital facilities for other health purposes and the decrease in expenditures for drugs. Little data are available, however, on these savings.

In the literature much has been made of the depressing effect of malaria on the mental as well as the physical energy of those afflicted and special stress has been laid on the adverse implications of malaria for education and innovation. Although there seems to be little doubt that malaria engenders apathy, it does not necessarily follow that its eradication, by itself, would result in a sharp increase in mental vigor and innovativeness. Malaria, along with other communicable diseases, malnutrition, and other factors, is part of the poverty syndrome. Populations afflicted with this syndrome have developed a world outlook, values, and attitudes which make it possible for them to endure the circumstances under which they are obliged to exist. Fatalism, past orientation, and disinclination to innovate on the part of such populations are elements of a realistic adaptation to the environment and are sanctioned and supported by culture. They may therefore change only slowly as the factors in the environment which gave rise to them are removed, especially when only one of several contributing factors is eliminated. One should, therefore, not entertain excessive expectations of the rate at which world outlook, values, and attitudes will change, or the speed at which behavior will become more vigorous, innovative, and future-oriented as a consequences of successful campaigns against malaria.

Since both mortality and morbidity from malaria have been reduced to insignificant levels, virtually all of the production gains and demographic consequences realizable from malaria containment have already been achieved; in fact the great bulk had probably already been achieved by the mid 1960s. From a production or demographic point of view, therefore, it makes relatively little difference whether malaria is eradicated or held to approximately its present low level by a less ambitious program. The latter is assumed to be the minimum acceptable course of action.

The marginal cost of eradicating the relatively few remaining cases of malaria is rising, while the marginal benefit has been declining and is probably very low, there being virtually no further benefits to be achieved in the future. The economic question becomes how to protect the gains achieved to-date at least cost. The resurgence of malaria as a result of technical, administrative, or financial inadequacies or failures would, of course, result in a fairly rapid rise in mortality and morbidity, the more so since there is far less acquired immunity in the community than twenty years ago. Such a resurgence, which is essentially what occurred in Ceylon subsequent to the virtual eradication of malaria in the early 1960s, would undoubtedly result in severe production losses for India.

Conclusion

The three salient points for India which emerge from this analysis are:

- The argument advanced by WHO and apparently generally accepted by public health authorities that eradication, although more expensive in the short run, is cheaper in the long run than control is incorrect; at any reasonable discount rate there is little difference between them from a cost point of view. Comparison of whatever alternative courses of action are considered, such as eradiction (if this is deemed technically feasible) and something short thereof which holds the incidence of malaria down to the present low level, should therefore include economic analysis based on discounted present value at a realistic discount rate.
- The economic benefits obtainable from the control/eradication of malaria, as well as the consequences for population growth, have already been realized in India, since both morbidity and mortality from malaria have been reduced to insignificant dimensions, although of course both have a continuing cumulative effect. It is not necessary or productive to allocate scarce research talent to quantifying these past gains, which in any case would be an enormously difficult task, producing results of at best dubious accuracy, since such knowledge, even if it were avail-

able, would not be useful for improved decision-making in the present or future. The issue now, therefore, is by what alternative courses of action, and at what cost (properly discounted), the already realized gains can be protected and preserved against the kind of devastating resurgence which Ceylon has experienced in recent years, i.e., the cost-effectiveness of alternative strategies.

- From an economic point of view the benefits achieved via increased production have been offset to a considerable but indeterminate extent by the rapid increase in the rate of population growth. On the other hand, the resulting improved health and increased life expectancy may be regarded as valuable gains in bettering the conditions of life for the Indian population, which is a central goal of the development effort. Moreover, because the campaign against malaria has inherently depended on virtually universal participation, the health benefits it has produced have been widely shared among the Indian populace. This broad benefit incidence of the malaria program must have been a force for greater equity, unlike some programs the benefits of which flowed predominantly to more privileged groups.

Going beyond the application of the findings of this analysis to the present situation in India and to anti-malaria programs several more general points emerge:

- Discounting for present value can and should be employed as a standard practice. Even when the benefits are difficult or impossible to quantify, the costs can normally be measured and alternative programs with broadly similar benefits can thus be properly compared.
- All the inputs and outputs of such programs should be identified with as much precision as possible and placed within a comprehensive conceptual framework so that important consequences, such as the effect on population growth rate, are not overlooked.
- Proposed health programs should specifically include an assessment of their likely demographic effects, so that the responsible authorities can make a rational choice, knowing the implications for population growth and the additional needs created for family planning and other population policies.
- Especially in poor countries with severe resource constraints such as India, preventive public health measures, such as anti-malaria programs, may be one of the cheapest and quickest ways of generating widespread improvement in human well-being, and especially of extending significant tangible benefits to the poorest third or half of the population.
- Even if the conventionally defined economic benefits of public health programs are less than the costs, which may or may not be the case in the instance here reviewed, economic analysis merely points out that highly valued humanitarian programs may have significant costs. Although economic analysis can be useful in illuminating issues and helping policymakers arrive at informed decision, it is only a tool; the decisions themselves must be based on political, social, and ethical as well as technical and economic considerations.

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