A TEXTBOOK OF

MALARIA ERADICATION

EMILIO PAMPANA

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PREFACE

This book has been written with the purpose of assisting the thousands of professional and non-professional workers who, all over the world, are engaged in malaria eradication programmes or are being trained in order to join them.

Malaria eradication is being pursued today in about one-third of the world population and still there is no textbook for this new venture in public health.

Efforts have been made to write this book in a language that could be understood by non-medical personnel. Not only by the entomologists, the engineers, and the administrators serving in malaria eradication programmes but also by journalists, civil servants, politicians, members of parliament: persons who are often no less responsible for the success or the failure of a malaria eradication programme than the technicians assigned to it. Consequently this book touches on a few subjects that might appear too elementary to the technical reader, such as the life cycle of the malaria parasite, with which he will, of course, be quite familiar.

E. J. P.

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CONTRACTIONS AND ABBREVIATIONS

in malaria eradication terminology

A. = *Anopheles*
a.b.e.r. = annual blood examination rate
a.p.i. = annual parasite incidence
i.p.r. = infant parasite rate
m.e. = malaria eradication
m.e.p. = malaria eradication programme
N.M.E.S. = National Malaria Eradication Service
P. = *Plasmodium*
p.e.s. = pre-eradication survey
p.r. = parasite rate
p.s.i. = pounds per square inch
s.r. = spleen rate
U.N.I.C.E.F. = United Nations (International) Children (Emergency) Fund
W.H.O. = World Health Organization
W.H.O., E.C.I. = Expert Committee on Insecticides of W.H.O.
W.H.O., E.C.M. = Expert Committee on Malaria of W.H.O.

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THE ERADICATION OF MALARIA

Definition

Malaria eradication means the extermination of the malaria parasites of man in the population of a large area. It does not mean the eradication of the species of mosquitoes that transmit malaria in that area. The World Health Organization Expert Committee on Malaria (W.H.O., E.C.M.) gave in 1956 the following definition: 'Malaria eradication means the ending of the transmission of malaria and the elimination of the reservoir of infective cases, in a campaign limited in time and carried to such a degree of perfection that, when it comes to an end, there is no resumption of transmission' (World Health Organization, 1957a).

The term eradication means uprooting. Malaria can be visualized as an infection having its roots—the malaria parasites—in the patient from whom an *Anopheles* mosquito picks them up with the blood, when feeding on the subject, and eventually transmits them to other human beings. It is superfluous to add that mosquitoes do not have malaria unless they get it from malarious subjects. Hence malaria eradication is to extirpate the roots of the infection—the parasites—from a given population so that the mosquitoes will find none to transmit.

To eradicate malaria there is no need to eradicate the vector mosquitoes, i.e., to achieve 'the total elimination of all members of the species [acting as vector(s) of malaria] so that they do not breed when the work is ended' (World Health Organization, 1957a). Vector species eradication would obviously have as a consequence the eradication of malaria; but the latter may be achieved notwithstanding the persistence of the vectors; there would be anophelism without malaria. Typical examples of achieved eradication with such results are the U.S.A. and Puerto Rico.

Anophelism without malaria might be reversible and become anophelism with malaria again if parasite-carriers are introduced in the area. It might be argued, therefore, that vector eradication would give more permanent results. But vector eradication is often impossible, and generally extremely difficult and costly; and it would not be really permanent, because vectors could be reintroduced from outside the country. Theoretically, final security against the return of malaria could be achieved in both processes: in malaria eradication by eradicating malaria from the whole world, in vector eradication by exterminating all the vector species from the world. The first objective is attainable, the second is practically out of reach.

Malaria Eradication and Malaria Control

There should be no confusion between these terms. Malaria control has been defined as implying 'the reduction of the disease to a prevalence where it is no longer a major public health problem' and carries the implication that the programme will never end, control having to be maintained by continuous active work. The W.H.O., E.C.M. 6th Report, however, did not define when a public health problem is no longer a major one. It is interesting to note that in the U.S.S.R., before 1955, the goal of the antimalaria campaign was to

TABLE 1

Differences between a Malaria Control Programme and a Malaria Eradication Programme

	CONTROL PROGRAMME	ERADICATION PROGRAMME
OBJECTIVE	The reduction of malaria to a prevalence where it is no longer a major public health problem	The ending of the transmission and the elimination of the reservoir of infective cases in a campaign limited in time
AREA OF OPERATIONS	Not necessarily covering all the area where malaria transmission takes place	Must cover all the area where malaria transmission takes place
MINIMUM STANDARDS	Good	Perfect
DURATION OF OPERATIONS	Without limits	Programme ends when certain requirements are met [see CHAPTER 9]
COST	Constantly recurring	Expenditure represents a capital investment and is not a permanently recurring cost
CASE-FINDING	Superfluous	Of paramount importance
EPIDEMIOLOGICAL INVESTIGATION OF POSITIVE CASES	Superfluous	Necessary in the late stages
EPIDEMIOLOGICAL EVALUATION OF RESULTS	By usual malariometric surveys	Proof of disappearance of indigenous new malaria cases
IMPORTED CASES	Do not deserve particular attention	Important and dangerous when spraying has been withheld
TOTAL COVERAGE	Unnecessary	Indispensable both for the spraying and the case-finding
ADMINISTRATION OF THE PROGRAMME	May not be the best and still be sufficient	Must be fully efficient and speedy; if not, danger of failure

The above table is a modification of that appearing in W.H.O., E.C.M. Sixth Report, p. 9 (1957).

eliminate malaria as a 'mass disease', this term meaning a minimum incidence of 10 cases per 10,000 inhabitants (Bruce-Chwatt, 1959a). At that level it may be admitted that malaria would no longer constitute a major public health problem.

Eradication on the contrary implies the termination of the active work because the eradication campaign is, according to the definition quoted above, limited in time.

The differences between a malaria control programme and a malaria eradication programme are listed in TABLE 1.

The Justifications of the Eradication Policy

Owing to the eradication campaign time-limits, economy, in the long run, would be one of the justifications of preferring eradication to control. To have no malaria cases instead of 1 case only per 1,000 inhabitants would always be an asset for a country, particularly if, in the long run, the process would be cheaper.

A second reason is the consequence of the very efficacy of the modern methods of malaria control by insecticides. In most countries, one or two years after the beginning of an insecticide campaign, malaria mortality and morbidity become extremely rare. At that time it is quite likely that the government decide to reduce expenses for the control of a disease which has become of minimal importance. As the disease, however, has not been eradicated, interruption of control would eventually lead to dangerous recrudescences of malaria, and control would have to be resumed all over again after having paid the price of heavy morbidity and perhaps mortality. The fight would have been abandoned when the enemy was still potentially strong; while in eradication it would be deliberately stopped only when the enemy is out of the country.

A third reason is that when malaria has become of minimal importance, as said above, the population might object to having their houses sprayed; and so they do, particularly if domestic pests such as house-flies, fleas, or bed-bugs are no longer killed by the insecticides owing to an early development of resistance in those insects. Then, even if the government continued controlling malaria, opposition of the population would interfere with efficiency and the results would become similar to those visualized in the preceding paragraph.

Finally, there is a fourth justification: the danger that the vector species might, while being exposed to insecticides year after year, become insecticide-resistant. Should this occur for the various groups of insecticides before malaria is eradicated, the population would be exposed again to the impact of the infection and deprived of that powerful defence that insecticides afford.

How Malaria Eradication Became the Objective of Antimalarial Activities

Till the Second World War malaria control was difficult, expensive, and economically feasible only in particular circumstances. Control of mosquitoes in their aquatic stage (larval control), insecticide spraying in the air of bedrooms, drainage, and the total reclamation of the area as developed by Italian malariologists under the name of *bonifica integrale*, were the main methods employed. Protection of individuals or groups could, of course, be obtained by house-screening, mosquito-nets or by drug prophylaxis, notwithstanding the low efficiency of antimalarial drugs of that period or their drawbacks.

Malaria control was economically feasible in towns or in communities of marked economic value, such as large mining, industrial or agricultural concerns, railway employees, army barracks and camps, and so forth. But malaria is chiefly a rural disease; and there was no hope of applying to all the villages of Asia, or all the *pueblos* of Latin America, larviciding methods or pyrethrum space-spraying of bedrooms, methods which were only partly effective and required repeating the operations a number of times during each month of the transmission season. In the great majority of rural areas man was powerless to control the disease.

The relationship between man and malaria was changed in favour of man when Mueller in 1939, in Basel, Switzerland, demonstrated that a chemical, first synthesized in 1874 by Zeidler in Germany, was a powerful insecticide, which did not need to be ingested or inhaled to kill insects, but only to be touched by the insect's limbs (contact insecticide); and which, owing to its chemical stability and its low volatility, could remain lethal to insects for months after it had been sprayed on a surface, such as the house walls (residual insecticide). That chemical was the dichloro-diphenyl-trichloroethane, a name which was eventually shortened to DDT. To these characteristics DDT added those of being only very slightly dangerous for man and animals —unless it was ingested—and of being relatively cheap.

Contact insecticides kill insects when they happen to walk or rest upon particles of the insecticide. Fortunately this is what generally happens with most species of the anophelines that are natural vectors of the disease. The female of the species (the male feeds on vegetable juices, not on blood) usually feeds at night, when man is generally indoors. After, and often before, she has sucked his blood and filled her stomach, she generally goes and rests on the bedroom walls for a certain time. If the wall had been sprayed with DDT, or with any other of the residual insecticides later discovered, such as BHC, chlordane, dieldrin, etc., a few particles will adhere to the hairs of the mosquito legs; they will eventually be absorbed within the body and kill the insect. If, instead of resting on the sprayed wall, the insect had alighted on an un-

sprayed surface, for instance on clothes hanging on the wall, it would have been spared. But it is known that after an anopheline has ingested human blood containing malaria parasites it will not be able to infect other human beings for some days. The sexual forms of the parasite must undergo, in the mosquito, a process of fertilization and development, which will result in the presence of infective forms (sporozoites) in the saliva of the mosquito. Only then will the mosquito be able to transmit the infection. Now, this process needs quite a few days, according to temperature; let us say generally 12 days. During this period most anophelines would feed every 48 hours, so that they would come back, for at least 6 nights, to feed on man and risk being killed by the sprayed walls. Clearly the chances that the mosquito will be killed are high; should it survive and become infectious, again the probabilities are that it will not survive long and distribute infections for a long time. The consequence is that, if all houses have their inner walls appropriately sprayed with insecticide, transmission of malaria will be stopped, and no new infections will occur.

Malariologists, however, long accustomed to consider malaria control as an ever-recurring measure, generally did not feel the urge of pushing the efficiency of the new method so far as to reach the end-point of transmission over large compact areas and eventually to stop insecticide applications. This concept was presented in 1948 at the Fourth International Congresses of Tropical Medicine and Malaria in Washington (Pampana, 1948a) but did not meet any support. The few malariologists who, in the early years of the DDT era, named their national programmes 'malaria eradication' seemed to have had in mind either the objective of achieving an enormous reduction of mortality and morbidity or that of suppressing entirely new infections by repeating year after year the spraying operations. A resolution on eradication of malaria was adopted at the 13th Pan-American Sanitary Conference in 1950, but the term was not defined at the Conference. The resolution did not seem very fruitful because a number of Latin American countries, instead of intensifying their antimalaria efforts, actually reduced them in the following years (Alvarado, 1956).

Even the Expert Committee on Malaria of W.H.O. emphasized repeatedly the need of annual spraying operations without end. In the very first report of that Committee it was stated that 'DDT probably will have to be used as a recurring measure, similar to the use of chlorine in water-supplies . . .' (World Health Organization, 1947).

But in 1951 it happened that, owing to difficulties in procuring sufficient amounts of DDT, Greece was not able to spray all the houses that it had been spraying annually since 1946. It was then decided, apparently on the technical advice of Livadas, to withhold spraying in two large territories, the island of Crete and the Peloponnese, and to continue it in the remaining malarious

territories. In Crete and in the Peloponnese, as well as in other areas, 'according to all evidence available (transmission) had been interrupted . . . by the end of 1949' (Livadas, 1958). A system of 'epidemiological surveillance' was set up where spraying was withheld, in order to find malaria cases and take appropriate measures; and it could prove that 'the abolition of the house-spray programme in 1,600 villages, the average number usually sprayed in Crete and Peloponnese, did in no way affect the existing balance in those areas from the standpoint of malaria'. In other words, no indigenous case of malaria occurred in the island, while a few hundred only occurred in the Peloponnese. These findings taught us the lesson that *if transmission had been fully stopped for a few years*—as in Crete—*spraying could be interrupted without the return of malaria.*

But we learnt another lesson from Greece. In the same year, 1951, the most important vector of Greece, *Anopheles sacharovi*, which was generally never found in sprayed houses, began to reappear. Specimens were found in houses a few weeks after spraying. They were found to be resistant to DDT. It was a warning that in other areas other vectors might also become resistant. Fortunately there were two important data: (1) that in the case of *A. sacharovi* 6 years of spraying had been required before resistance became apparent; and (2) that 5 years' spraying in Crete had been sufficient to prevent any new indigenous case occurring after cessation of spraying. Then it was recollected that, when malaria does not kill, it disappears from the patient's blood in most cases within 3 years from the beginning of the infection, even without treatment. It can be concluded that if a very large area is sprayed with DDT with a maximum efficiency for at least 3 years it is possible to stop spraying in the fourth, provided that a system of case-finding and treating is operating. This is the concept of malaria eradication as we know it today. The 3 years of spraying may become 4 or 5 where the first spraying has not been able to stop transmission; but ideally the years of spraying should be as few as possible so that when operations are stopped one may hope that no insecticide-resistance has appeared. Consequently, should malaria be reintroduced from abroad, our best weapon will still be fully effective. 'Obviously the larger the area throughout which the end-point of transmission is attained all at the same time, the earlier and the more safely can the spraying be discontinued' (Pampana, 1954b).

The soundness of these ideas was soon confirmed. In 1954 and 1955 they were internationally adopted: first by the 14th Pan-American Sanitary Conference (1954) and in the following year by the 8th World Health Assembly in Mexico. Then the malaria policy of W.H.O. changed its objective, from malaria control to malaria eradication from the world.

It must be recognized that a few delegations at the Assembly expressed doubts and raised some objections. It was thought by some that the scare of insecticide-resistance, then found in a single species and in a few localities, had