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MALARIA CONTROL

ACHIEVEMENTS, PROBLEMS & STRATEGIES

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Roll Back Malaria
Communicable Diseases
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PREFACE

The Roll Back Malaria initiative was launched in May 1998. It is based on the Accelerated Malaria Control efforts in Africa during the 1990s. UNICEF, UNDP and the World Bank joined WHO in forwarding the Roll Back Malaria partnership in October 1998. They were joined by many other governments and private sector bodies late that year. Partners anticipated that by working together within an agreed strategy they would be able to contribute to halving of the world's malaria burden by the year 2010. To do this they agreed to support interventions and approaches which have been shown to have the greatest promise. They reflect the strategies adopted at the 1992 Ministerial Summit on malaria control, in Amsterdam. The emphasis is ensuring that people at risk of malaria can access and use cost-effective malaria control tools as well as strategic investment in developing new ones.

In addition, the RBM effort gives high visibility to the importance of many different groups – within and outside government – being involved in the provision of services and commodities, as a co-ordinated but flexible movement. The effort also gives high priority to governments and development agencies working in synergy – as partners.

Actions to Roll Back Malaria have to be backed by effective health services: within the RBM movement, malaria control is often synonymous with efforts to develop national health sectors. At the same time, the multiple determinants of malaria infections imply that intersectoral action is also essential.

This book is useful for all who are deeply involved in efforts to Roll Back Malaria – public health professionals in malaria-affected countries, policy makers and personnel in funding agencies. It is historical perspective on the achievements and challenges of malaria control, written by someone with profound knowledge of the history. It explains the origin of the 1992 global malaria control strategy endorsed by Health Ministers in Amsterdam, focussing particularly on the need for early diagnosis and effective treatment for malaria illness. It refers to the relationship between international malaria control and research efforts (page 90): the lessons referred to here have already been learnt in the establishment of the Roll Back Malaria Partnership and RBM Project in WHO.

The author is responsible for views expressed in this publication, which are not necessarily shared by the World Health Organization or other Roll Back Malaria partners. These items – some of which are controversial – should contribute to further discussion, analysis and planning of national Roll Back Malaria actions. References to Primary Health Care (page 96); the Impact of Socio-Economic Development (page 98) and the future (page 112) are particularly challenging.

I wish to express my thanks to Dr Kazem Behbehani, Director in WHO, and former head of the Division of Control of Tropical Diseases, who commissioned this work.

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FOREWORD

History offers to the one who studies it a measure for the just and well-founded criticism of the doings of his own time, places in his hand the thread by which he unites past conditions and efforts with those of the present, and sets before him the mirror in which he may observe and compare the past and present, in order to draw therefrom well-grounded conclusions for the future.

Baas, C.C. (1889), quoted by Russell, P.F. (1955)

Progress far from consisting in change depends on retentiveness ... Those who cannot remember the past are condemned to repeat it.

Santayana, G. (1922) The life of reason: or phases of human progress

The last hundred years have seen the development of scientific malaria control with the discovery of the malaria parasite and of its mode of transmission, explaining past empirical achievements and providing a basis for new approaches and developments. Malaria control was greatly improved as a result of overall technological development, which provided new methods of vector control and eventually better drugs and insecticides. Furthermore, the socioeconomic development of most of the affected populations contributed to many of the great successes of malaria control achieved in areas of temperate climate.

Considerable progress has been achieved, but also there have been a considerable number of setbacks. Nevertheless, public health literature has always paid more attention to success than to failures, the former being used to appeal for further action, while the latter are often explained away and soon forgotten. Today it is difficult to find a public health worker who does not know about Gorgas and the Panama Canal, but only a small group of specialists has heard of Mian Mir, even if the latter may offer more lessons than the former.

Malaria fieldwork is fascinating and stimulating; it requires both mental and physical effort; it is very rewarding as there is always room for doing visible good in the conditions of malaria-endemic areas but, due to the relative isolation of field stations, has sometimes not had access to frequent professional criticism. It should not be surprising if some malariologists, who lived through some of the major achievements of malaria control, tended to attribute their success mainly to the effect of their intervention, often ignoring any concomitant ecological or socio-political change which might have contributed to and sometimes determined that success. As a result, each successful application of a new attack measure, or a new approach to the use of existing methods has led to some expectation of general applicability, even if malariologists of broad experience and perspective warned against such generalisations.

The history of malaria control during the twentieth century has been marked by the profound impact of the global eradication campaign launched in 1955, which created expectations of a final solution to the problem and set up operational structures in the health services which have influenced the subsequent development of malaria control policies even after the abandonment of the campaign itself.

The demonstration of the impressive long persistence of the powerful insecticidal effects of DDT in the 1940s, together with the effectiveness and safety of the new antimalarial drugs, particularly chloroquine, proguanil and pyrimethamine, provided strong support to the proponents of an eradication campaign. The faith in the new technologies, backed by the optimism of industry and the impatience of politicians, acquired an irresistible political appeal and, although some experienced voices expressed their scepticism, they were impotent to prevent the eradication proposal from imposing itself with the force of an ideology.

Russell (1955), while estimating that "among the 2 500 millions of people in the world today, more than half live in potentially or actually malarious communities" and that "in 1954 some 250 million persons will suffer attacks of malaria and that very likely 2½ million will die from it", considered it justified to entitle his book *Man's mastery of malaria* and concluded that "while keeping in mind the realities one can nevertheless be confident that malaria is well on its way towards oblivion. Already as a malariologist, I feel premonitory twinges of lonesomeness, and in my own organization I am now a sort of 'last survivor'". This statement proved somehow prophetic as thirty years later it became a common dictum that the eradication campaign failed to eradicate malaria but succeeded in eradicating malariologists.

The effects of the malaria eradication campaign has many similarities with other utopian political pursuits of the century, being characterized by:

(a) an ideological base so appealing, in its origin, that gave it an irresistible political force,
(b) the formulation of a highly prescriptive orthodoxy,
(c) the establishment of a central power, which recruited and trained its own peripheral cadres,
(d) the establishment of operational and bureaucratic structures, which took over and displaced previous antimalarial services, and the early dissociation of operational planning from research, including epidemiological and field research,
(e) the loss of sight of its objective and its replacement by the demand for formal politically correct performance,
(f) the rapid translation of knowledge and expert judgement into strict guidelines for action, which could serve for a standard monitoring and evaluation of peripheral performance,
(g) the progressive loss of professional and technical staff, as the system became increasingly rigid and bureaucratic, particularly after the campaign came under serious criticism in the 1960s,
(h) the considerable resilience of the peripheral structures, which have resisted, in many areas, for the last decades the changes needed to regain the original purpose and objective of malaria control.

The abrupt termination of the global campaign led to the search for a valid malaria control strategy, which should have found its roots in the active period of policy development before the Second World War, which had led to the continuous progress in understanding and controlling malaria, from which the hope of eradication had erupted. Nevertheless, this does not mean that it is necessary to copy the past; and no study of history relieves from the responsibility of facing today's problems, both with all the accumulated knowledge of the past and with a continuous awareness of current developments.

In the words of Fantini: "A cause de la complexité de la réalité biologique, épidémiologique et sociale de la malaria, chaque cas est à la limite unique, et chaque intervention dans cet équilibre délicat doit être toujours accompagnée d'une activité de recherche. Pour cette raison, l'exemple historique du paludisme se présent comme paradigmatique d'un aspect épistémologiquement important : la relation entre théorie et réalité. Il permet de dégager dans l'action médicale, les rapports étroits entre connaissance et action, entre savoir et savoir faire, entre connaissance et transformation de la réalité" (Fantini, 1992).

As Sadun (1972) reminded us, we should be conscious of past achievements and "aware that, as stated by Bernard de Chartres in the 12th century, we are dwarfs perched on the shoulders of giants. We see more and farther, not because our vision is better or our height is greater, but only because they lift us". He points out, however, that there are some drawbacks in an exaggerated admiration of history: "it is time consuming, it may have an ego-damaging effect by showing that many of our observations had already been made a long time ago, and by exalting the ancient achievements it may lead us to disregard those pertaining to the present time '*dum vetera extollimus recentium incuriosi*' (Tacitus: Annals, II, 88)".

1. HISTORICAL DEVELOPMENT OF MALARIA CONTROL

Should there be rivers in the land, which drain off from the ground the stagnant water and the rain water, the people will be healthy and bright. But if there be no rivers, and the water that the people drink be marshy, stagnant and fenny, the physique of the people must show protruding bellies and enlarged spleens.

Hippocrates (460-377 BC) Airs, Waters, Places quoted by Russell (1955)

Archaeological evidence suggests the early acquaintance of man with malaria, and the historical records from Babylonian, Assyrian, Indian and Chinese civilizations indicate the frequency of the disease in those areas. Benign tertian and quartan malaria were known in classical Greece. Hippocrates describes them clinically and even epidemiologically, as the quotation above shows, and, although undisputed clinical descriptions of *P. falciparum* malaria do not occur until Celsus (25 BC-54 AD) and Galen (c. 130-200 AD), it appears to have invaded the Mediterranean in the form of severe focal epidemics -- as during the siege of Syracuse – as from the fifth century BC to become endemic during Roman times (Grmek, 1994, de Zulueta, 1994). Celsus' description in his «*De medicina*» is particularly precise: "... Now quartan fevers have the simpler characteristics. Nearly always they begin with shivering, then heat breaks out and, the fever having ended, there are two days free; thus on the fourth day it recurs. But of tertian fevers there are two classes. The one, beginning and desisting in the same way as quartan, has merely this distinction, that it affords one day free, and recurs on the third day. The other is far more pernicious; and it does indeed recur on the third day, yet out of forty-eight hours, about thirty-six, sometimes less, sometimes more, are in fact occupied by the paroxysm, nor does the fever entirely cease in the remission, but only becomes less violent".

1.1. Empirical development of methods of control

It is interesting to note that, since antiquity, man was able to recognize some methods of preventing malaria and of protecting himself from mosquito bites, without actually establishing any connection between the two practices except perhaps in a few isolated circumstances.

1.1.1. Prevention of disease

... for though healthy conditions, depending as they do upon soil and climate, are not in our power but in Nature's, yet by care we can do much to mitigate the graver evils.

Varro (37 BC) quoted by Russell (1955)

The distribution of prehistoric settlements shows that even before written history, men recognized the unhealthiness of certain areas and this gave rise to what seems to be the most primitive form of malaria control -- the avoidance of malarious areas.

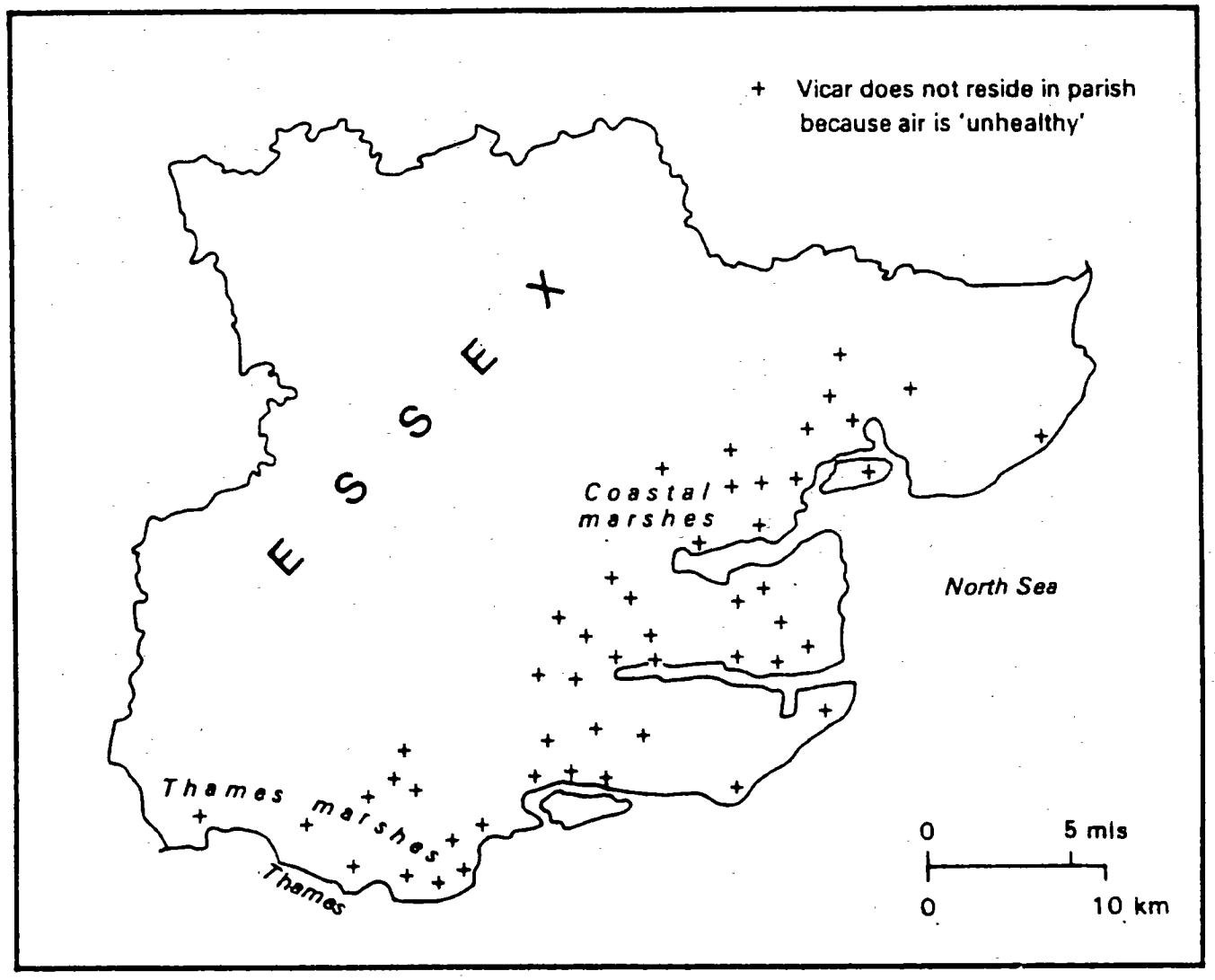
Site selection for the location of new settlements and military camps was essential for the consolidation of imperial conquests, as shown by Roman writers on military and civilian engineering (e.g. Varro, Vitruvius), farming (e.g. Columella, Palladius), and also for the construction of farm-houses and the villas of the Roman aristocracy (e.g. Pliny the Younger, first century AD).

Residence in notoriously malarious areas continued to be avoided, throughout history, by those who had a choice. A well-documented example of this avoidance, studied by Dobson (1989, 1994), shows that in 18th century England, marshlands in Essex, Kent and Sussex, particularly those at the mouth of the Thames, were so unhealthy that men of wealth and education avoided living there and even vicars were authorized to reside outside their parishes because the air was unhealthy and "much subject to marsh agues" **(Map 1).** Landowners also avoided living on their farms and left the care of flocks and crops to local marsh men, who were described as "stupid, apathetic and fatalistic" or "poor and ignorant wretched people".

Environmental sanitation was the logical consequence of the identification of malarious areas, and of the recognition that they shared certain identifiable common factors, at least some of which could be corrected. Sanitation works were undertaken by the early civilisations of Mesopotamia, Egypt and the Indus valley.

One of the first records of sanitation work done specifically for the control of an epidemic is that of Empedocles of Agrigentum (c. 490-430 BC), who, according to a legend recorded by Diogenes Laertius (third century AD), delivered the city of Selinus, in Sicily, from an epidemic by diverting two streams so as to flood the stagnating lower reaches of a river, the noisome smells from which were the presumed cause of the epidemic. There are many references indicating that Roman engineers, e.g. Vitruvius (c. 88-26 BC) and Columella (c. 3 BC-65 AD), were very concerned about marshes as a cause of fevers and undertook important drainage works. Even the construction of the Cloaca Maxima in Rome, begun by Tarquinius Priscius (616-578 BC), had had the primary purpose of lowering ground water levels.

Important sanitation work, both for health and agriculture, continued during the Middle Ages and into modern times. A particularly well-documented history is that of the Pontine Marshes, which Roman emperors, popes and Italian kings attacked with an almost cyclical mixture of successes and failures throughout recorded history, as documented by Celli (1925) **(Figure 1)**. Drainage in the European Middle Ages is particularly associated with the work of the Benedictine Order, which transformed wasteland and marshes into fertile fields. There are several other major examples of sanitation of extensive areas, achieved through the accumulation of the work of many generations, e.g. in Holland, southern France and the English Fens. A particularly strong advocate of drainage as a solution of the malaria problem was Lancisi, who in 1717 published a treatise on swamp fevers *De noxiis paludum effluviis eorumque remediis*. Here he not only proposes a plan for the drainage of marsh lands since "it is better not to fall ill than to be cured" but also puts forward the theory that malaria may be caused by noxious juices inoculated by biting marshy insects. Lancisi also recognized that not all marshes were dangerous sources of fevers. As Russell (1955) mentions, at the end of the nineteenth century there were some extensive anti-malaria drainage projects in places as widely separated as New York and Sierra Leone, Brazil and Hong Kong.



Map 1 Vicars in 18th century Essex refused to live in the coastal marsh parishes because the air was 'unhealthy' and 'much subject to marsh agues'

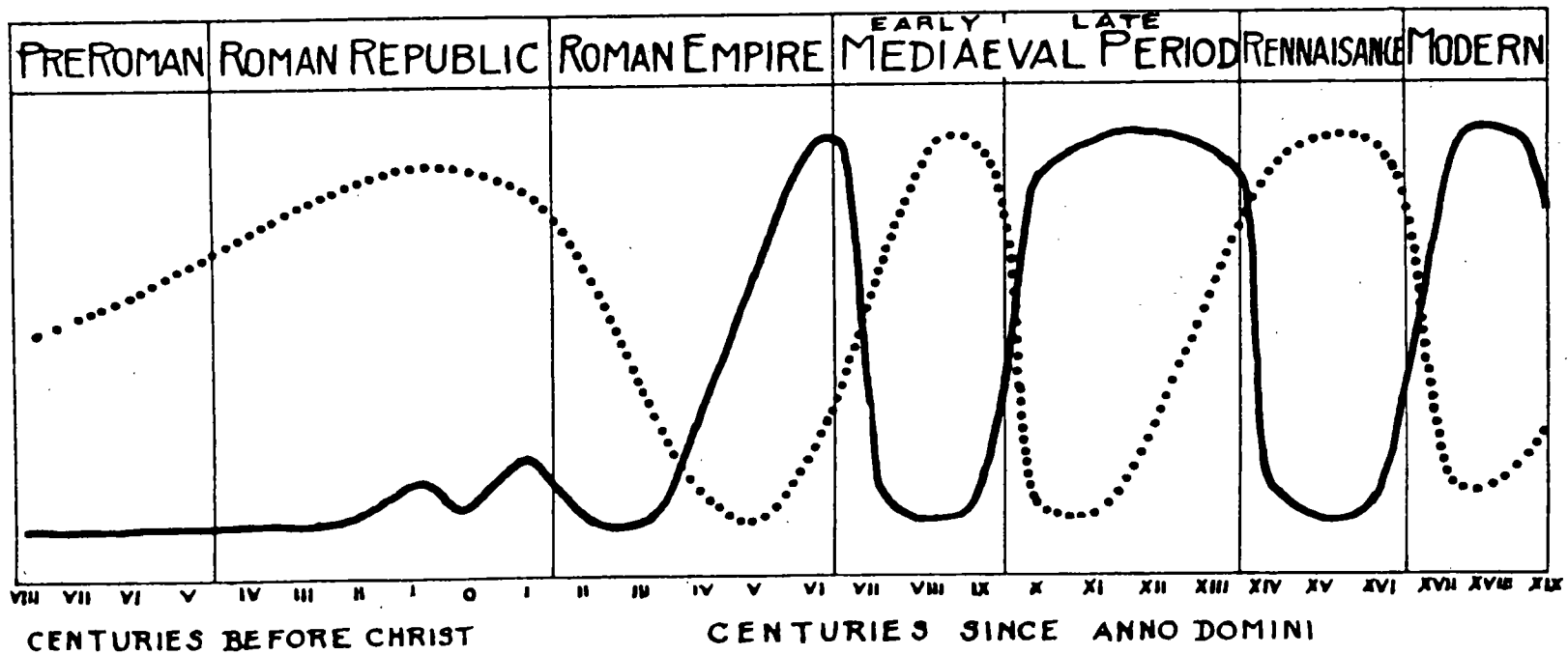


Fig. 1. Showing cyclical trends in the incidence of malaria (solid line) in the Roman Campagna, and the relation of the fluctuations to current agriculture (dotted line). (After Celli, 1925.)

Regulation of agriculture included not only land reclamation and drainage but also the control and even the prohibition of some crops, which were regarded as causing fever epidemics, particularly rice cultivation in Europe. It does not seem that malaria was a major problem in the Iberian Peninsula before the introduction of rice cultivation by the Arabs, about the twelfth century, after which it appears to have become prevalent. According to Villalba (1802), in 1342 -- about a century after the conquest of the kingdom of Valencia by the Aragonese -- King Peter II of Aragon prohibited the cultivation of rice in the vicinity of the city in order to control fever outbreaks, and in 1403 King Don Martin extended the prohibition to the whole kingdom, as he attributed to rice cultivation a deadly epidemic and the decline of population. In 1483 King Don Alonso made rice-growing a capital offence. Such prohibitions were subsequently repeated following major epidemics up to the eighteenth century, indicating that their enforcement soon weakened in the absence of an alternative staple food. A controversy slowly developed over the dangers and benefits of rice cultivation to public health. It was observed that in lowland swamps, close to the sea and unsuitable for other crops, rice was not only economical but also beneficial to public health, as land preparation and freshwater irrigation circulated stagnant water and prevented disease. In the second half of the eighteenth century King Ferdinand VI ordered the planting of rice in swamps as a sanitation measure and finally, in 1789, after a Royal Commission studied the problem, a royal decree was promulgated regulating rice cultivation.

1.1.2. Prevention of mosquito bites

> *Gnats are abundant. This is how the Egyptians protect themselves against them: those who dwell higher up than the marshy country are well served by the towers whither they ascend to sleep, for the winds prevent the gnats from flying aloft; those living about the marshes have a different device, instead of the towers. Every man of them has a net, with which he catches fish by day, and for the night he sets it round the bed where he rests, then creeps under it and so sleeps. If he sleep wrapped in a garment or cloth, the gnats bite through it; but through the net they do not even try at all to bite.*
>
> **Herodotus of Halicarnasus (*c.* 484 BC) Histories, book II, para. 95**

Methods of protection against mosquito bites, such as **bednets**, have a very long history, going back to ancient Egypt and China. They were developed in the search for comfort without their connection with disease protection being established, until Lancisi observed that they could not only protect against mosquitos but also against the miasmata emanating from swamps.

While at the time of Herodotus the use of mosquito nets seems to have been rather limited, they became more common in later Greek and Roman times. They were a sign of luxury and somehow seen as effeminate; for example, Horace (65-68 BC) wrote: "and among the military standards, oh, shame! the sun sees a mosquito curtain" (Epod. IX, 16). Although they do not seem to have been used in mediaeval Europe, Marco Polo observed them in South India, and there are numerous examples of their use by travellers or expatriates in mosquito-infested areas.

The considerable improvement in communications during the eighteenth and nineteenth centuries made it easier to compare observations about conditions for the occurrence of malaria, which fuelled discussions on the different etiological theories, such as the miasmatic or paludic, the telluric or the insect theories. Among the arguments in favour of the mosquito origin of malaria (King, 1883, quoted by Boyd, 1949) were:

- the malaria season and the mosquito season coincide, both increasing in late autumn;
- malarial country is suitable for mosquito breeding;
- similar measures afford protection against both malaria and mosquitos;
- exposure to night air signifies exposure to mosquitos;
- those whose occupations afford especial risk from malaria, such as soldiers, tramps and fishermen, are especially exposed to mosquitos at night;
- the occurrence of malaria following breaking of the soil or making excavations in previously healthy districts is consequent on mosquitos breeding in the water retained in the resulting holes.

1.1.3. Specific disease treatment

The discovery of effective antimalarial drugs and their use for treatment and for prophylaxis also has a long history. The Chinese used *Artemisia annua* for several centuries and the South American Indians seem to have used *Cinchona* bark, at least for the treatment of fever, long before the Spaniards became aware of its properties at the beginning of the seventeenth century.

The introduction of malaria into the American continent and the dates of the first recorded use of *Cinchona* bark and of its introduction to Europe continue to be the subject of debate. Centenaries of the discovery of *Cinchona* were celebrated in 1826, 1930 (Wellcome Historical Museum) and 1938 (X Pan American Sanitary Conference). In any case it is clear that in the early years of the seventeenth century its use spread among Spaniards in the Americas, and that it was sent to Europe, where the Jesuit priests facilitated its distribution. They brought it to Rome, where it received the enthusiastic support of Cardinal Juan de Lugo who, after successful tests carried out in the Santo Spirito Hospital by Gabriel Fonseca, the Pope's physician, distributed the bark free to the poor and persuaded the Jesuit Order to spread its use in their missionary work from 1649 onwards (Russell, 1955). In spite of the obvious success of *Cinchona* in many cases, the occurrence of relapses, the uncertainty of diagnosis and dosage, the variability of active principles in different barks and frequent adulteration -- in addition to religious prejudice -- influenced the ups and downs of its subsequent use. Sydenham (1624-89) and Morton (1637-98) greatly contributed to its recognition in non-Catholic Europe, and Torti (1658-1741) helped to define its indications by establishing a nosological classification of fevers in his *Therapeutice specialis ad febres periodicas perniciosas.* Finally the isolation of quinine and cinchonine by Pelletier and Caventou in 1820 initiated modern malaria chemotherapy.

An early recommendation for public health action is that of Dr Joseph Masdevall, Inspector of Epidemics of the Principate of Catalunya who, referring to a major epidemic in Mexico which caused more than 12 000 deaths, requested King Charles III of Spain: "... since cinchona is so effective to treat and prevent this disease, I cannot but beg your Majesty to take the most

appropriate measures to ensure that all the villages of this continent be provided of such effective antidote, and that it be sold at a moderate price, so preventing the frequent adulterations that apothecaries make of this bark". Masdevall also advocated the use of *Cinchona* bark as a prophylactic: "Individuals who cannot avoid living in an area infected by one such epidemic could divide about half a drachm of good bark into several portions, without powdering, and chew some of them several times a day, swallowing them slowly with the saliva on different occasions until consuming the half drachm ... during all the time of the epidemic". He also commented that the bark was not as effective for prevention as for cure (Masdevall, 1786).

1.2. Different perceptions of the malaria problem and its control

> *... de toutes les maladies auxquelles les régions de la zone tropicale doivent leur grande insalubrité, la fièvre paludéenne est certainement celle qui exerce l'influence la plus grave et la plus générale; pas de climat insalubre sans elle, pas de climat salubre là où elle existe.*
>
> **Dutroulau (1861)**

The epidemiology of malaria, being the result of the interaction of a variety of factors, can in theory be affected by changes in any of them. Malaria transmission requires sufficient man-vector contact for a mosquito, which has bitten an infective case, to bite one or more susceptible individuals after the parasite has completed its development in the mosquito. This will require the sufficient density, survival and man-biting habits of the vector, which in turn depend on the vector species, the availability of suitable breeding places, temperature and humidity, availability of suitable daytime resting places and alternative sources of blood. The duration of infectivity of a case will depend on the availability and actual use of health care services, while the determinant factors of transmission include the climate, the types of housing and animal shelters, and the level of socioeconomic development. Most of these factors have threshold levels and in some situations it may be possible to interrupt malaria transmission by forcing a single factor below its threshold. This is the reason for the success of malaria control in some areas though draining swamps or by water management of impounded waters, distribution of *Gambusia* fish, zooprophylaxis, house improvement, etc., while the same interventions have failed in other areas. Unfortunately, in areas of high malaria endemicity, most factors are present with an intensity far above their threshold, so that the eco-epidemiological system can tolerate considerable reductions of any factor without affecting the level of endemicity.

Perhaps one of the oldest recorded epidemiological observations is the difference in malaria experience between the local people and newcomers arriving in endemic areas. Malaria control developed quite different approaches according to whether the main priority was the protection of endemic populations or the immigrants; an intermediate situation was the protection of development projects in endemic areas where, besides the exposure of newcomers, there was the creation of new risks for the local population.

Intercontinental colonial expansion, as from the fifteenth century, brought about a dramatic change in the scale and diversity of human contacts and therefore in the diffusion of all kinds of infectious diseases. The importation into the tropics of European technology and methods for the

exploitation of natural resources, as well as the establishment of more and more rapid trade routes and the control of trade, fed what already appeared as an ever-increasing exploitative development of the tropics. This was characterized by extensive ecological disturbances, large-scale monocultures, often of imported crops, wherever they could be produced more cheaply (taking into account scale of production, cost of labour and cost of transport), and large-scale movements of labour forces, often forced to live in crowded and unhealthy conditions. Labour remained a marketable commodity well after the abolition of slavery prevented the actual ownership of people; mass recruiting agencies in impoverished and overpopulated areas provided the labour necessary for the construction of railways, irrigation systems, plantations, and other public or commercial large-scale works, as it was often cheaper to import labour than to train and concentrate the native populations.

All these developments considerably expanded the demand for effective malaria control. The needs of colonial enterprise in particular acquired a predominant place, at least for the major colonial powers. At the same time, the industrial revolution and the demographic growth of the nineteenth and twentieth centuries brought about considerable changes in the distribution of population and their relations to the environment, such as the growth of cities, the need for agricultural expansion, the continuous increase of population movement, increased demand for temporary labour and the mechanization of agriculture. These changes contributed, in many areas, to the practical elimination of man-vector contact, while in other areas they created new situations of exposure for susceptible groups. Malariologists studying local situations tried to describe "the malaria problem" as seen from the point of view of those factors which seemed to them as the key to upset the epidemiological equilibrium. Malaria has therefore been variously defined as a "social", an "entomological", a "rural", a "poverty" or a "socioeconomic" problem.

Admitting that all these definitions have relevance in particular situations, it may be possible to identify two extreme positions in the attitudes of malariologists and health authorities towards malaria control, according to the main target of their interventions: (a) to care and protect people from the disease and its effects, or (b) to protect people from infection by combating the parasite and its vectors.

In fact, these different positions originated as the response to different requirements but, in their formulation, they resulted in quite different concepts of the problem, the social space to be protected and the relative position of the enemy to be fought (Garcia, 1979). It is possible to distinguish three typical, rather stereotyped, positions which generate their own basic concepts of public health action:

(a) the protection of a susceptible population in an endemic environment, where the disease is seen as an external enemy which has to be prevented from invading the free areas and whose territory has to be progressively conquered, thus creating the concept of an antimalarial campaign and culminating in that of eradication; its model is that of military action, as revealed by its use of such terms as attack, campaign, weapons, armament, strategy, tactics, logistics, brigades, squads; its emphasis is on attack, organization, discipline and immediate effectiveness;
(b) the control of an endemic situation by a specialized service which sees the disease as an infiltrating danger, spreading more or less unnoticed among the population; the enemy is within, it has to be detected, isolated and, if possible, eliminated; its model is that of the

police services and it uses such terms as surveillance, vigilance, case detection, reporting, investigation, focal distribution, population movement, origin of infection (autochthonous, imported), tolerance levels, alarm signals, foci elimination; the emphasis is on information systems and response capacity;

(c) the control of an endemic situation as part of health development, where the disease is seen as an omnipresent oppressor against which it is necessary to mobilize all the resources of the community, first to survive, then to be strengthened and eventually to revolt; its models are national liberation movements and its vocabulary includes such terms as community mobilization, participation, public information and education, decentralization, intersectoral collaboration; the emphasis here is on developing and strengthening local capabilities and acquiring the best possible knowledge of the oppressor and its moves; sustainability of gains is an essential consideration, since failed attacks will result in harsher repression and the strengthening of the oppressor.

The history of malaria control during this century shows frequent confrontations between these points of view, particularly the first two extremes, which alternately dominated the international stage in an apparent oscillation. Both claimed successes and accused the opponents of stagnation or regression during the periods of their predominance.

In fact, the problem has been the search for "the right approach", applicable everywhere, when in fact each of the approaches mentioned above, developed in response to particular problems, is still appropriate for some specific situations. Here are some examples:

- malaria control in economic development projects in tropical plains or forests, such as public works or plantations, which may attract labour from densely populated hypoendemic highlands and will require the disciplined control referred to under (a);
- the early detection and control of epidemics will require the information systems referred to under (b);
- the control of highly endemic malaria, particularly in Africa, today calls for the development and strengthening of local resources, supported by a health infrastructure that can benefit from currently available control measures and eventually be able to use new techniques as they are developed.

1.3. The malaria problem during the first half of the twentieth century

1.3.1. The Italian strategy

> *De tous les pays d'Europe, c'est en Italie qu'on peut trouver le meilleur modèle, encore inégalé d'ailleurs, de ce que doivent faire les pouvoirs publics pour la lutte contre le paludisme.*
>
> **Marchoux (1926)**

During the last twenty years of the nineteenth and the beginning of the twentieth centuries, the Italian parliament gave a high priority to public health, guiding the establishment of a health infrastructure throughout the recently unified country and fostering the fight against malaria as

one of its main functions. Its legislative work progressively defined the responsibility of the State, other official agencies and the private sector in public health action (Fantini, 1992).

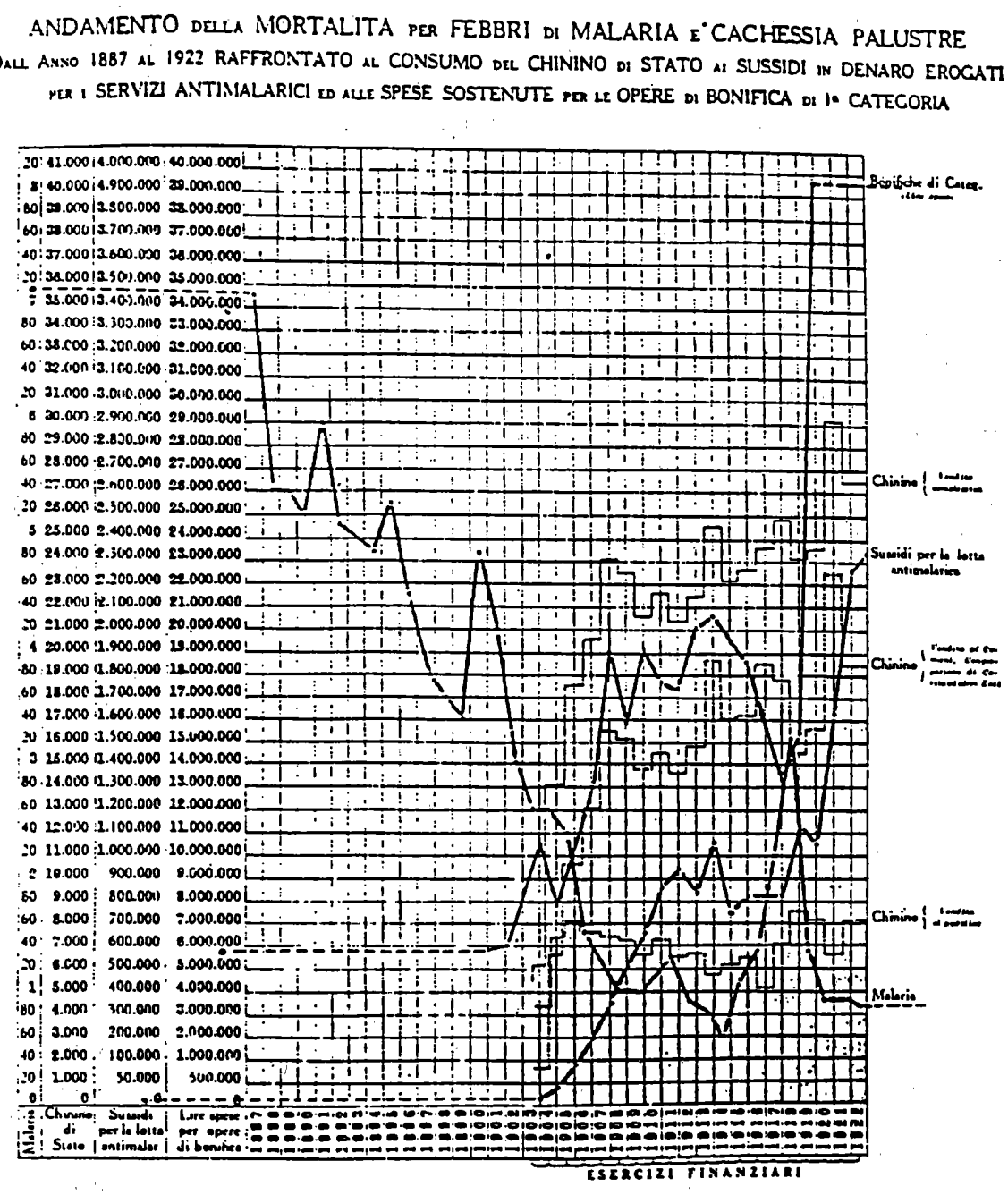
The Italian antimalarial law of 23 December 1900 controlled the production and sale of quinine by the State, the *chinino dello Stato*; this was supported by the laws of 2 November 1901 and 19 May 1904, establishing free distribution to workers and settlers in malarious areas. Eventually, the decree-law of 30 December 1923 set the framework for prophylactic action, established the coordination of all the services dealing with health in all ministries, and required that all actions should follow the rules set up by the General Directorate of Public Health.

The General Directorate of Public Health inspired and supported the formulation of pertinent laws and regulations, issued circulars and instructions, collected and analysed information, distributed subsidies, provided training, promoted and supported research and epidemiological studies, and coordinated and supervised all activities. The General Directorate was guided by technical commissions constituted by experts, received information from a corps of Inspector Physicians and was represented in all the provinces by Provincial Malaria Physicians who, with the agreement of the prefects, determined the quinine needs for each commune, supervised purchase and distribution, organized treatment and prophylactic services, established plans for control activities in each affected locality and fixed the amounts to be included in each communal budget for malaria control. Provincial physicians were assisted by the physicians of the health service assigned to the regions. The General Directorate was also in official relations with the Malaria Commission of the League of Nations.

The principal executive agents were the communes and charitable institutions, particularly the Red Cross and official bodies such as the railways, the army, the Rome governorate and the autonomous malaria control bodies in some provinces such as Venice and Sicily. Their medical staff consisted of community and other physicians who were provided with precise instructions and were assisted by technical personnel trained under the guidance of the General Directorate of Public Health. Particularly important was the role of the Practical School of Malariology, the Higher School of Malariology and, eventually, the Malaria Experimental Station, established in collaboration with the Rockefeller Foundation.

Malaria control activities were mainly funded from a special account, named "*Support for the control of the causes of malaria*", which received all the benefits from the sale of quinine **(Figure 2)** and the income from the collection of fines imposed for infractions of the law. In addition, the General Directorate had an annual budget of 35 million lire and the State, in the form of a wide variety of subsidies, made an investment of 1 500 million lire in sanitation improvements during the first quarter of the century, not counting the expenditures of the provinces and of private enterprises. The General Directorate emphasized small sanitation operations (*picola bonifica*), mechanical protection, larviciding (eventually the introduction of *Gambusia* fish) and zooprophylaxis.

Fig. 2 Results of systematic quininisation



An evaluation of malaria control in the southern railways (Filippini, 1927) showed that malaria morbidity (attacks per year) among the workers, which in 1880 was 104% per year, was reduced to 39% by 1904 and to 6% by 1914. Although it increased during the war to reach a maximum of 36% in 1921, it was reduced to 18% in 1926. Mortality was practically eliminated; even when morbidity increased, as in 1921, the case fatality was 0.08%. Labour loss, which in 1880 was calculated at 4.5 days lost per worker, was reduced to 0.03 days in 1923. Quinine consumption reached a maximum of 2 755 kg in 1908 and a minimum of 925 kg in 1923.

1.3.2. Early success and failures of mosquito control up to the First World War

The discoveries of Laveran, Ross and Grassi laid the basis for a unified theory of malaria epidemiology, giving the impression that all essential aspects were known and that it was possible to design a scientific strategy for malaria control. The effectiveness of quinine, bednets, drainage and sanitation was validated and more precise methods of vector control, prevention of man-vector contact and chemoprophylaxis were developed. Nevertheless, the failures of Ross in Freetown (1899-1902) and of Christophers and James in Mian Mir (1902-4) showed the enormous practical difficulties of large-scale mosquito control.

The Mian Mir failure appears to have had an important influence on subsequent malaria programmes in India and elsewhere (Bynum, 1994) and contributed to the hardening of the positions of the people involved, among them Ross, Christophers, Stephens and James. Ross, in particular, although originally consulted, remained erratic in his participation and soon disengaged himself, becoming violently critical of the conduct and evaluation of the experiment, as illustrated by the comments in his book on malaria prevention "There is no doubt that the general policy of a *clique* in India has been opposed to mosquito reduction, and has not been very keenly interested in any other form of malaria campaign. A party in that country has been advocating quinine on the Italian model, and appears to have persuaded the Government that it will cost nothing, while mosquito reduction must always be enormously expensive" (Ross, 1911).

In contrast, the highly visible success of Gorgas in Panama (1904-8) had a great political impact; he received the greatest honours such as the honorary degree of Doctor of Science from the University of Oxford, being made Major-General by the United States Congress and being appointed Surgeon General of the Army by the President; on his death in 1920 the *Lancet* called him "the best known and most uniformly successful medical administrator not of his age but of any age". Most contemporary malariologists, headed by Ross, were highly impressed and politicians thought that finally the malaria problem was solved. Thus Freemantle (1911) said: "Dr Gorgas, by his medical dictatorship, has enabled the United States to triumph where De Lesseps failed, and has taught the world that attention to the public health is the avenue to achievements and to wealth beyond the dreams of avarice".

The concept became dominant in the United States, and was propagated from there, that "malaria was a simple function of anopheline density and that the one is quickly responsive to changes in the other" (Hackett, 1937). Nevertheless, that American thesis failed to convince many European malariologists, as Hackett commented: "As a matter of fact, the antilarval methods proposed by the Americans did not seem to work very well outside the United States. Panama was not really a convincing demonstration, because of certain extraordinary features. The immense sums spent

on the sanitation of the zone ten by forty miles in area did not have to be raised by taxation of the local population, but came in virtually unlimited quantities from an outside source, bent under any circumstances on making a success of the Canal. The financial resources of the people and the economic value to them of protection from malaria was not taken into consideration".

While attempts to control malaria by eliminating anopheline breeding places were failing in Mian Mir from 1902 to 1909, and in other places, Watson in Malaysia was succeeding in solving local problems by concentrating on studying the micro-epidemiology of malaria and identifying the main vector species and their specific breeding and biting habits as the basis on which to design specific malaria control measures. This approach, which was further developed in Indonesia by Swellengrebel, who used the term "species sanitation", must be distinguished from the general "antimalarial sanitation", which attacks all mosquito breeding places. Species sanitation designs the specific approaches to control the main malaria vector species, based on a detailed understanding of anopheline ecology and malaria epidemiology, with due attention to operational feasibility and local affordability (Swellengrebel, 1950; Bradley, 1994; van der Kaay, 1998).

1.3.3. Malaria control during the First World War, the great post-war epidemics. Anophelism without malaria

The First World War consolidated the use of malaria control for the protection of armies operating in malarious areas, based on **chemoprophylaxis**. The use of *Cinchona* and later of quinine as chemoprophylaxis for personal protection had been proposed, as mentioned above, long before Laveran's discovery. Koch was the first, after the discovery of mosquito transmission, to emphasize systematic chemoprophylaxis and careful treatment of all patients as a method of malaria control which, after the success in Stephansort (New Guinea) in 1900, became the basis for malaria control in the German colonies.

In 1916, the French army in Macedonia suffered a serious malaria epidemic, when between June and December 60 000 cases were recorded, half of the military force. General Sarrail wrote to the War Minister: "My army is immobilized in the hospitals". The Sergent brothers were commissioned from Algiers and found that, although chemoprophylaxis was supposed to be compulsory, it was mostly neglected; for example, the general commanding the region south of Salonica, said: "Vous me faites rire avec vos histoires de moustiques. Ce n'est pas cela qui donne la fièvre; ce sont les miasmes que l'on respire avec le mauvais air; il n'y a pas moyen d'y échapper. Ne venez pas raconter des inventions de savants à un vieux colonial comme moi. Je connais les fièvres, moi, je les connais mieux que vous, docteur: je les avais déjà eues quand vous n'étiez pas encore né". They managed, nevertheless, to establish a highly disciplined programme of chemoprophylaxis supported by mosquito protection of barracks, severe disciplinary measures and all means of information and propaganda, including postcards for soldiers' correspondence (Milleliri & Weingarten, 1990), and succeeded in preventing further outbreaks. These measures were evaluated as follows: "Par un retour étrange de fortune, c'est l'Armée d'Orient, menacée de désagrégation complète, en 1916, par le paludisme, qui, reconstituée grâce à la lutte hygiénique entreprise, ouvre, en 1918, à nos armées victorieuses, la voie du triomphe" (Sergent & Sergent, 1932).

Following the war, focal malaria epidemics occurred throughout Europe in many regions where it had not been known for many decades. Particularly severe was the pandemic during the Russian civil war, in the unusually hot summers of 1920 and 1921, reaching the northernmost point of distribution of malaria transmission, north of the polar circle at Archangel in Russia (Tarassévitch, 1923).

These epidemics provided numerous examples of the lack of a clear relation between anophelines and malaria, which had already been noticed by Celli (1911): "The *Anopheles* are never wanting where the fevers exist, but their quantity is not always in direct proportion to the intensity of the epidemic; in fact, it is frequently in inverse proportion. On the other hand, there may be plasmodia and *Anopheles* without malaria developing itself ... Plasmodia and *Anopheles* may therefore persist, and, notwithstanding this, the malaria may become attenuated and disappear". This phenomenon, which was described by Roubaud (1920) as "anophelism without malaria", became the great epidemiological puzzle of malariology for more than a decade (Fantini, 1994).

These developments contributed to a growing disillusion about the prospects of vector control, reflected in the observation by the Malaria Commission of the League of Nations that, in several areas of Europe which "had undertaken an energetic campaign against malaria, the disease yielded to the measures which were taken, but reappeared with added virulence as soon as these measures were somewhat relaxed. This is a very serious result which brings in its train disillusion and discouragement" (Lutrario, 1927).

1.3.4. The Dutch school

Following the serious epidemics of 1919-21 in the province of North Holland, the provincial government appointed Korteweg, Schoo and Swellengrebel, the developer of species sanitation in Indonesia, as advisers to their provincial Malaria Commission. They soon discovered that the experience from Indonesia was not applicable to North Holland and therefore concentrated on the study of the local epidemiology and anopheline behaviour. They confirmed the hypothesis, enunciated by Korteweg in 1902, that *P. vivax* infection could have a long incubation period, explaining that the peak of transmission in autumn (the period of highest sporozoite rate) coincided with a period of low and declining malaria incidence. The long incubation period was confirmed experimentally by James (1927) and by Schüffner, Korteweg & Swellengrebel (1929).

The official control strategy consisted of larviciding around the main cities, adulticiding in cattle sheds (by brigades using lysol and vacuum cleaners, until pyrethrum became available after 1926), attempts to enforce screen protection of new houses and attempts to obtain blood slides from all suspected malaria cases. None of the control measures achieved more than about 50% coverage; nevertheless, Swellengrebel was able to report to the First Malaria Congress in Rome that the epidemic of malaria in North Holland had been controlled, if not eradicated, and that this was due to the use of quinine, particularly by rural medical care, and to the improvement of social conditions, including the stabling of cattle, and not to a general anopheline reduction, since the Netherlands remained the country with the greatest number of anopheline breeding areas.

After 1926, the Committee was entrusted with malaria research in the whole country and with malaria control in North Holland. Control was based on larviciding and the extension of activities to human dwellings; people were instructed to keep their bedrooms free of mosquitos. Public information and instructions, including a film, a school book, posters, leaflets, stamps and songs, were essential elements of the strategy, and efforts were made to enforce the screening of bedrooms. By 1933 it was reported that half of the families of North Holland were practising mosquito control. Entomological studies showed that there were two distinct types of *Anopheles maculipennis*: one was the already named *A. messeae*, which did not play a role in transmission, bred in fresh water and fully hibernated; the other, named *A. atroparvus* by van Thiel, was the main vector, breeding in brackish water and undergoing gonotrophic dissociation (semi-hibernation) in autumn and winter, that is, continuing to feed about once a week without developing and laying eggs. This was the first clear differentiation of two of the species of *Anopheles maculipennis* complex. Malarious houses which had no features particularly attractive to anophelines could be explained by the coincidence of semi-hibernating *A atroparvus* and gametocyte carriers during autumn and winter.

Professional teams had carried out selective spraying of malarious houses bimonthly from August to November since 1936, but the scarcity of pyrethrum during the Second World War, dictated strict selection of the villages to be sprayed and this provided additional proof of the validity of the selective spraying strategy. After the war and with the availability of DDT, a comparison was made between the practice of selective spraying and the "total coverage" advocated by the Rockefeller Foundation; the final evaluation concluded that the results were similar but that selective spraying was considerably cheaper (Verhave, 1987).

1.3.5. Malaria control in the United States

Malaria had long been a major public health concern, particularly as it affected the big social and ecological transformations of the nineteenth century. It was in the United States of America that the mosquito theory had been most thoroughly developed and it was there that the anti-mosquito approach to malaria control became most solidly established. One example of the enthusiasm for malaria control was the plea and plan that Hoffman put forward in 1916 for the eradication of malaria throughout the Western Hemisphere (Hoffman, 1928).

Mosquito control was organized in military camps during the First World War, which served as models for anti-mosquito projects in civilian areas, protecting 1 750 000 civilians and more than 800 000 military personnel by the end of the war. These projects were continued after the war by local programmes for the protection of towns and villages on their own initiative.

The Rockefeller Foundation decided in 1915 to address the malaria problem, which was defined as "the most serious medical and sanitary problem with which we have to contend", and between 1915 and 1919 it funded four cooperative malaria experiments in Mississippi and Arkansas, and also supported the United States Public Health Service in organizing "Cooperative Malaria Control Demonstrations" between 1920 and 1922.

Rose, Director of the International Health Board, concluded in 1919 that "the practical measures for fighting malaria, then, are clearly indicated: (1) to eliminate Anopheles by preventing their breeding; (2) to screen the houses against this mosquito; (3) to sterilize by quinine the blood of human malaria carriers. In a given demonstration one or all of these methods may be used, according to local conditions" (Russell, 1955).

An important project during Roosevelt's "New Deal" was the overall development of the Tennessee River basin, which included the Tennessee Valley Authority Malaria Control Programme, which set the methodology for malaria control in impounded waters (TVA, 1947) and was followed by a number of local water management and drainage programmes.

Russell (1955) emphasized the role of vector reduction, including the eventual use of DDT, in the control of malaria in the United States. He considered that organized anti-vector measures had considerably accelerated the disappearance of malaria, which was due to a complex of causes, including the substantial economic advances which were made in the South and commented that "These (economic advances) have brought about much greater use of screening and of household insecticides such as pyrethrum spraying. Since 1930 hardly a house in the formerly malarious area has been without a 'flit-gun'. There has been notable improvement in quality and quantity of anti-malaria medication, and more frequent use of doctors. Quinine, which was $ 4 or more per ounce in the Civil War period, dropped in price to about 25 cents in 1913 and not long thereafter Bass's 'standard treatment' widely displaced the less effective 'chill tonics'. There has been a tremendous amount of anti-malaria and agricultural drainage. Le Prince in 1927 estimated that some 450 millions of dollars had been spent on farm drainage, and no less than 110 000 miles of open ditches, and 45 000 miles of tile drainage constructed. There has been a disappearance of mill-ponds and wide control of impounded waters. Finally, one notes vastly improved general and public health education, and a considerably expanded animal husbandry".

The growing influence of the malariologists of the Rockefeller Foundation, the success of their demonstration areas and the spectacular effectiveness of DDT created in the United States a conceptual prelude to the global eradication campaign, more as a result of a political than a scientific debate (Spielman et al., 1993). A necessary step was the final eradication of malaria from the United States by an active national campaign. Soper (1960) quotes, with satisfaction, that in 1945 the budget for the extended Malaria Control Program of the USA (which was to become in 1947 the National Malaria Eradication Program) was approved, while Henry A. Johnson was declaring in his Presidential Address to the National Malaria Society: "We are frequently reminded of the possibility of eradicating malaria in the United States, now that it is at a low ebb. I feel this is an untenable concept as we do not yet know in sufficient detail just where and under what conditions the disease occurs, or will occur in its last natural habitant. Possibly malaria will be eliminated but I much prefer to entertain the hope that we will build malaria out in our future developments and that we will attempt to 'reduce' rather than 'eliminate' it in its existing natural setting ... it is unwise ... to put malaria control operations into practice unless the disease is causing a measurable economic loss and unless the cost is in a measure commensurate with the economic ability of the people to pay".

That debate shows that the aggressive vector control, referred to as the American approach, did not represent even a majority opinion among the members of the National Malaria Society. Moreover, after the launching of the Global Malaria Eradication Programme, which may be

considered the consecration of that "American" approach, there were as many, if not more, critics of the eradication policy in the United States as in Europe.

An evaluation of malaria eradication in the United States (Andrews et al., 1950; Langmuir, 1963) concluded that malaria was really vanishing, but that the rapid decline during the late 1940s, which affected the trend of morbidity but not that of mortality, was mainly due to a change in the method of morbidity reporting by the States of Mississippi, in 1947, and South Carolina, in 1949, requiring the identification of malaria patients. The inception of the National Malaria Eradication Program did not actually show any measurable effect **(Figure 3)**.

1.3.6. The recognition of spontaneous disappearance

> *... The reason, as a merry fellow told me, who said he had had about a dozen and a half of wives (tho' I found he fibb'd a little) was this: that they being bred in the marshes themselves, and season'd to the place, did pretty well with it; but that they always went up into the hilly country, or to speak their own language into the uplands for a wife: that when they took the young lasses out of the wholesome and fresh air, they were healthy, fresh and clear, and well; but when they came out of their native air into the marshes among the fogs and damps, there they presently chang'd their complexion, got an ague or two, and seldom held it above half a year, or a year at most; and then, said he, we go to the uplands again, and fetch another.*
>
> ***Daniel Defoe: Tour through the whole Island of Great Britain 1724-1726***

Malaria had been highly endemic in some limited areas of Central and Northern Europe and the United States, but had disappeared from most of these areas without any organized specific public health action against it; such apparently spontaneous disappearance has been the object of heated debate. It is true that the geographical distribution of malaria before the end of the nineteenth century is based on imprecise information and that the terminology used has been the subject of diverse interpretations. Nevertheless, the coincidence of summer and autumn ague or marsh fevers with areas of extensive marshes of brackish water, where *Anopheles atroparvus* still breeds in high densities, are strong arguments for considering them as malaria. In 1655 5 257 deaths were reported in England as caused by "fever and ague" while by the beginning of the twentieth century malaria mortality was zero and only a few cases were occasionally diagnosed. Malaria had also been endemic in many areas of France, such as the lowland marshes in Flanders, the low valleys of the main rivers, such as the Somme, Seine, Loire, Gironde, Charente, Garonne and Rhône, the Landes, the Vendée, the Camargue and certain areas of the interior such as Bresse and les Dombes -- where the population was so affected by malaria around the numerous swamps that it prompted the promulgation of a law in 1821 requiring the filling in of all pools of stagnant water, which state agents could undertake and then charge the landowner. Malaria had spontaneously disappeared from most of these areas and although many of them suffered epidemic outbreaks between 1918 and 1921, they again disappeared without specific organized antimalarial measures. Marchoux (1926) attributed this disappearance to the general improvement of living conditions, including housing, clothing, stabling of animals, health care, nutrition and so forth.

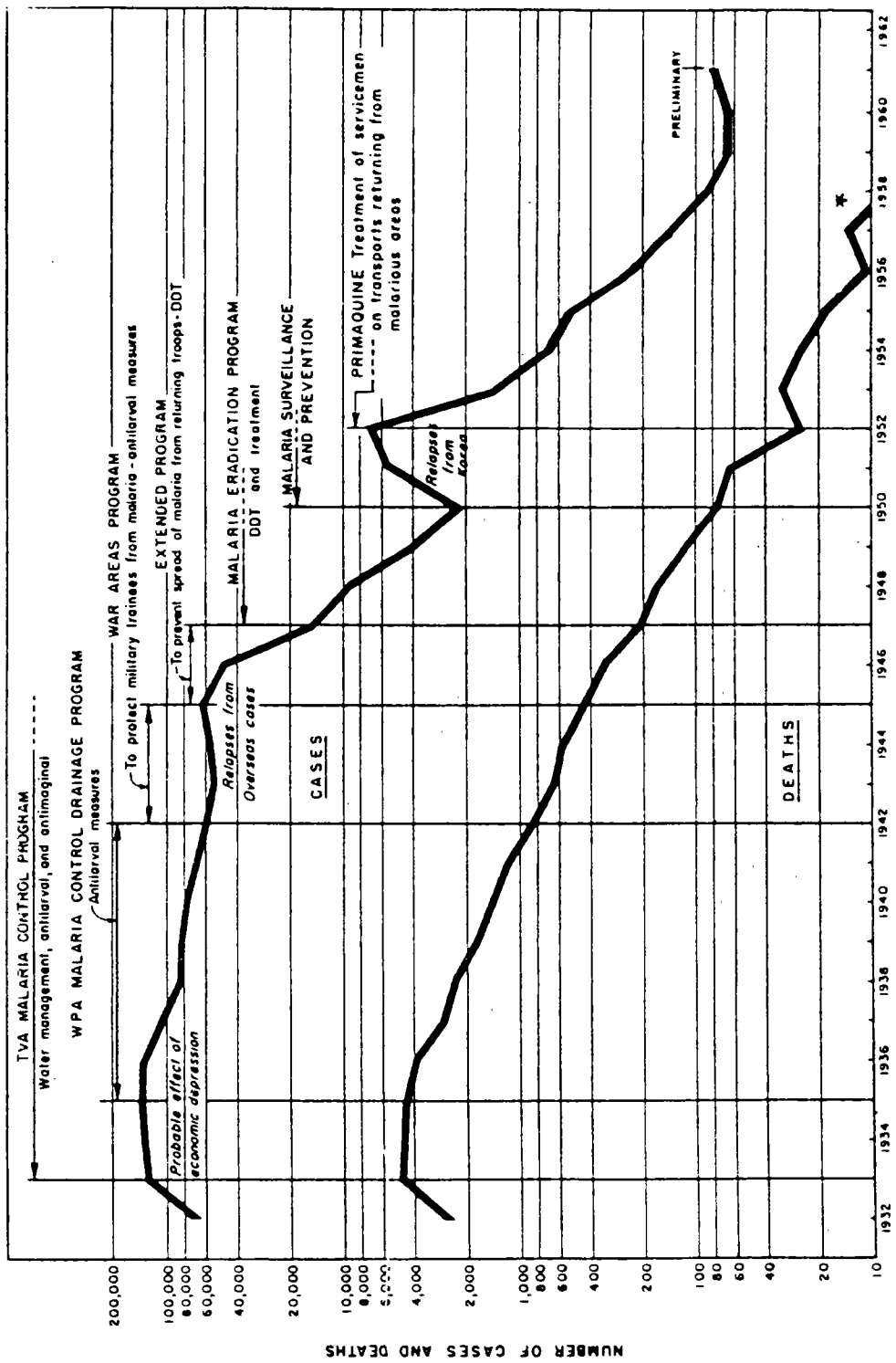


Fig. 3 Reported Malaria Morbidity and Mortality in the United States, 1932-61

James (1929), after considering each factor which had been thought to have some influence on the disappearance of malaria from England, came to the conclusion that "the diminution of local malaria in England was due neither to natural causes nor to the intentional application of any particular preventive method reputed to be specific, but to progressive improvements of a social, economic, educational, medical and public health character".

Although no preventive method was consciously applied by a health authority, the "progressive socioeconomic improvement" included many changes which can be recognized as having had a direct impact on reducing malaria transmission, many of which were consciously applied by individuals and communities. Indeed, some became official policy of general sanitation, like the French law of 1821 mentioned above; it is not clear how extensively the law was enforced, but its promulgation is an indication of public concern about marshes, in tune with Lancisi's recommendations of 1717, which made drainage an individual and community concern, independently of the existence of specific laws. Equally, if not more important, was the improvement of houses and the separation of dwelling quarters for humans and animals as well as the wider availability of cinchona and eventually quinine. Bonservizi (quoted by Hackett, 1937) had recognized as early as 1903 that the preference for animal blood had brought about a dissociation between man and the mosquito, once domestic animals were well stabled.

The apparently spontaneous disappearance of malaria from many areas may stem from the previous expansion and intensification of transmission as a result of the extension of agriculture and large-scale population movements caused by the industrial revolution, together with population growth since the end of the eighteenth century; eventually, as the human ecology became stabilized, malaria transmission declined. A similar, but more intense, expansion of transmission could have occurred in the United States with the colonization of the West and the movements of population resulting from the Civil War. Barber (1929), discussing the disappearance of malaria from the country, wrote: "It would seem *a priori* that where so great a fire has burned and gone out of itself, there must have been a lack of suitable fuel. It is plain how closely the prevalence of malaria was associated with pioneer life and its decrease with the agricultural development of the country".

A study of the malaria epidemiology and control efforts in Spain's Ebro delta, under the auspices of the League of Nations, showed that malaria had dramatically increased as a consequence of the expansion of rice cultivation and colonization which followed the construction of irrigation canals in 1862, 1912 and 1919-20, without appropriate drainage. Malaria decreased in the intervals, and finally responded to the establishment of a network of antimalarial dispensaries during the 1920s, with the practical disappearance of pernicious malaria, as well as that of severe anaemia and splenomegaly, while the numbers of cases of the benign tertian form remained stationary (Cartañá et al., 1933).

1.3.7. The new school of malariology and the strategy of the Malaria Commission

> *The Commission has always insisted that the fight against malaria must be waged not as a separate and isolated task but as part of a general social, economic and sanitary campaign by an enlightened public health service which is able to obtain assistance from other Government departments and from unofficial agencies, and to secure continuity of action and unity of purpose.*
>
> **League of Nations: Second General Report of the Malaria Commission (1927)**

By the end of the 1920s, those doubting that anopheline control could solve all malaria problems saw themselves as representing a *new school of malariology* (James, 1930; Gill, 1930) which emerged in clear confrontation with the prevailing views (Editorial, 1930). The *new school*, represented by the Malaria Commission of the League of Nations and including James, Swellengrebel, Pittaluga, Gill, Sanarelli and Senior-White, considered that the great variability of local conditions required study to find appropriate methods of control, the only practical generalization being the recognition that malaria control was only a part, even if a very important part in some areas, of health improvement and socioeconomic development, which could be promoted by strengthening health care services. The *old school*, championed by Ross and Watson (Ross, 1930; Watson, 1930), insisted that the only valid malaria control was the reduction of transmission, through specific measures of vector control and environmental sanitation, and that lack of progress was due to inadequate implementation.

The Second General Report of the Malaria Commission (1927) came to doubt that the discovery of the transmission of malaria by mosquitos had made a very important contribution to malaria control, and James (1930) said that the simplistic view of equating malaria and vector control had quasi-paralysed the fight against malaria for 30 years.

Malariologists in the United States continued, nevertheless, to equate malaria control with anopheline control. In 1927 the Malaria Commission sent two very experienced and competent malariologists (S.P. James and N.H. Swellengrebel) in 1927 to study the situation in the United States. Their report said in substance that malaria was decreasing at a constant rate from north to south, a course which had begun, like that of other social diseases, before active measures had been taken against it. This report created a serious controversy because malariologists in the United States considered it unjust to the great and costly accomplishments in draining and protection and, as Hackett (1937) notes, the report was merely circulated in mimeographed form and was not officially published to the world.

Summarizing the world experience up to that time, the Second Report of the Malaria Commission said in 1927: "The history of special antimalarial campaigns is chiefly a record of exaggerated expectations followed sooner or later by disappointment and abandonment of the work. This record of failure and disappointed hopes makes it clear that the only prospect of real progress lies in renewed activity in the continuous study of the disease in all its aspects". The Malaria Commission adopted the view that the feasible approach at the time was to strengthen the private and public health sector in order to reduce mortality and the duration and severity of the disease; it considered that malaria was impregnable to frontal attacks but would eventually succumb after improvements in the social condition of people living in malarious areas (Malaria Commission, 1927).

1.3.8. Early detection and control of malaria epidemics, study of risk and epidemic forecasting

These important elements of any malaria control strategy received particular attention from those malariologists who did not consider permanent vector control a feasible proposition for most of the areas at risk. The Malaria Commission, therefore, promoted and supported the development of epidemic forecasting methods suitable for different epidemiological situations.

Christophers had studied the great epidemic of 1908 in the Punjab, which affected a population of some 30 million in an area of 500 000 square miles. He showed that similar epidemics had occurred in the same area at intervals of about eight years, and devised a method of mapping the spread of these epidemics by calculating an *epidemic figure* involving dividing the deaths recorded during the month of greatest epidemic prevalence by the normal monthly mortality; these figures calculated by registrar unit (thana) were mapped and lines of equal mortality drawn, showing the extent of each epidemic. He found a high correlation between fever and rainfall (0.67, probable error 0.168), but much higher when an indicator of hunger (the "human factor", indicated by the price of food grains) was introduced; the correlation coefficient between fever and the product of prices and rainfall was 0.80 (probable error 0.099). Further studies by Perry, and by Gill in 1914, showed that the spleen rate dropped considerably after an epidemic and that epidemics were largely due to the low endemicity during the inter-epidemic periods, leading to an absence of immunity in children as well as a general decline of immunity in the other age groups (Christophers, 1949). These epidemics not only showed a certain periodicity but always affected parts of the same general areas and were therefore designated as "regional epidemics".

Christophers and Bentley, in 1908, described the serious epidemics due to the admixture of immunes and non-immunes living under the miserable conditions of labour camps in highly labour-intensive economic projects in the tropics; they coined the term *tropical aggregation of labour* to designate these conditions, which they considered were associated with a high risk of epidemic malaria. They may have contributed to the serious malaria epidemics in Mauritius, that occurred after the original epidemic of 1865 following the introduction of *Anopheles gambiae* (Julvez et al., 1990); as Christophers comments, "it is probable that the conditions in Mauritius, sometimes ascribed to introduction of *Anopheles gambiae* from the African continent, were really due to large-scale importation of labour from India which occurred about this time in connection with sugar planting" (Christophers, 1949).

Following the study of the malaria epidemic of 1921, Gill was requested to elaborate a **system of epidemic forecasting**, which was approved and established in the Punjab (Nicol, 1938). Forecasting continued, following Gill's recommendations, up to the mid-1940s, based on the study of four factors:

(a) a **rainfall factor** measuring the July-August rain in 192 recording stations, which gave an indication of the transmission potential; only rainfall was used because humidity was recorded only in 10 stations in the Punjab, which showed a very close correlation between rainfall and humidity in July-August;

(b) a **spleen-index factor** given by spleen rates in schoolchildren in 286 representative communities during the previous two or three, and eventually five years, which gave an indication of the immunity status and therefore of the areas more likely to be affected by an epidemic;
(c) an **economic or human factor** given by the average price of food grains during the preceding two years; although not a direct cause of an epidemic, famine and stress have a high influence on its severity and intensity; and
(d) an **epidemic potential factor** for each locality (registration centre), giving a coefficient of variability, calculated by multiplying the standard deviation of the October fever mortality for the years 1868-1921 (excluding 1918) by 100 and dividing it by the number of observations (53 years); this coefficient varied from 31 in Kangra to 106 in Sialkot.

The first factor, indicating the imminent risk of increased transmission, was actually a determinant factor, while the other three factors signal the expected impact and spread of an epidemic.

The actual intensity of past epidemics was gauged by the **epidemic figure**, which was redefined as the quotient of the mean monthly fever mortality in October-December over that of the four months April-June for the same year; this figure would not exceed 1 in inter-epidemic years, but could be as high as 10 in epidemic years.

Gill also used a **diffusion index**, the number of registration centres in a district with an epidemic figure over 2.5, and an **intensity index**, the percentage of registration centres with an epidemic figure over 5.0.

The imminent risk was indicated by the rainfall factor which, although it gave only about one month's warning from its detection in August and the expected start of the epidemic in September, was extremely useful for preparing emergency relief, provided there was an appropriate organization to deliver it. The emergency action included: (a) the provision of adequate supplies of quinine by special relief units to the villages at risk, and (b) the provision of supplementary essential foods, particularly milk for infants, and other public services, since epidemics were likely to disrupt the whole life of the communities and the high mortality was often not only the direct but a secondary effect of the disease (Christophers, 1949).

Regional epidemics were also described in many subtropical areas, from Ceylon to South America, where they appeared as periodic exaggerations of normally short and weak seasonal transmission. Gabaldón (1946), describing the regional epidemics in Venezuela, identified two indicators, the *ratio of epidemicity* and that of *endemicity* which, when applied to longitudinal data, permitted the identification of the **epidemic potential** of an area. In Venezuela he was able to describe a **paraquinquennial cycle**, distinguishing the *one-peaked* epidemics due to *Anopheles albimanus* which followed the typical pattern of epidemics due to abnormal rains, from those due to *A. darlingi*, generally *two* or *three-peaked* epidemics. The latter occurred in areas of very low population density, and Gabaldón attributed this pattern to the low population density (32/km^2) which did not permit the infection to reach all the people in one season, which required two or three years (see also § 4.6).

Stimulated by the severe epidemic in Ceylon of 1934-35, the Malaria Commission decided in 1937 to draw the attention of Health Administrations to the "urgent necessity for carrying out research on the subject of great malaria pandemics, not only during the epidemic but also prior to its outbreak" (League of Nations, 1938). It circulated the description by Covell (1938) of the "Methods of forecasting and mitigating malaria epidemics in the Punjab", and after reviewing the studies by Christophers and Gill, as well as a report by Parrot and Catanei (1939) about the determining factors of epidemics in Algeria, it gave its support to the work in Punjab. It recognized that the main determinant of an epidemic was a break of the equilibrium between infection and immunity, and recommended that forecasting be based on the monitoring of hygrometry and pluviometry, the evolution of the splenic index, the economic factor and the **epidemic potential** (the coefficient of variation of mortality established during as long a period as possible) (Organisation d'Hygiène, 1939).

Nevertheless, the human or economic factor was slowly being neglected in the Punjab, in part -- as Zubbrig (1994) notes -- because the selected indicator (grain prices) became less fluctuating, losing its value as an indicator of hunger, but perhaps also because of a tendency of malariologists to explain all the epidemiology only in terms of cases, parasites and vectors. The submission of Parrot and Catanei discussed only the influence of premunition, and the detailed study by Covell and Baily (1932) of the regional epidemic in Northern Sind in 1929 does not even mention the human factor.

1.3.9. The revival of vector control, the integrated transmission control or **bonifica integrale**

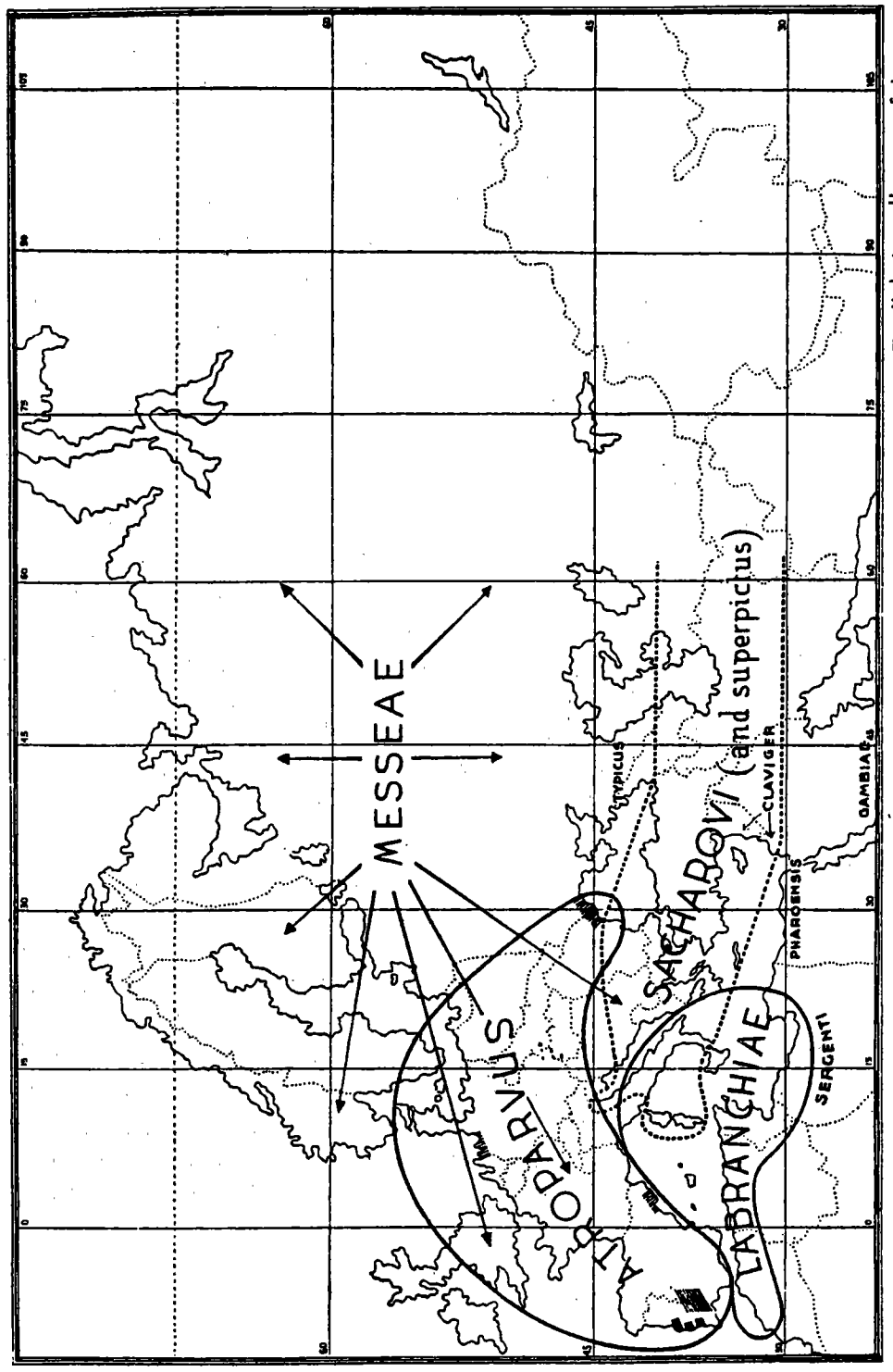
The Rockefeller Foundation, which supported the Malaria Experimental Station in Italy between 1924 and 1934, sought to demonstrate that malaria control in Italy, as elsewhere in Europe, could best be achieved by anti-vector measures rather than by the organization of case treatment and prophylaxis with quinine or other drugs.

The Malaria Experimental Station was concerned with the great variability of the malaria problem in apparently similar ecological settings. As Hackett (1957) comments, "Why should malaria disappear permanently from the plain of Naples and the adjacent valley of the Sarno, located between two notoriously unhealthy regions to the north and south of them, or from the Ligurian coast or southern Tuscany (in close touch with the notorious Maremma) or in Jolanda di Savoia, a small central zone of the malarious Po delta -- all islands surrounded by a sea of malaria -- and still remain inextinguishable in Emden and around Amsterdam? Similarly, why efforts to support socioeconomic development in the absence of malaria control failed in some areas while in others seem to have been the cause of the disappearance of malaria?". Those failures had been particularly numerous in the attempts to cultivate the Roman Campagna. As an example, Hackett mentions the tragic experiment of an Italian fruit canner, Mr Cirio, to establish a model agricultural colony of Venetians on the fertile Pontine Marshes in 1897; the local doctor wrote: "It was enough to move one to tears to see those robust colonists come down from their mountains in the pink of health, only to fall stricken with the thunderbolt of pernicious malaria against which neither the generous living provided by Cirio, nor the quinine which I distributed with open hands, was any barrier".

The problem of *anophelism without malaria*, which had dominated malaria research in Europe for decades (Fantini, 1994), was finally solved by the discovery that *A. maculipennis* was actually a complex of species which could only be morphologically differentiated in the egg stage (Missiroli et al., 1933). Its vectorial ability ranged from the very efficient *A. sacharovi* and *A. labranchiae*, through *A. atroparvus* and the poor vector *A. messeae*, to the non-vector species *A. maculipennis s.s.* Hackett (1937) therefore explained the "spontaneous" disappearance of malaria from some areas, while stubbornly clinging to some other, even quite prosperous areas, by stating that "as a result of a more scientific agriculture the map of malaria in Europe is thus steadily contracting toward the limits set for it by the spread of the anophelines which we have defined as inherently dangerous. Beyond this there can be no further 'natural regression'". That limit was the distribution of the major vectors *A. labranchiae* and *A. sacharovi*, while malaria had disappeared spontaneously from the areas of distribution of *A. messeae* and had resisted, but eventually subsided, in some foci of *A. atroparvus* **(Map 2)**.

The biological explanation of the problem of anophelism without malaria made vector control appear again as a practical proposition and the means of overcoming the limits set by the presence of the inherently dangerous species of *Anopheles*. Armed with all the accumulated knowledge and the dictatorial authority of the fascist government, Italian engineers succeeded in draining and reclaiming the notorious Pontine Marshes and the Roman Campagna between 1930 and 1940, reclaiming some 81 000 ha of farmland, building three new cities and establishing more than 50 000 colonists. As Russell (1955) says: "In addition to the advantages of modern tools, Mussolini's engineers had the intelligent help of public-health physicians who knew not only the cause of malaria and the facts of its mosquito transmission, but who also realized that drainage alone will not control malaria in Italy where the vector insect finds canals and ditches highly suitable breeding places. So larviciding, screening, and the use of antimalarial drugs were skilfully integrated into the bonification scheme".

Failures to control with larviciding and quinine some severe seasonal malaria epidemics transmitted by *A. gambiae* and *A. funestus* in South Africa suggested to Park Ross the need to use a more rapid agent. Pyrethrum had been used as an insecticide in a few isolated instances and, during the 1930-31 season a trial of systematic spraying was organized in one village and a large-scale trial of weekly spraying was carried out during the 1932-33 season; the results were so good that this was adopted as the main control measure during the season 1933-34 for the whole epidemic area. The method received the support of de Meillon in South Africa and was selectively used by Swellengrebel in the Netherlands in 1934, and by Covell, Mulligan and Afridi in India from 1936. The results were thoroughly discussed at the League of Nations Pan-African Health Conference in Johannesburg in 1935 (Park Ross, 1936) and widely circulated by the Malaria Commission.



Map 2 Distribution of the malaria vectors of the western palearctic region: four members of the *maculipennis* complex, and secondary vectors of other species

Politicians had not found attractive the slow developmental strategy of the Malaria Commission, always preferring the promises of full and relatively rapid solutions made by the vector control enthusiasts, so they were ready to extrapolate the new successes of vector control to other areas. This attitude responded not only to the political appeal of short-term solutions but also to the public demand for quick action, under the influence of the great publicity given to the success of controlling malaria in Panama, the Roman Campagna and to the construction of roads and railways through highly malarious areas, including in the tropics. An example of public pressure may be illustrated by the following comment in the Report of the Civil Medical Service in Dutch East Indies for 1911-1918: "Indeed compelled by the 'God-Sakers' (as people, who keep on urging *"for God's sake let us do something"* are called in British India) extensive grounds have been cleared of jungle and bushes, at the cost of much money and labour, in the hope of freeing the district of malaria with no other result than that the malaria was seen to spread with unabated violence, and that moreover the funds reserved for the combating were lost" (Civil Medical Service, 1920). Pushed by public demand, many public health workers had undertaken unnecessary drainage or filling works, prompting even such an advocate of vector control as Sir Malcolm Watson to say that "a malariologist need not necessarily suffer from hydrophobia" (Hackett et al., 1938).

Malariologists often found it difficult to convince politicians of the limited applicability of the methods used in development projects to endemic areas. Dr Bagster Wilson and his wife, malariologists from East Africa who were sent to observe effective malaria control in India, commented in their joint report: "The only examples of effective malaria control that were shown to us were those conducted by private or semi-private enterprise ... The work on the Bengal-Nagpur Railway was a revelation of what can be done in intensely malarious country, given sufficient inducement coupled with persistence, ingenuity and unfailing resource. But the cost (sums such as three thousand rupees per annum for a single small station) was a further discouragement to any thought of applying such measures in poor rural areas" (Wilson & Wilson, 1936).

1.3.10. Man-made malaria, landscape epidemiology

> *Man-made malaria is a curse of the tropics, and much of it can be avoided. The breeding places may be created by digging large holes in the ground to obtain earth for road making; by faults in irrigation systems; by leaking taps in water pipes; by engineering works that interfere with the natural lines of land drainage. The correction of all these errors is usually much more difficult and costly than their prevention.*
>
> **Bruce-Chwatt (1985)**

> *Man as an individual is a puny animal, but as a species he has the force of a geologic process or a climatic shift.*
>
> **Bates, M., quoted by Hackett (1949)**

As mentioned above, man has often been able to modify its environment to make it more suitable for survival but in most cases environmental modifications were made in pursuit of short-term economic ends, often with total disregard of their health consequences; it is therefore quite common for economic development projects to contribute to the creation or enlargement of vector

breeding places or to an increase of man-vector contact. This creation of "man-made nurseries for vector larvae", as Russell called them, often results in the intensification or spread of malaria, generally referred to as "man-made malaria".

Russell (1952) listed as common sources of man-made malaria, without pretending to be comprehensive, "borrow pits adjacent to mud villages, or to highway, railway and canal embankments; brick pits and quarry pools; drainage obstructed by culverts, too high or too low, by fills for rails, roads and assorted construction projects; seepage-producing cuts; casual siting of villages, labour lines and military encampments; careless opening up of jungle; unnecessary seeding of a countryside with gametocyte carriers; poorly planned drainage or none at all; all sorts of man-made water-holding places like agricultural wells, garden pools, eaves gutters, cart tracks, cisterns and so on; uncontrolled impoundment of water for power, flood control, or other purpose. Finally, there is a vast amount of malaria directly due to improper handling and use of irrigation water. For example, sometimes great quantities of water will be brought into an area, but there will be no provision to take the water away. Thus, in Sind and elsewhere irrigation has resulted in water-logging with greatly increased malaria incidence. Waste irrigation water, over-irrigation, neglected channels, leaking sluice-gates, fallow fields unnecessarily wet for prolonged periods -- all are increasing the malaria problem in many places". Human activities may not only increase malaria risk but may also interfere with the feasibility of control; for example, since residual insecticides acquired their prominent role in malaria control, the indiscriminate use of insecticides in agriculture has constituted one of the main determinants of insecticide resistance of malaria vectors, particularly in areas of extensive cotton and rice plantations, making control considerably more difficult.

Efforts were made, particularly during the 1930s, to establish norms to govern engineering practices in malarious areas in order:

1. to avoid creating additional breeding places;
2. to determine how to correct errors once they were made;
3. to involve health authorities from the planning phase of the project.

Many such guidelines were established and were sometimes promulgated as compulsory legislation, although enforcement varied considerably from area to area, and local enforcement efforts were often abandoned after the launching of national malaria eradication campaigns.

The great variability of the malaria problems in the vast territory of the Soviet Union, and the requirements of central planning, led to recognition of the need to adapt malaria control to local conditions, following the principles of the theory of natural focality of human diseases first formulated in 1929 (Pavlovsky, 1964). Selection of control measures, even after the introduction of DDT, was strictly based on the epidemiological conditions of the areas according to what was called "landscape epidemiology", which meant not only considering the landscape as the physical ecology but also taking account of the social, administrative and political conditions which could have an influence on the malaria problem and on the applicability and effectiveness of control measures (Lysenko, 1960).

The principles of landscape epidemiology were applied to only a few malaria eradication programmes, but were the basis for developing the concept of stratification which, after 1978, became an important element in the redefinition of a malaria control strategy.

1.3.11. The medical and the public health approach. Value of achievements

> *It is better not to fall ill than to be cured.*
>
> **Lancisi (1717) quoted by Russell (1955)**

> *Le traitement des malades et des porteurs des germes reconnus par l'examen du sang ou par la palpation splénique doit, par devoir d'humanité, passer avant tous les autres mesures.*
>
> **Abbatucci, quoted by Bini (1926)**

As can be seen from the preceding discussion the history of antimalarial programmes during the first half of the twentieth century saw frequent confrontations between the so-called "American" and the "Italian" or European approaches to malaria control.

Although the development of the Italian *bonifica integrale* and the spectacular solution of the problem of the Roman Campagna seemed to tilt the balance in favour of vector control or, at least, of transmission control, the old Italian approach which gave priority to case management continued to be favoured by the Malaria Commission and most European malariologists. As mentioned above, malaria was seen as one of the many diseases affecting more intensely and severely the poor and rural populations. Malaria control was aimed primarily at the mitigation and eventual prevention of the effects of the disease through the provision of care for the sick and the detection and control of epidemics; transmission control was attempted by mobilizing individual and community participation in the improvement of disease management, irrigation practices and environmental sanitation. The role of the government was seen as promoter and supporter as well as validator and disseminator of knowledge, as coordinator and eventually, through legislation, as regulator, but only exceptionally as the executor of local activities.

This point of view is clearly expressed in the recommendations for malaria control in the report of the League of Nations Intergovernmental Conference of Far-eastern Countries on Rural Hygiene (Morin, 1937): "The future of the prophylaxis of rural malaria seems bound in the first place with the development of rural dispensaries planned as educational health centres and as centres for the local reduction of parasite infestation, and in the second place with the creation of a network of very simple experimental stations of anopheline biology which would allow of the institution of a service of epidemiological forecasts. The ultimate development of rural malaria prophylaxis in the Far East seems to depend both of making rural population 'prophylaxis conscious' and upon the further development of our knowledge concerning the behaviour of the insect vectors considered in relation to man".

Nevertheless, the so-called American school, represented by Hackett and the Rockefeller Foundation, continued to consider that case management was the domain of medicine and not of public health and that, therefore, malaria control should consist above all of prevention of infection through transmission control, mainly in the form of specific activities carried out by

organized health services. In Hackett's words, "if people are continually falling over the edge of a cliff, it is cheaper to build a fence around the top than a hospital at the foot".

Hackett was particularly vocal in minimizing the value of the improvement of general health brought about through giving greater access to opportune diagnosis and treatment by organizing, supporting and guiding disease care services and mobilizing community action. Commenting on the "European approach", he wrote "the basis of antimalarial work in Spain is supervised treatment of the sick. Quinine in fact appears here at its very best. One sees all the general advantages arising out of well-organized medical assistance – healthy-looking children, a lowered death rate, and the absence of *falciparum*. The trouble is, malaria does not disappear" (Hackett, 1937). A similar judgement is made about the enormous decrease in malaria mortality in Italy before 1930, as shown in the legend to the maps in **Figure 4**.

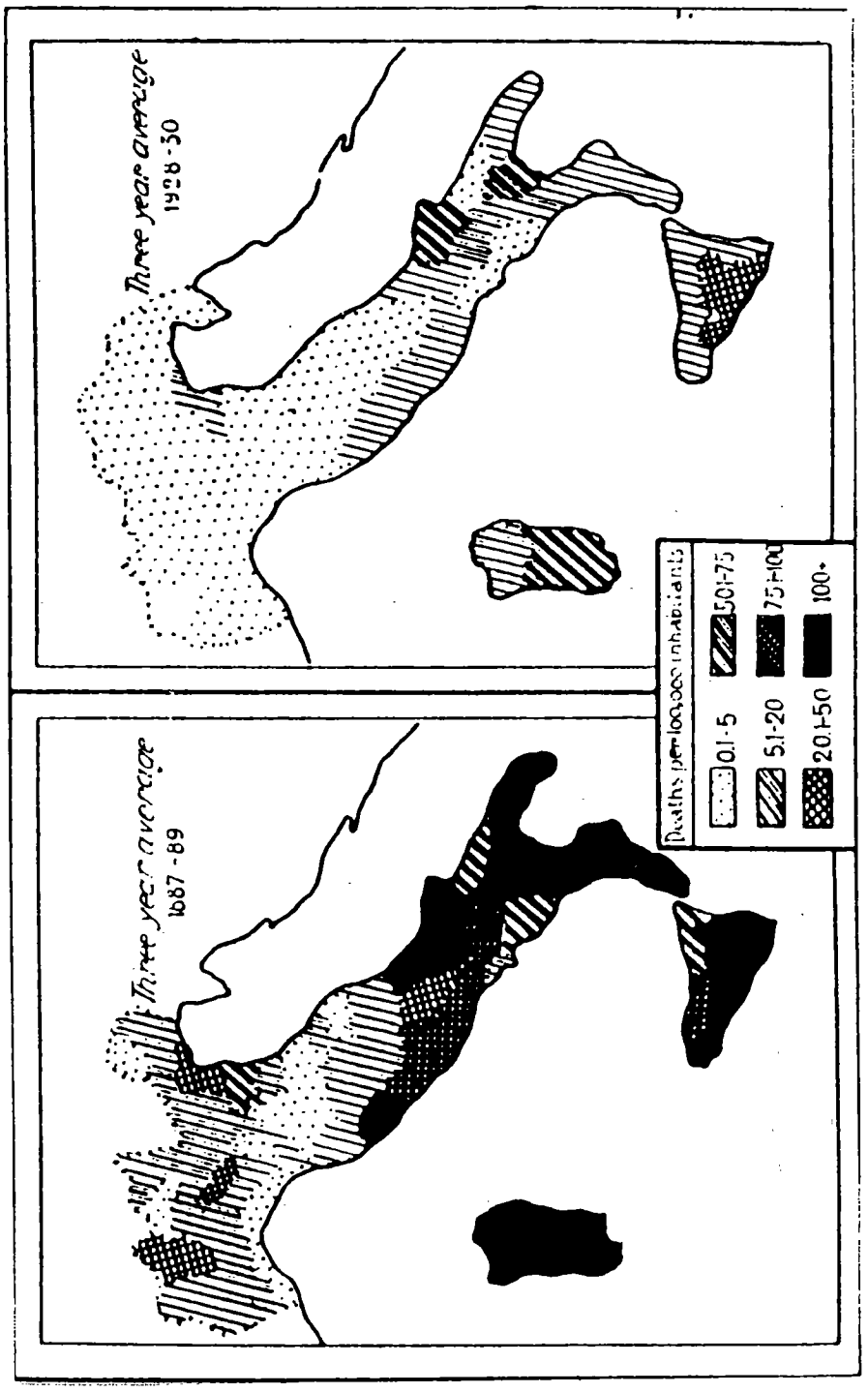
1.3.12. Achievements of malaria control before the advent of DDT

The first half of the twentieth century represents the most fruitful period in the study of malaria epidemiology and in the development of malaria control methodology. It can be divided into two main periods: the first two decades, when most control methods were developed and tested, and the period between the great pandemics of 1920-21 and the Second World War, which saw the development of large-scale malaria control programmes, the study of the diversity of malaria epidemiology and the development of pragmatic approaches to malaria control. Hackett said (1937): "There is no objection at all to using any combination of methods which seem expedient, and within one's means ... The objectionable thing is the shotgun method of applying them indiscriminately without knowing how far the cost of each is justified by results under local conditions. It is not rare to find inexperienced people attempting everything badly and accomplishing nothing ... But there is no *a priori* reason why simultaneous attacks on different fronts should not be better than a single offensive. Cromwell's order was: 'Neglect no means'".

Discussing the development of malariology during the second quarter of the century, Evans (1989) refers to it as the *epidemiology of minutiae*, somehow undervaluing the enormous progress achieved not only in malaria control but also in the development of health services, as the networks of malaria dispensaries set up in Southern Europe became the bases for the development of epidemiological and rural health services. The Rockefeller Foundation, which promoted vector control in Europe closer to the views of the "American school", became during this period an important resource for strengthening the technical competence of these services.

In fact, most of the countries which succeeded in eradicating malaria during the 1950s and 1960s were those which had developed national malaria control programmes in the previous decades and had built up the human and organizational resources which permitted the correct implementation of the new methods -- the use of synthetic insecticides and drugs -- based on an adequate understanding of their malaria problem and their variability.

Figure 4 DECREASE IN MORTALITY FROM MALARIA IN ITALY OVER A FORTY YEAR PERIOD



Source: Hackett, 1937

Examples of the success of malaria control before DDT are not only the improvements in general health and mortality figures shown in § 1.3.10 and Figure 4 but also the practical eradication achieved in Southern Europe, the Soviet Union and the United States before the Second World War **(Figures 5.1 to 5.4)** through sanitation and particularly through the widespread improvement of health services and their peripheral projection in the form of antimalarial dispensaries in highly malarious areas. It is interesting to observe the similarity in the evolution of the malaria problem in Spain and Italy, both of which suffered post-war epidemics, the former after the civil war (1936-39) and the latter after the Second World War campaign in Italy (1943-44). In both epidemics, the registered morbidity reached levels comparable with those attained in 1918 and both subsided quite rapidly, in Italy with the help of a DDT-spraying campaign, in Spain without. The most important difference was that, while the Spanish epidemic produced high mortality, the Italian did not, most probably due to the rapid mobilization of diagnostic and treatment facilities and the wide availability of drugs in Italy. Although the Italian success in controlling the post-war epidemic was widely used to promote the global malaria eradication campaign, many experienced Italian malariologists (e.g. Coluzzi, 1961) thought that it was mainly due to the satisfactory general antimalarial organization based on a solid health infrastructure.

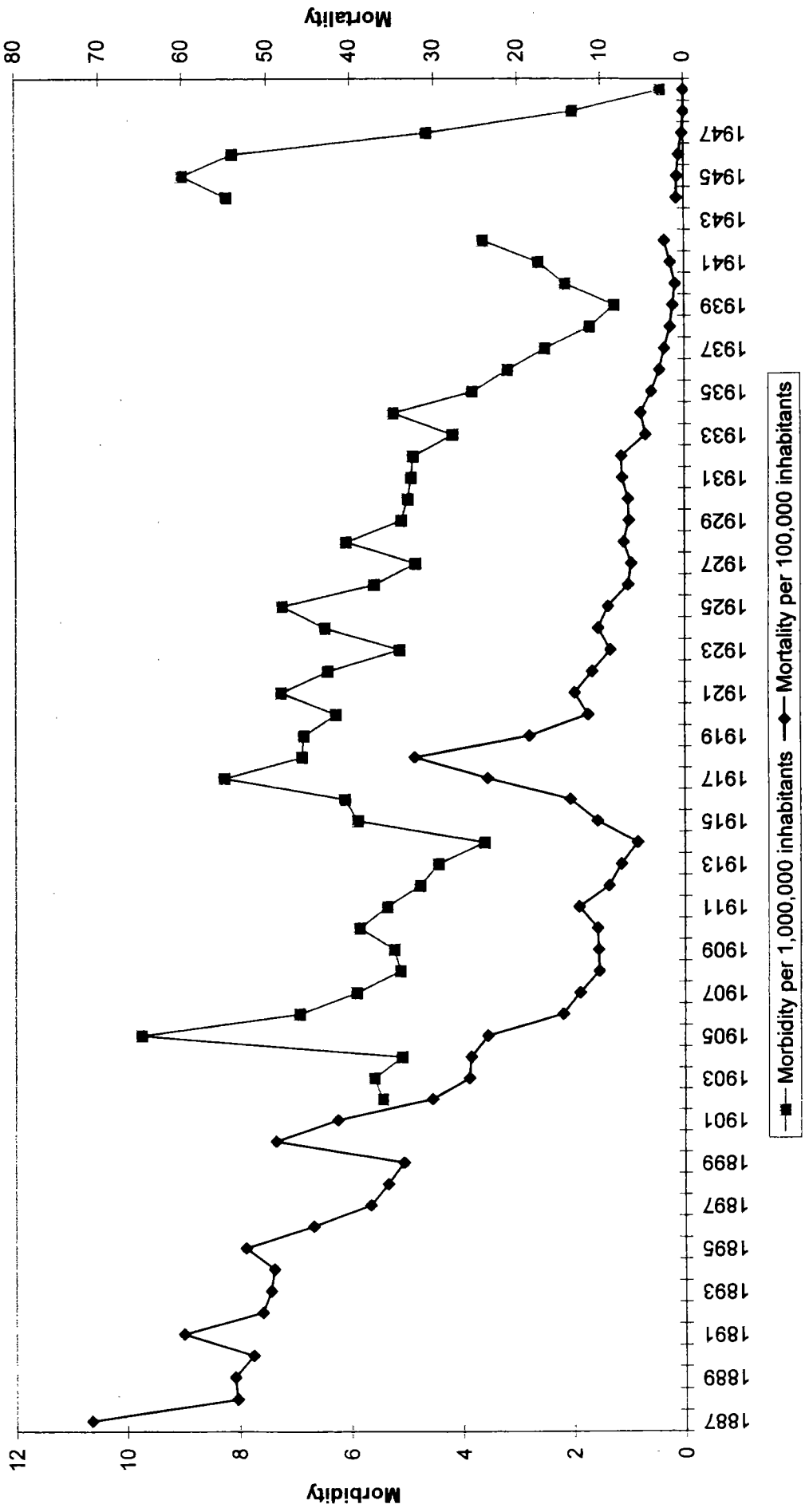
2. THE GLOBAL MALARIA ERADICATION CAMPAIGN

2.1. The genesis and launching of the global malaria eradication programme

The idea that it could be possible to eradicate malaria has its roots in the optimism which, at the end of the nineteenth century, surrounded the great discoveries in microbiology. Pasteur had said that it was within the power of man to rid himself of every parasitic disease, and Chapin declared in 1888 that any disease that could be prevented in part could be prevented in its entirety (Soper, 1970). As mentioned above, Hoffman presented in 1916 a "plea and a plan for malaria eradication in the Western Hemisphere".

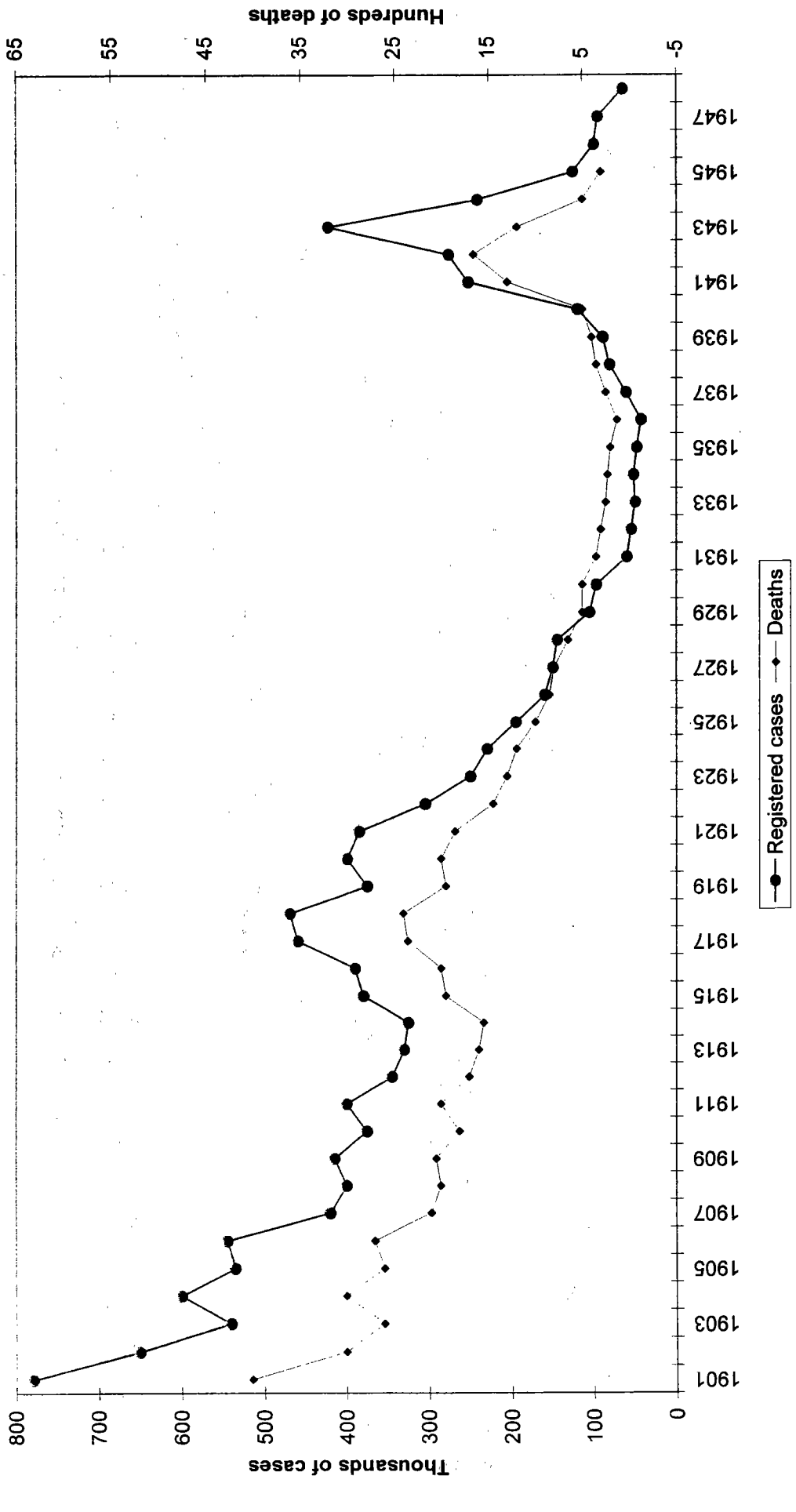
The Pan American Health Organization (PAHO) included malaria in the agenda of all Pan American Sanitary Conferences after the Third Conference in 1907, which discussed the problem and recommended to Member Governments a wide distribution of information on malaria, free distribution of quinine to the poor, the inclusion of malaria in the reports of the Port Health Authorities and the exemption from taxation of all products used in the prevention and treatment of the disease. As mentioned above, the work of the Rockefeller Foundation, the Malaria Commission of the League of Nations and national malaria control and research institutions had advanced the understanding of malaria epidemiology and obtained important successes in control.

Figure 5.1 Registered malaria cases and deaths in Spain (1901-1948)



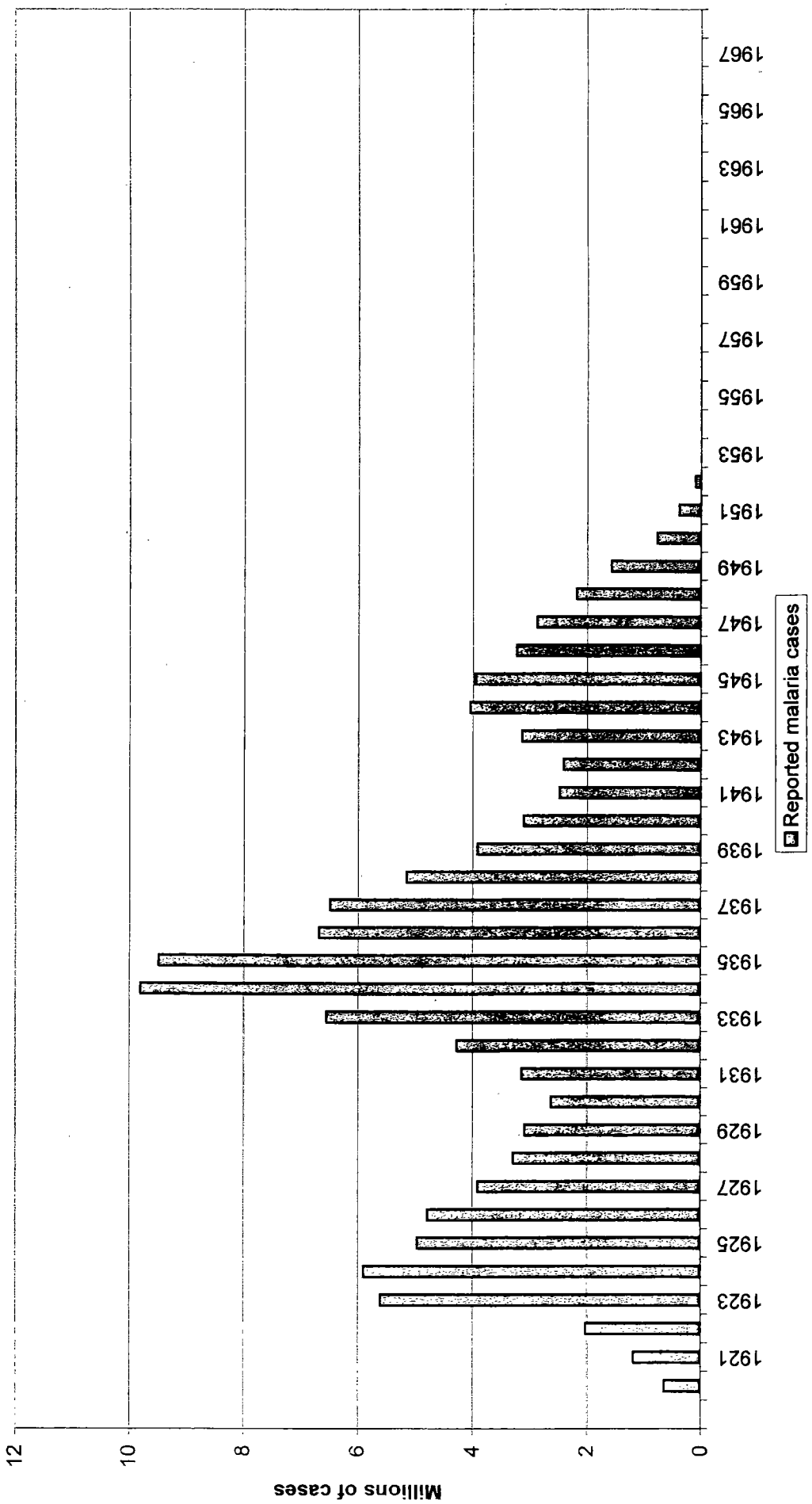
Source: Benn (1947) A.C.I.S. (1950)

Figure 5.2 Reported malaria cases in the USSR (1920-1968)



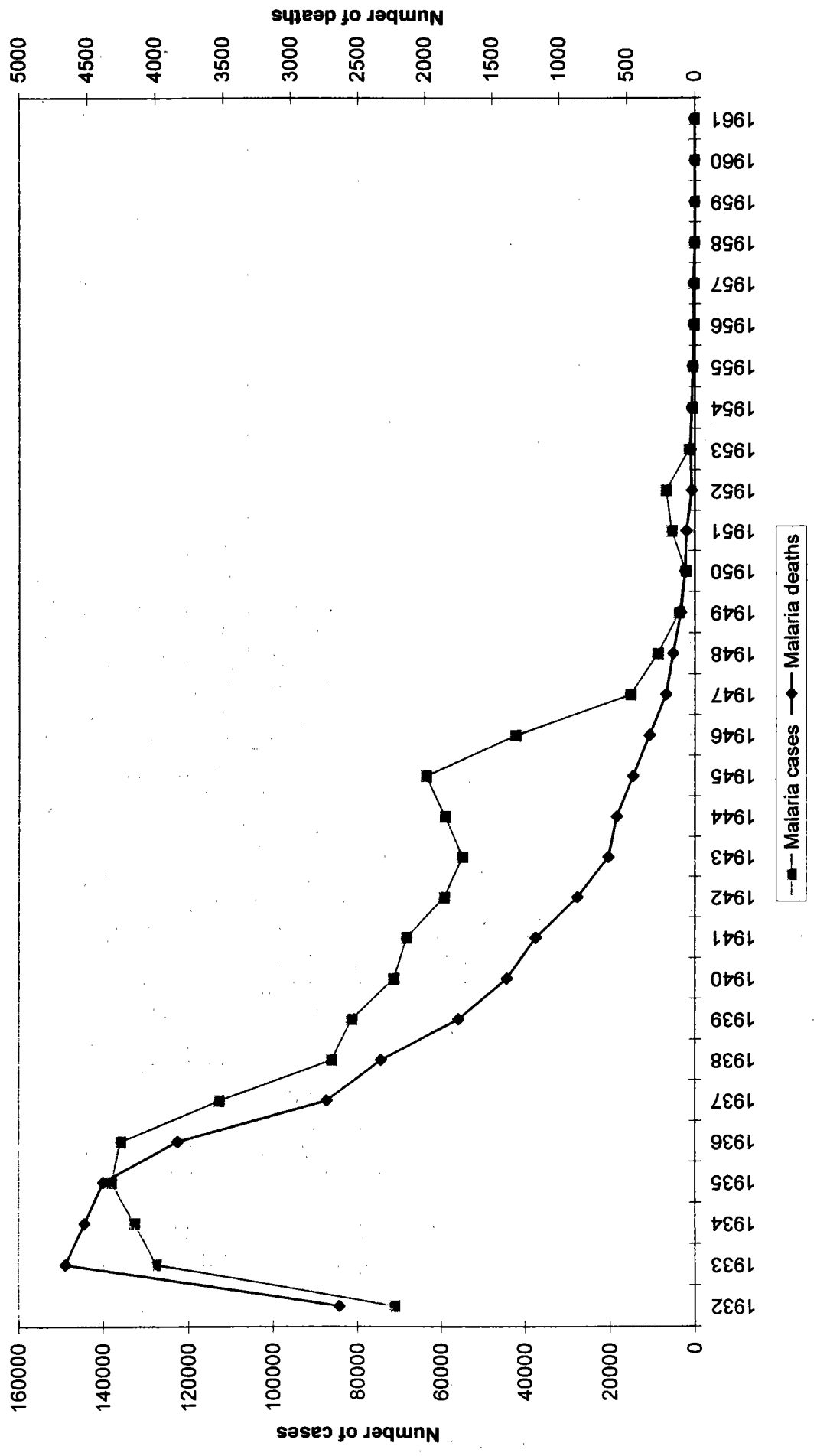
Source: Rico Avello Rico (1950)

Figure 5.3 USA



Source: Sergiev Duhanina, 1966 and Sergiev et al., 1969

Figure 5.4 REGISTERED MALARIA CASES AND DEATHS IN THE UNITED STATES (1932-1961)



Source: Langmuir (1963)

The discovery of the residual activity of DDT created the expectation that malaria control was within reach of most, if not all, countries, since transmission was eliminated in large areas of Italy, Cyprus, Greece and large areas of Venezuela and coastal British Guiana. Its use was rapidly expanded in the early 1950s. Greece had to reduce DDT spraying in 1951 due to financial restrictions, and since this proved not to lead to a resumption of transmission, it was concluded that spraying could be interrupted when the malaria reservoir had been eliminated from a large territory (Livadas, 1952). Similar observations were soon made in the United States and British Guiana.

Gabaldón, who had started to use DDT in Venezuela in 1945, said in 1952: "The malarial land has been traditionally a beautiful land arousing powerful attraction, but it has also been a treacherous land which charms only to kill and now, when we can possess it fully, we feel great rejoicing and admiration"; and again: "With no malaria our countries have enlarged their territories without detriment to their neighbours, and it is gratifying to point out that no military deed has ever produced among us so many territorial advantages". These quotations were later used by the UNICEF Regional Director for Latin America in his address to convince the Executive Board in 1954 of the need to support the malaria eradication campaign.

Nevertheless, some disappointing results were also reported. The Expert Committee in its 4th session (WHO, 1951) discussed the poor results in some areas of Africa and the Philippines, as well as the irritant effect on vectors observed with DDT in Africa and with BHC in Malaysia. Resistance of *A. sacharovi* to DDT was reported from Greece (Georgopoulos, 1951; Livadas & Georgopoulos, 1953). The 5th session of the Expert Committee (WHO, 1954) considered that the possibility of resistance, as well as the inactivation of the insecticide on certain mud surfaces, should not deter governments from embarking on malaria control, but it urged vigilance and appropriate study of the phenomena involved.

The danger of insecticide resistance suggested the need for rushing into a race to eradicate malaria before resistance to DDT (or other alternative insecticides) made the task impossible. As a result, governments and WHO were subjected to a growing political demand for eradication projects, which was better received in PAHO than in WHO -- still under the influence of the cautious scepticism of many European malariologists.

The Fifth Report on the Status of the Antimalarial Campaign in the Americas, presented to the Fourteenth Pan American Sanitary Conference (PSC) at Santiago de Chile in 1954, recalled that the previous conference had discussed "the technical and economic possibilities of co-ordinating a plan for the eradication of malaria in the Americas. In considering these possibilities, the aspects of epidemiology, organization, technical assistance, and the cost of an overall programme were analysed, and finally summarized as follows: five years after the introduction of DDT, two countries (Argentina and the United States) had almost solved their endemic malaria problem; two others (Brazil and Venezuela) were on the way to an early solution; and a fifth country (Ecuador) was vigorously pursuing the same goal; these five countries accounted for 75% of the dwellings in the malaria zone of the Continent; and the programs started in Central America and other countries with the aid of the Pan American Sanitary Bureau (WHO/PASB), and UNICEF would reduce the remaining figure to only 20% by the beginning of 1951. There was therefore a reasonable expectation that the balance would be covered in the following five years" (PASB/WHO, 1954a).

Nevertheless, after five years it was estimated that 22% of the inhabitants of malarious areas were still without protection, and it was concluded that the rate of progress had slackened, possibly due to: (a) a decrease of interest in malaria when its importance as a public health, economic and social problem had declined, (b) lack of financial support to expand the programme, (c) the weakening of the intellectual drive for the pursuit of routine field work, and (d) additional responsibilities taken on by the national malaria services, leading to a dissipation of efforts. The report insisted on the urgency of a coordinated eradication campaign in view of the danger of spreading DDT resistance (Alvarado, 1954).

An added argument was presented as "a compelling economic reason", namely that "the cost of operations of a program simply for the control of malaria amounts, in the long run, to a high figure, since annual expenditures must be made if low transmission indices are to be maintained. The cost of an eradication program, although high during a certain period, decreases with the relatively lower cost of the surveillance necessary to obtain the definite assurance that eradication has been achieved. Moreover, it is worthwhile recalling the well-known fact that the cost of a malaria eradication program is repaid in the long run, and with interests in the form of gains made in all aspects of living". It was pointed out that the Bureau required important additional personnel and financial resources, but it was recommended that "such funds should be considered as extraordinary, that is not subject to the regular budgetary processes, so as to permit long range planning and the administrative flexibility required to meet the various situations that might arise" (PASB/WHO, 1954a).

The Sanitary Conference was presented with a country-by-country estimation of the total costs of the campaign, based on two sprayings per year, although it was mentioned that Puerto Rico at least would require only one. It was also estimated that additional funds should be mobilized above the national contributions for malaria control in 1954; these additional funds varied widely for individual countries. The totals for the Americas were estimated, in relation to a contribution by the countries in 1954 of US$ 10 747 000, as follows:

Year	Estimated annual costs	Contributions by countries in 1954	Estimated additional funds required
1955	13 487 000	10 747 000	3 964 000
1956	20 392 000		9 671 000
1957	25 096 000		14 375 000
1958	25 966 000		15 245 000

The Fourteenth PSC then gave the Pan American Sanitary Bureau responsibility for supporting and coordinating the eradication of malaria from the Americas, and authorized its Director to obtain the financial participation of public or private, national or international organizations in support of the campaign (PASB/WHO, 1954b).

The UNICEF Regional Director for the Americas, addressing its Executive Board in 1955, stressed that "between malaria control and eradication there is as great a difference as that between night and day. Control -- now we have to face this conclusion, unpleasant as it may be -- is a primitive technique ... Now we know exactly -- at least we hope so -- the schedule of an

eradication campaign which will last four or five years, followed by three years of consolidation, after which it is possible to leave the campaign under the sole responsibility of the government, that is, without international assistance ... Actually, we can say that we have carefully weighed the risk and the outcome. On the one hand, indefinite repetition of expenditures facing a public opinion every time less convinced of the need of these expenditures, because it had grown too easily used to a state of relative health; on the other hand, a blow, once for all. On the one hand, a slow but sure approach to the point where our present insecticides would be useless; on the other hand, a race against this risk, with the almost certainty of reaching the goal before the critical point -- if we take into account the conclusive success attained in the United States, Venezuela, French Guiana, British Honduras, Argentine and many parts of Brazil. For us, and with a very thoughtful sense of responsibility, it is not possible to hesitate" (UNICEF, 1955).

Again in 1954, the Second Asian Malaria Conference meeting in Baguio (Philippines) recommended that the ultimate goal of nationwide malaria control programmes should be the eradication of the disease (WHO, 1956).

The following year the WHO Executive Board recommended the policy of malaria eradication to the Eighth World Health Assembly, and the Joint WHO/UNICEF Committee on Health Policy recommended to the Executive Board of UNICEF that it should support national and regional malaria eradication projects and should convert malaria control plans into eradication plans as soon as possible, making the required changes in policy.

In May 1955 the Eighth World Health Assembly, meeting in Mexico City, decided that the World Health Organization should take the initiative in providing technical advice and encouraging research and coordination of resources in implementing a programme whose ultimate objective was the worldwide eradication of malaria. The Assembly authorized the Director-General to obtain financial contributions for malaria eradication from governments and private sources, and established a Malaria Eradication Special Account.

The Global Malaria Eradication Campaign was approved by a World Health Assembly of 81 members, where Africa South of the Sahara was represented only by three independent countries, Ethiopia, Liberia and South Africa, and by the metropolitan governments of the colonial powers, Belgium, France, Portugal, Spain and the United Kingdom. The discussion was joined by eight delegates favouring the programme and seven expressing serious reservations, particularly Dr Togba from Liberia who, as quoted in the WHO Official Records, "considered that document A8/P&B/10 (Malaria Eradication Proposal by the Director-General) was certainly excellent propaganda but was not sure that enough thought had been given before it had been released to delegates. ... Large-scale malaria control might present no great difficulties in a relatively well-developed country like Venezuela or an island like Ceylon, but the magnitude of the task of spraying residual insecticides in every village of Liberia, in the face of bad communications and adverse weather conditions, could hardly be imagined unless it had been experienced... He thought that it would be ill advised to arouse the hopes of governments and run the risk of censure when results failed to come up to expectations". He also considered that the proposed appropriation of funds "was not even a drop in the ocean. The sum to be allocated to the African Region would not be enough to eradicate malaria from one large town".

The delegates of both the United Kingdom and France expressed serious reservations about the affordability and sustainability of the enterprise, and indicated their doubts on the implied urgency. Sir Eric Pridie (United Kingdom) said that "efficiency was surely more essential than haste" and proposed that the question should be further studied by the Expert Committee on Malaria. Dr Garcin (France) proposed that the financial side of the question should be approached from the regional point of view, seeing that, since Africa was practically excluded from the plan, it was not complete. Dr Duren (Belgium) supported both proposals. Replying to the discussion, Dr Russell (WHO consultant) emphasized that "whatever WHO decided to do, a campaign for world-wide malaria eradication was already under way". He agreed that "WHO should not proceed too hastily, but he also emphasized that it should not be left behind". He denied that Africa was excluded, even if there were more difficulties in Africa than elsewhere and said that "even if complete eradication was delayed in Africa, that region would certainly benefit from the programmes in other parts of the world ... On the financial question, he emphasised that studies had revealed that it was cheaper in the long run to plan for total eradication than to contemplate a continuous programme of amelioration. Naturally, the governments concerned would have to incur expenditure but WHO would assist in showing the most economic methods". He finally concluded that "it was important that WHO should maintain its leadership in the world-wide campaign to eradicate malaria and the Director-General was requesting only a very modest sum for that purpose".

The resolution was finally adopted by 46 delegates voting in favour, two against and six abstaining, although most serious criticisms continued to be voiced in private talks despite the overwhelming result of the vote (Gramiccia & Beales, 1988).

After the Assembly, even the colonial governments of Africa expressed disillusion at not having been consulted about the resolution. Moreover, as countries in Africa and the Western Pacific became independent, they realized their inability to pursue the eradication policies and their interdependence with their neighbours for success and maintenance.

The 6th session of the Expert Committee was devoted to the formulation of a malaria eradication campaign. It defined malaria eradication as: "**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**". Great emphasis was placed on the need for exceptionally good organization and planning outside the routine of the health departments. The feasibility of eradication was seen as dependent on good management, methods and money, and malariologists were cautioned against yielding to the attraction of research while neglecting the managerial and financial aspects.

The Committee defined the campaign as consisting of four phases: preparatory, attack, consolidation, and maintenance. The duration of the campaign was expected to be no more than ten years to reach the maintenance phase, which should continue as long as there was malaria in the world. The expected normal duration of the phases of the programme was no more than one year for the preparatory, three or four for the attack and three for consolidation phase. Interruption of transmission was expected to be achieved during the first year of attack and operations were to be continued for three years afterwards to ensure the elimination of the

reservoir, as it was considered that *P. falciparum* infections would die out in less than one year and *P. vivax* infections in less than three.

The Expert Committee recognized that "the problem of finding an effective and economical method of eradicating malaria in tropical Africa has not yet been solved", that this may be due to the "peculiarity of the habits of *A. gambiae*, the very long transmission season and the extremely high endemicity, complicated with restrictions of communications and the low level of development of administration" and that "indeed, these physical handicaps are likely to form an effective barrier to a large-scale eradication programme in this area and perhaps in other countries with comparable conditions". The Committee recommended "increased emphasis and assistance" to pilot projects in Africa, including combinations of residual spraying and chemotherapy.

In spite of the recognition by the Expert Committee, "from the political point of view, it is interesting to note that the 'temporary' exclusion of Africa from the eradication programme ... was neither mentioned in the resolution of the World Health Assembly that started the campaign nor in those of the following assemblies" (Gramiccia & Beales, 1988).

There was a conflict between the justification of the programme as a race against the development of insecticide resistance on the one hand and, on the other, the need for careful planning (based on adequate knowledge of the local epidemiological, ecological and social conditions) and a highly efficient organization to carry out the programme, which was clearly beyond the capabilities of most of the highly endemic countries. A solution was sought in oversimplification and standardization, despite the warning of the Expert Committee that there could be no rigid acceptance of details of procedure, because even small differences in the epidemiology of the disease might well make a great difference to the ease or difficulty of eradication and to the nature of the surveillance and emergency services that were needed (WHO, 1957).

2.2. Implementation of the global malaria eradication campaign

The political pressure which had forced the adoption of the programme precluded any selection of area priorities. The campaign was therefore launched everywhere at the same time, and soon most of the malarious countries in the Americas, Europe, North Africa, Asia and the Western Pacific declared their antimalarial programmes to be eradication campaigns, even if they did not meet the degree of perfection or of epidemiological knowledge required by the definitions of the Expert Committee. Such deficiencies were overlooked since it was felt that they could thereby obtain autonomy and be freed from the chronic apathy of the health services; moreover, international support had become available only for malaria eradication campaigns.

Contributions to the WHO Special Account for Malaria Eradication remained very meagre: between 1956 and 1963 44 countries contributed US$ 20.33 million, of which the United States contributed $ 17.5 million (86.1%), but contributions practically stopped after 1963, when that country ceased its contributions.

WHO assisted countries in preparing comprehensive plans of operations, provided technical assistance for implementing and evaluating the operations, and supported the training of professional and technical personnel. International Malaria Eradication Training Centres were established in all WHO regions for the training of senior professional staff and the local training of programme staff at all levels were given support. WHO also tried to coordinate the external inputs into national and intercountry programmes from the international assistance agencies collaborating with the global campaign, particularly UNICEF, USAID and the United States Public Health Service.

Pilot projects in tropical Africa reported success in interrupting malaria transmission in some forest areas (Liberia and southern Cameroon) and in high plateau areas of hyper- and mesoendemicity in south-western Uganda. In contrast, projects in savannah areas (e.g. northern Cameroon, Ghana, Nigeria, Tanzania) were unable to interrupt transmission and attempts at countrywide eradication (e.g. Ethiopia, Zanzibar, Zimbabwe) were hampered by serious problems of implementation. Even those countries where pilot projects had been successful could not expand the tested antimalarial activities, which were eventually discontinued even in the pilot project areas. As a result, tropical Africa remained excluded from the campaign.

Outside tropical Africa, success -- although slower than anticipated -- was at first remarkable. In the Americas and Asia, interruption or at least great reduction of transmission was being observed in most areas under the attack phase. Progress towards eradication was measured from the beginning by the steady advance of the programmes through the phases of the campaign. WHO established a registry of countries and areas which had achieved eradication, after confirmation by a special evaluation team whose report had to be approved by the Expert Committee.

Figure 6 shows the progress of the campaign during its first ten years, expressed as changes in the distribution of population in the originally malarious areas at each phase of the campaign, and **Maps 3 to 5** present the distribution of malaria in 1946, 1964 and in 1970. **Map 6** shows, for comparison the distribution in 1994. Both the distribution of the population by phase **(Figure 6)** of the programme and the geographical distribution of malaria **(Maps 4 to 6)** shows considerably fewer changes after the mid-1960s, with general stagnation of progress after 1965, although advances and retrogressions continued to occur on a smaller scale in many areas. Most of the entries into the maintenance phase (malaria-free or eradicated) shown in **Figure 6** correspond to countries which were well advanced in their malaria control programmes prior the launching of the global eradication campaign; this is confirmed by the list of countries where eradication has been certified by 1970 **(Table 1)**. After the first entry in 1961 for a large part of Venezuela, the procedures for entering into the WHO registry where changed so that only whole countries were included.

Nevertheless, as areas advanced into the consolidation phase of the programme, the expectation that a surveillance mechanism would be sufficient to keep those areas malaria-free after interruption of spraying was not fulfilled in many areas, and resurgences of transmission started to occur in areas in the consolidation and maintenance phase, necessitating reversion to the attack phase.

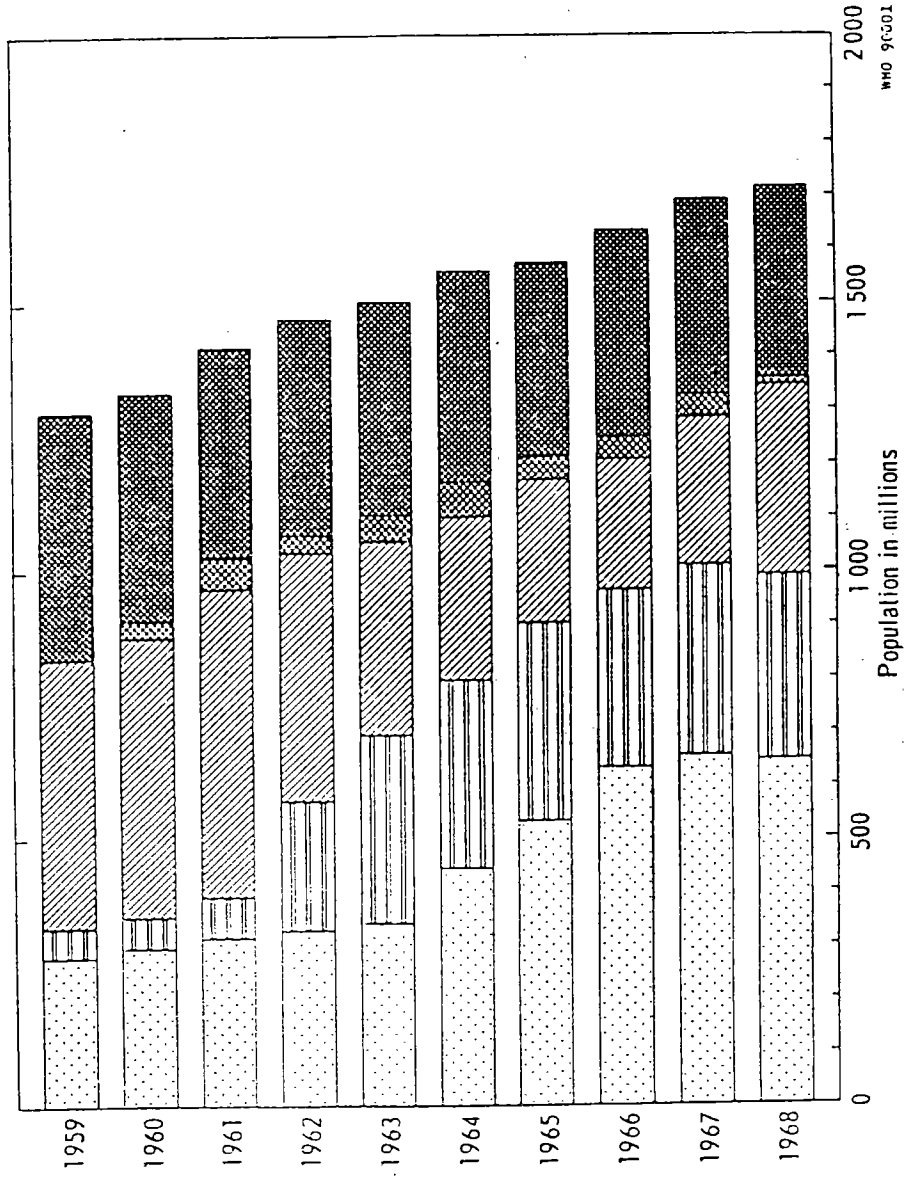
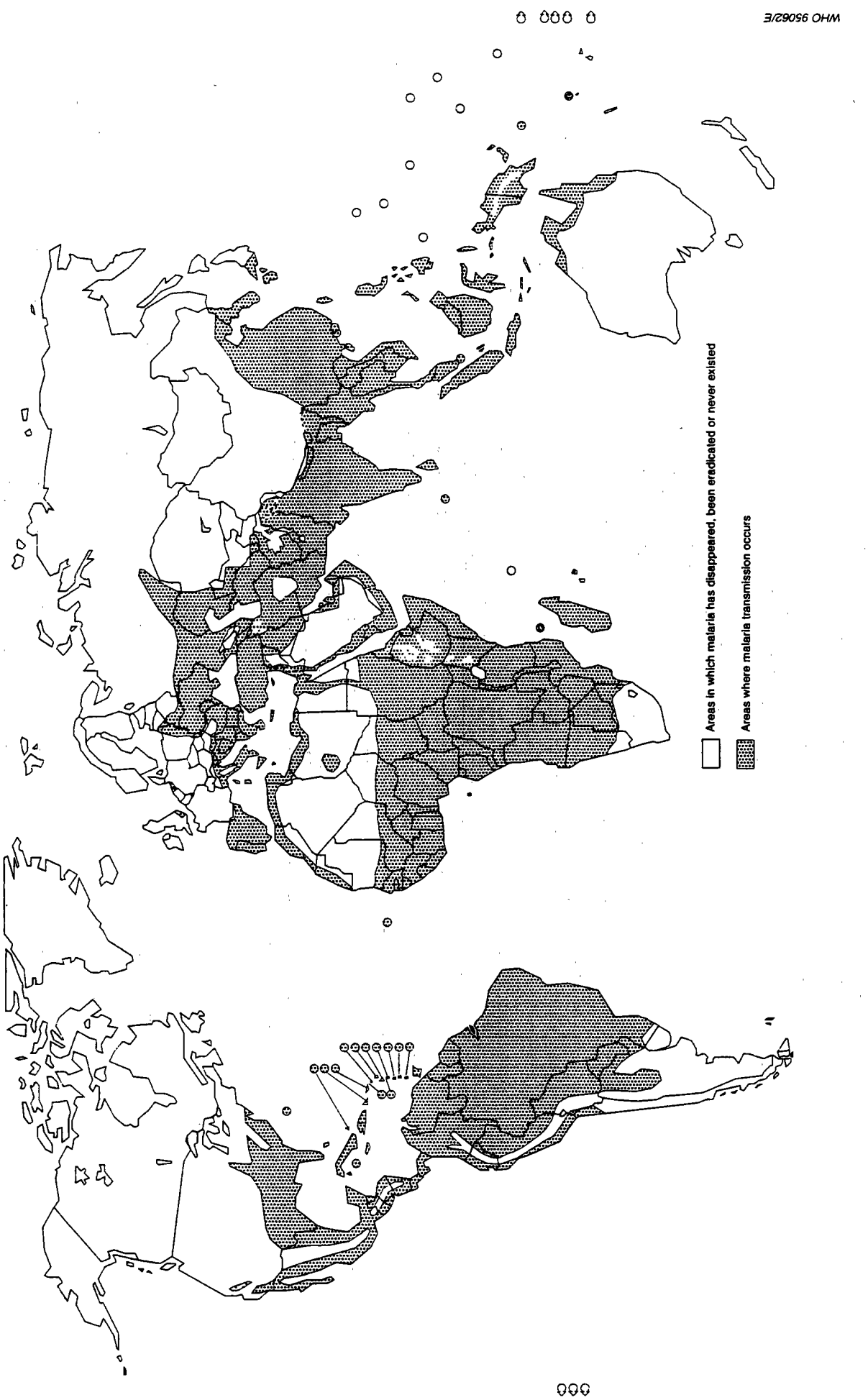
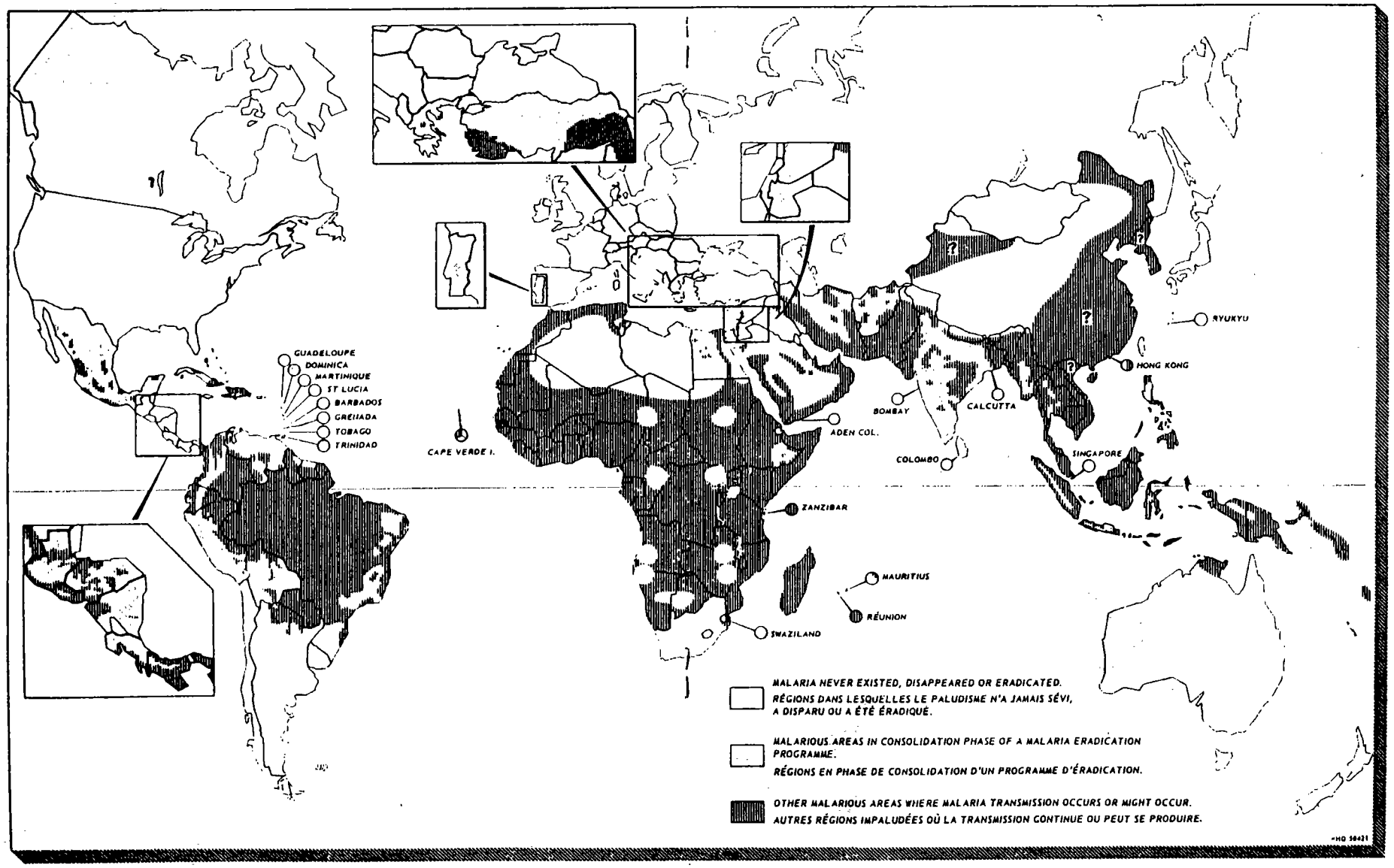


Fig. 6 Changes in the distribution of population in the originally malarious areas of the world by phase of malaria eradication between 1959 and 1968


WHO 95062/E
Areas in which malaria has disappeared, been eradicated or never existed
Areas where malaria transmission occurs

ÉVALUATION ÉPIDÉMIOLOGIQUE DU PALUDISME, 30 JUIN 1964 *



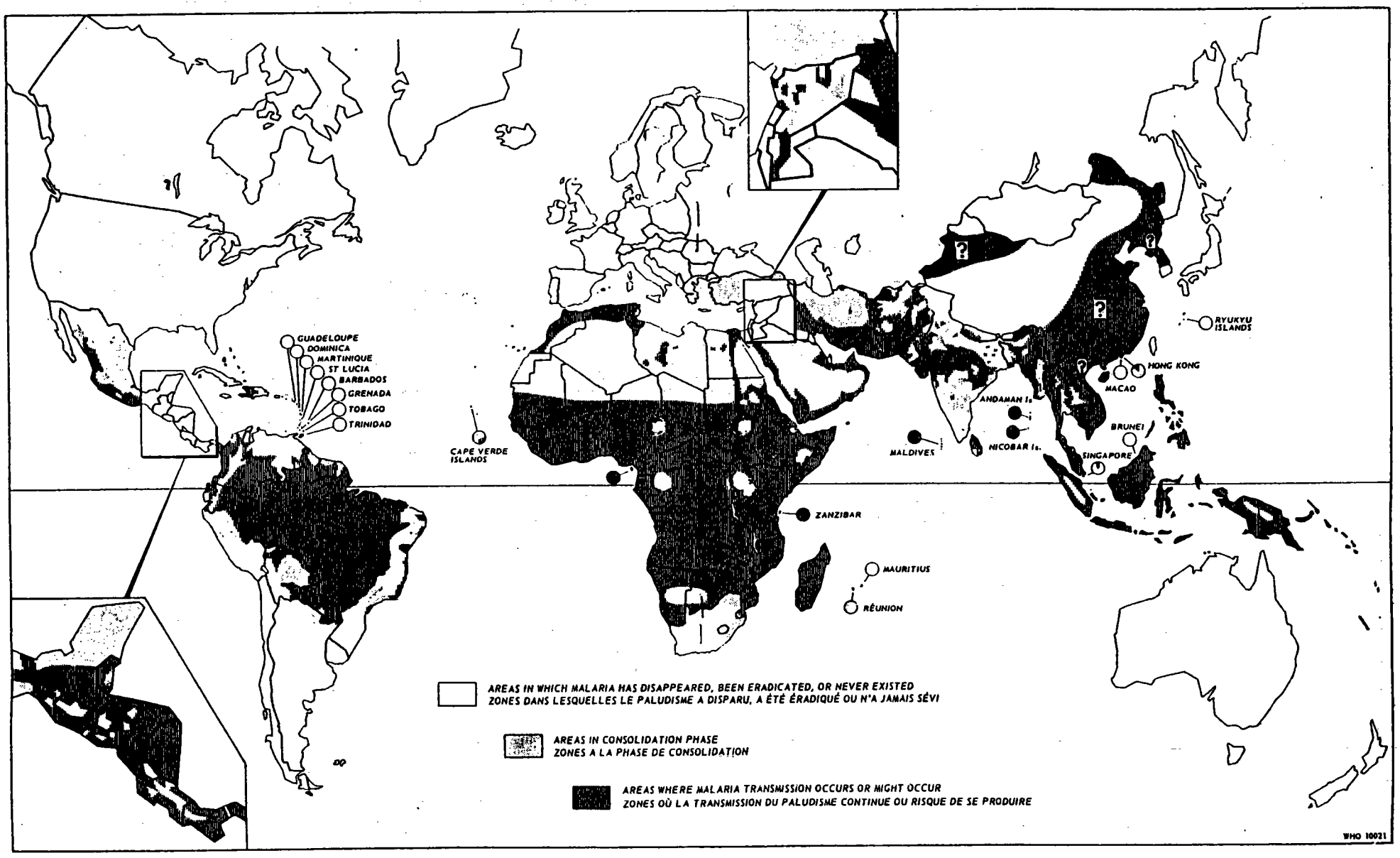
* La zone correspondant à l'Inde ci-dessus représente la situation au 31 décembre 1964

EPIDEMIOLOGICAL ASSESSMENT OF STATUS OF MALARIA, 30 JUNE 1964 *

* The epidemiological situation shown above for India is as at 31 December 1964.

EPIDEMIOLOGICAL ASSESSMENT OF STATUS OF MALARIA, 30 JUNE 1970

ÉVALUATION ÉPIDÉMIOLOGIQUE DU PALUDISME, 30 JUIN 1970



Epidemiological assessment of the status of malaria, 1994.

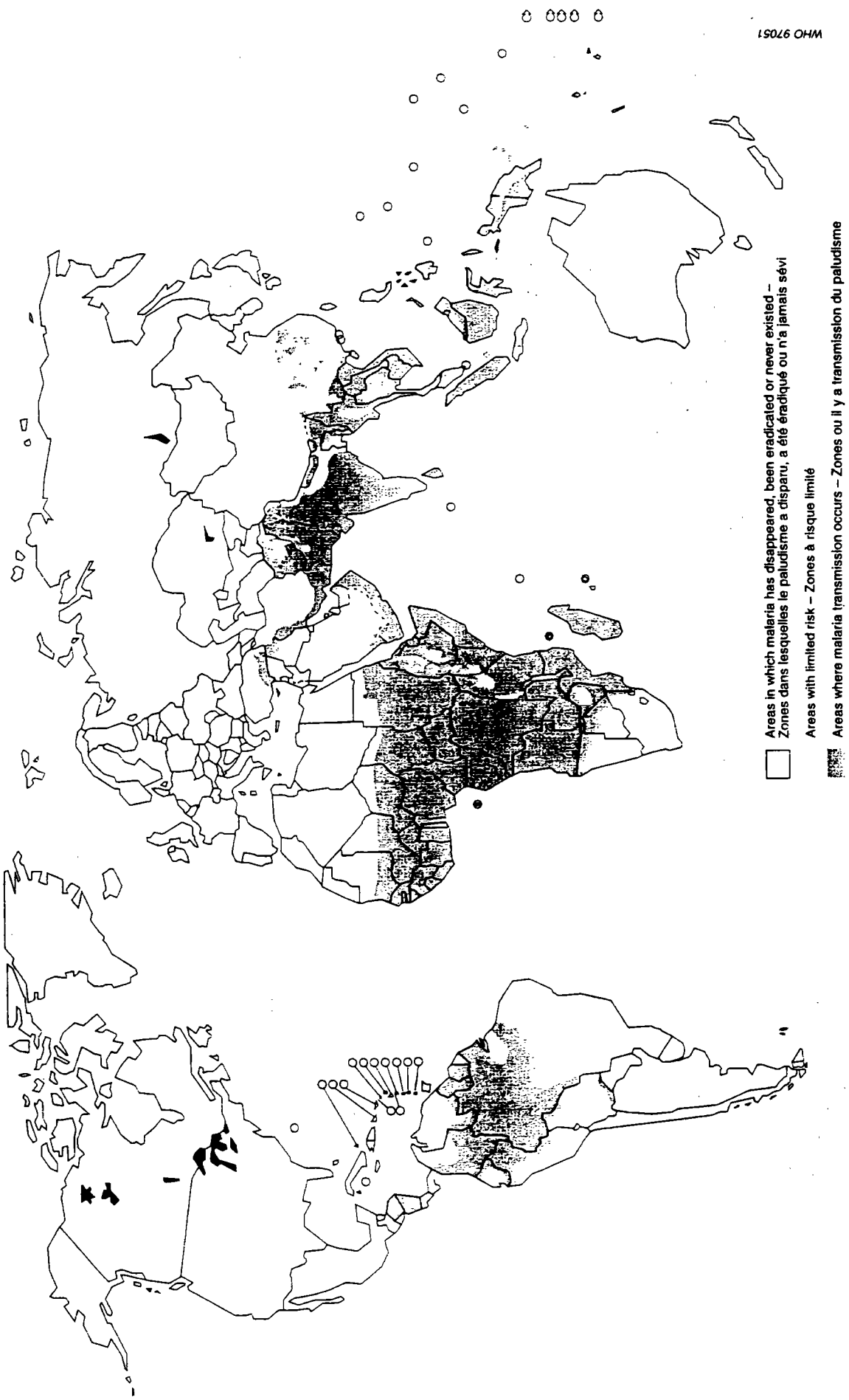


Table 1. Countries or areas included in the WHO Official Registry of Malaria Eradication, up to 1970

Country or area	Registration date
Venezuela (Northern part: 400 000 km²)	Jun 1961
Grenada and Carriacou	Nov 1962
St. Lucia	Dec 1952
Hungary	Mar 1964
Spain	Sep 1964
Bulgaria	Feb 1965
China (Taiwan)	Dec 1965
Trinidad and Tobago	Dec 1965
Dominica	Apr 1966
Jamaica	Nov 1966
Cyprus	Oct 1967
Poland	Oct 1967
Romania	Oct 1967
Italy	Nov 1970
Netherlands	Nov 1970
United States	Nov 1970
Puerto Rico	Nov 1970
Virgin Islands (United States)	Nov 1970

The operational nature of the campaign demanded clear evaluation guidelines and criteria for advancing through the different phases (attack, consolidation and maintenance). Nevertheless, while the prescriptions of the standard programme for eradication formulated by the Expert Committee were based on ten years' experience in the use of DDT, there were very few models on which to base the guidelines for setting up surveillance procedures for the consolidation phase of the programme. The Expert Committee struggled, through its seventh to twelfth sessions, to extract such guidelines from the limited data available and theoretical considerations of the epidemiology of disappearing malaria, the persistence of untreated infection and the threat of asymptomatic infections. The guidelines were generally presented as tentative and requiring local validation but, because of the demands of the campaigns, they came to be universal standards for the organization of the programmes' epidemiological services (Nájera, 1989).

2.3. The neglect of local epidemiology

The expectations concerning the universal efficacy of the attack measures obviated the need for the detailed study of the local epidemiology that had been required in previous approaches to malaria control.

The development of a mathematical model of malaria epidemiology contributed to the acceptance of the eradication policy. The epidemiology of malaria had been a challenging subject for the development of such models since the beginning of the century (see Ross, 1911). Macdonald (1957) saw mathematical epidemiology as the culmination of scientific understanding of epidemiology, consolidating previous phases of its development such as descriptive epidemiology, circumstantial epidemiology, etiological epidemiology, biological epidemiology and local epidemiology. He claimed that a mathematical model would eliminate the unsatisfactory situation facing malariologists when they moved to different "malarious areas in Africa, India, Ceylon and Malaya, in each one of which it was not only necessary to learn a new set of facts, but also a new set of explanations on how they fitted together". Macdonald's mathematical model was offered to provide "a complete picture of the epidemiology of malaria" which, it was claimed, gave a "realistic representation of natural happenings" by integrating biological and circumstantial data into a coherent whole.

Somehow the idea that the epidemiology of malaria could be unified in a single theoretical model gave a major impulse to the concept that all malaria situations could be controlled by a single method. In fact, the model made explicit the greater contribution to the interruption of transmission which could be made by a reduction in the expectation of life of the vector than by a reduction of vector densities or even the man-vector contact. The timely publication in 1957 of Macdonald's book on malaria epidemiology and control consolidated the belief in the feasibility of global eradication, particularly among those who did not fully understand the mathematics of the model and who took it as the scientific description of epidemiological reality and concluded that there was no need for further epidemiological knowledge; all that was needed at local level was a quantitative measurement and even that was soon replaced by a qualitative assessment of whether a particular area was or was not malarious.

The study of the local epidemiology of malaria was still recommended for planning a campaign, e.g. Pampana (1969) in his textbook on the subject recommended that "A complete and careful malaria survey (not a simple malariometric one) must generally be carried out in the pre-eradication period, in order to know exactly where malaria transmission, however feeble, takes place and to define the epidemiological characteristics of the infection in the various parts and seasons of the country. This will imply recording of epidemiological, entomological, climatological, and anthropo-sociological data of the country, baseline knowledge for planning the malaria eradication programme and its future evaluation."

Nevertheless, the role of epidemiology during the implementation of the campaigns was minimized, as stated by Gramiccia in 1966, then Chief of Epidemiological Evaluation of the Malaria Eradication Division of WHO: "Il est évident qu'avant le début d'une campagne d'éradication, les observations épidémiologiques doivent traiter surtout des faits naturels concernant la biologie et les relations dans le temps et dans l'espace des trois éléments de la chaîne: l'homme, le vecteur et le parasite, entre eux et avec le milieu dans lequel ils existent.

Mais une fois récoltés tous les éléments de base nécessaires pour planifier scientifiquement et avec un espoir de succès fondé sur des faits suffisamment prouvés dans les conditions locales, l'épidémiologie se doit de tenir compte de l'efficacité des mesures adoptées, de l'extension et de la qualité de leur application, car ces mesures deviennent alors la cause fondamentale des variations dans la prévalence du paludisme".

Unfortunately, even for planning, the role of epidemiology was neglected or stereotyped. Plans of operations for malaria eradication campaigns followed standardized models, emphasizing budget and requirements for external assistance US/AID and WHO advisers becoming some sort of travelling salesmen for "planops", as they were commonly called. The most important epidemiological feature was the delimitation of the "malarious areas", which was soon replaced by the exclusion of the assuredly "non-malarious" areas, the most common procedure being to consider "malarious" any area below the altitude of the highest locality where malaria transmission had been demonstrated or suspected. The motto was "if in doubt, spray".

Some experienced malariologists tried to retain the respect for epidemiology, but to not much avail. Cambournac (1966) recollected that "En 1948, nous avons écrit à propos de l'utilisation des insecticides à effet rémanent: Le paludisme, en dépit de tout, continue à être un problème local et seule la connaissance détaillée de tout ce qui concerne son épidémiologie, dans chaque région, pourra nous conduire à son éradication".

The campaign required an understanding of the "epidemiology of disappearing malaria" (Yekutiel, 1960; Soper, 1960) and of the potential development of malaria outbreaks from small origins in areas free from the disease; it was highlighted that "in this special context of malaria eradication, therefore, any unexpected multiplication of cases, on however small a scale it occurs, is to be regarded as an epidemic, so that one could legitimately speak of epidemics of half a dozen or some other very small number of cases, and indeed attention must be directed to epidemics of this sort of size, which might occur following reintroduction of the disease, or its reappearance from some remaining gametocyte carrier. The planning of surveillance consists largely in working out mechanisms whereby such happenings could be recognized in their early stages" (Russell et al., 1963).

The classical study of the genesis of epidemics, their determinants and potential forecasting lost its previous importance. Even the concepts of "outbreak" or "epidemic" were replaced by that of "focus", and it was important to distinguish whether a focus was "residual" or "new" and in either case whether it was "active" or not, i.e. with or without active transmission (with only relapses or imported cases). This terminology contributed to efface even further any characterization of malarious areas by their epidemic potential. Russell's textbook on malariology, which treated the subject of "forecasting epidemics" in its 1946 edition, did not do so in its enlarged 1963 edition, including instead a discussion on outbreaks from small origins, from which the above quotations are taken.

The main role of epidemiology was therefore the *detection* of residual malaria and of the re-establishment of malaria transmission, but it was realized that existing epidemiological methods based on "compulsory" reporting of cases or malariometric surveys were insufficient to detect small foci in rather isolated areas. There was, nevertheless, no experience on how to ensure the "deliberate case finding" thought to be necessary to detect small foci. It was

considered that nothing short of total coverage with a system of case detection would be sufficient; it was decided that it would be adequate to concentrate on fever cases, dismissing the problem of asymptomatic infections on the grounds that they would rapidly decrease after a long interruption of transmission. Sergiev, quoted by Pampana (1969), stated that in the Soviet Union there were none after malaria transmission had been interrupted for the last three years. A case detection system should ensure the examination of every fever case occurring in the area; two mechanisms were set up; an "active case detection", consisting in the visit of every house at monthly intervals to collect a thick blood film from every person having had fever since the last visit, and a "passive case detection", which requested a blood film from every fever case attending any health post. Confirmation of the disappearance of the malaria reservoir could only be provided by the absence of autochthonous cases after the end of attack on the vector; timely investigation of each detected case was essential for the discovery and appropriate elimination of residual or new foci of infection. The total load of positive cases which could be investigated by the epidemiological services was considered to be the main criterion for interruption of spraying and advancing the campaign to the consolidation phase.

These broad criteria were not considered sufficient to guide the managers of actual campaigns; more specific operational criteria were required for the evaluation of individual campaigns, including standard values of the "annual blood examination rate"(ABER), to be used as a criterion to indicate the adequacy of the surveillance system and of the "annual parasite incidence" (API), which should indicate when a campaign could safely advance into the consolidation phase.

Pampana (1969), in the second edition of his textbook of malaria eradication, says that "Malariometric surveys have lost much of their importance in malaria eradication programmes. We are no longer interested in assessing how much endemicity decreases from year to year, as we were in control operations. We are interested only in seeing malariometric rates approaching the zero level, because then we must be quick to replace them by a more sensitive tool, which is deliberate case-finding. Even the most sensitive indicator of transmission among the various malariometric rates, that is the infant parasite rate, loses its meaning when it approaches zero". Particularly demonstrative is his statement that "emphasis on malariometric surveys during an m.e.p. (malaria eradication programme), or satisfaction in reporting that the parasite rate has decreased, for example in the n^{th} year from 80 to 10 per cent, denotes either a lack of awareness of what eradication means or a poor attempt at masking unsatisfactory results". Nevertheless, he also states that "for operational reasons WHO has decided to consider adequate the activities of a case detection organization of the proportion of blood slides examined during the last 12 months, in relation to the population covered by the detection, is above a certain level; the term ANNUAL BLOOD EXAMINATION RATE has been suggested for this proportion (abbreviated ABER). If this rate is above 10 per cent case detection would be quantitatively adequate in all cases; in seasonal transmission areas or other particular epidemiological conditions even an ABER of 3-5 per cent might be adequate". A similar demand resulted in the establishment of a criterion for the interruption of spraying operations; an annual parasite incidence (or API) was defined as the number of positive cases detected referred to a thousand inhabitants; spraying could be interrupted when the API was less than 0.1, i.e. one case per 10 000 population.

2.4. Implementation problems

The overriding emphasis on operational aspects of campaigns resulted in neglect of their capacity to recognize and solve problems, except those for which a routine monitoring system was included in the original plan. These in turn were considered technical problems and consisted mainly of insecticide resistance and, to a lesser extent, exophilic behaviour of vectors. The slowing down of the progress of the campaign was therefore attributed to either operational or technical problems, with technical supervisors tending to see only operational problems and operational staff claiming the existence of technical problems.

Reported insecticide resistance in malaria vectors showed a dramatic increase between 1955 and the early 1960s, although frequently this was merely the recognition of a previously developed phenomenon, as in many areas, particularly in the large cotton growing areas of Central America, of south-eastern Anatolia and of the Persian Gulf, resistance was detected on first testing. Emphasis on testing resulted in the cessation of spraying in some areas at the first indication of resistance and a change to dieldrin, with the rapid appearance of dieldrin resistance and the occurrence of cases of dieldrin intoxication, and the consequent return to DDT. It had been observed that resistance to this insecticide developed much more slowly (among other factors, the most frequent resistance mechanism is inherited as a recessive character) and DDT could therefore remain operationally effective with a relatively high proportion of survivors to the discriminating dose in susceptibility tests (in some areas up to 30-40% survival rates in tests). By 1964, DDT resistance was reported in 14 anopheline species (WHO, 1970).

The solution to the insecticide resistance problem was considered to be the replacement of DDT with an alternative insecticide, but the only such alternatives at the time were dieldrin, which had been shown to be too toxic for general use, and gamma-BHC, which had a very short residual effect. In addition, resistance to the two latter insecticides developed much more rapidly than to DDT. WHO established a Global Programme for the Evaluation and Testing of New Insecticides in 1960 (Wright, 1971), which during the first decade of activity reviewed and tested over 1 000 compounds for potential use in public health. However, the number of compounds submitted for testing diminished afterwards, as industry took a greater interest in other products such as herbicides and fungicides (WHO, 1996). The strict requirements of safety, effectiveness and residual effect for antimalarial indoor residual spraying made testing a long and costly process; in fact, only two insecticides were accepted during the first decade: malathion and propoxur.

While there existed a good and simple standard method for susceptibility testing, there was no simple standard for irritability or repellency, and therefore observation of these phenomena was much more rare and irregular. Nevertheless, while multiple resistance to all available insecticides had been a major problem only in the Pacific coast of Central America and in some areas of the Persian Gulf, problems associated with exophily and excito-repellency seemed to be quite common and more difficult to interpret. In some areas, outdoor resting and biting vectors could maintain transmission without coming in contact with sprayed walls. In contrast, in other areas, particularly dry and arid areas, the irritant effect of the insecticide denied naturally endophilic vectors their daytime resting inside the favourable microclimate of bedrooms or stables, forcing them to search for alternative resting places, which exposed them to greater mortality, decreasing their vectorial capacity.

Although this problem should have been expected, the detection of chloroquine resistance in 1958-59 in the border areas of Colombia-Venezuela and Thailand-Cambodia came as a surprise and was denied for some time until the first resistant strain was isolated in 1960. It was soon found to be widely distributed in northern South America and Brazil and throughout the Indochina peninsula.

An even greater surprise was the recognition that, even outside tropical Africa, not all endemic areas responded to the prescribed attack measures, although they were correctly implemented. The eighth report of the Expert Committee had already made an analysis of the causes of failure, although it considered that those problems were only of local importance and could eventually be resolved. Nevertheless, some countries started to report the existence of "problem areas", and WHO organized special teams to investigate such areas, although it was thought that open recognition of such problems could erode confidence in eradication; for example, the publication of the report of the investigation of the "problem areas" in Mexico in 1962 was delayed for more than two years (de Zulueta & Garrett-Jones, 1965). Soon "problem areas" were recognized in many countries of the Americas and Asia. They included: mainly areas of extensive agriculture attracting large temporary labour forces; those under certain cultures, such as cotton, rice or sugar cane, requiring intensive use of agricultural pesticides and leading to multi-resistance of malaria vectors; colonization and mining in jungle areas; population groups engaged in charcoal burning, or in "slash and burn" subsistence agriculture in forest areas; dispersed tribal populations which were hard to reach by the campaign both geographically and culturally; international border areas; and areas of socio-political unrest.

Many more problems were encountered during the consolidation phase of the campaign. The standard surveillance system calling for total coverage with a continuous mechanism of case detection and the collaboration of all medical care services, proved more difficult to organize and supervise than the spraying of every house. In addition, such a system required the support of a network of specialized laboratories to examine the continuous flow of blood slides collected, a complex logistic system for their circulation and a capacity to visit, treat and investigate every individual positive case.

Programmes generally insisted on meeting predetermined rates of blood slide collection, with the result that both laboratories and surveillance workers soon became overloaded with work which was, therefore, delayed and perfunctory. The inadequacy of the surveillance system became particularly obvious from its inability to detect resurgences of transmission in time to implement an adequate response (see § 4.6 below).

Many endemic countries of the Americas and Asia had very poor or no rural health services to provide the required passive case detection. Most Asian countries compensated by strengthening their active case detection. In Latin America, most countries had, since the late 1950s, enlisted the collaboration of village residents as "voluntary collaborators" for the purpose of collecting a blood slide from each fever case occurring in their community and treating them with chloroquine. This practice was generalized throughout Latin America in the 1960s and spread to some countries of Asia and the Pacific during the late 1970s and the 1980s (Pribadi et al., 1986; Okanurak et al., 1991). The coverage and productivity of voluntary collaborators were very variable and although they were mainly selected by their neighbours and supervised by staff of

the national antimalarial services, their whole performance was seldom evaluated, only their capacity to produce blood slides.

Full implementation of the strict requirements of the surveillance system was hardly possible anywhere, whilst some form of effective working surveillance and response capability was established in countries or areas with a solid health infrastructure. By contrast, areas lacking that infrastructure experienced enormous difficulties in meeting the requirements for blood collection, slide examination, epidemiological analysis and capacity of response.

It was concluded that the consolidation phase of the campaign required the collaboration, and therefore the existence, of a rural health infrastructure. The Expert Committee (WHO, 1961) recommended that countries lacking an adequate health infrastructure should, before engaging in an eradication campaign, plan for "a parallel correlated development of rural health services to assure the effective implementation of the consolidation and maintenance phases of the future malaria eradication programmes". This proposal was the basis for the **pre-eradication programmes**, which were supported by the Executive Board and the Health Assembly in repeated resolutions after 1962, when the Assembly (resolution WHA 15.19) urged governments with malaria eradication programmes in operation to ensure active participation of the health services (WHO, 1973). Nevertheless, at country level there were often conflicts between malaria programmes and general health services, which often prevented the implementation of the pre-eradication programmes. These programmes required the development of rural health services to conform to the needs of malaria eradication, when in practice even working collaboration between the services presented frequent problems.

2.5. Relations with the general health services

> *We do not necessarily need a fully developed health system before attacking special problems; we often begin by attacking certain diseases in order to develop a general system.*
>
> **Strode, cited by Hackett (1937)**

The Expert Committee had stated (WHO, 1957) that "the administration of malaria eradication should be distinct and separate so as to secure the efficient management of the programme ... In countries where the public health service is not well developed, the development of an eradication service will be a pattern of an efficient service and will serve as a nucleus around which the public health service could be built".

As mentioned above, the failure of many programmes to cope with resurgence of transmission during the consolidation phase, before large areas had to revert to the attack phase, had prompted the proposal of pre-eradication programmes, but the question of relations between the eradication campaign and the general health services became the subject of continuous debate, particularly after the mid-1960s. On this question:

- most programmes agreed on the need for a supporting health infrastructure to monitor the success of the programme and particularly to identify and eliminate in time, new or residual foci of infection during the consolidation phase. Pre-eradication programmes

were being implemented in countries which had not started a national campaign, particularly in Africa, but many countries in Asia and the Americas with on-going eradication campaigns also lacked an adequate infrastructure, for which they tried to compensate by establishing networks of "voluntary collaborators" to collect blood slides from and give presumptive treatment to fever cases.

- the integration with the general health services, which had originally been rejected, became an issue discussed by the Expert Committee and regional meetings; in general, integration was considered acceptable only for the maintenance phase, provided that health services were capable of implementing all the requirements of malaria surveillance.

In countries of southern Europe which had eliminated malaria endemicity, the old antimalarial dispensaries had served as the basis for the development of rural health services, and even in the United States the malaria control organization was incorporated into the different stages in the formation of the Centers for Disease Control. Few malaria eradication campaigns attempted such full integration, preferring instead the integration of some specific disease control programmes, such as "major endemic diseases", "vertical health campaigns" or "rural endemic diseases". Such forms of integration facilitated common administration and logistics, while maintaining the identity of each programme and, in some cases, also unfortunately maintaining their isolation from the general health services.

2.6. Doubts about the feasibility of malaria eradication

As early as 1961, Coluzzi warned against excessive reliance on residual spraying, recalling that malaria had been practically eradicated from Italy before DDT and that the success in controlling the serious epidemics following the Second World War with the use of DDT was "mainly due to a satisfactory general organization and to a control programme relying not only on the action of insecticides, but also on *chemiotherapy* and on *drainage operations*", concluding that the extrapolation of the successes, so far attributed to DDT spraying, to countries with poor developed infrastructure was "risky to say the least". Even more important was his warning about the danger of a "partial victory" where the required infrastructure to maintain the results achieved was not in existence, and where the loss of previous immunity would create conditions for severe epidemics with high mortality (Coluzzi, 1961).

By 1963, the campaign suffered a financial crisis with the end of contributions from the United States to the Malaria Eradication Special Account, which forced WHO to absorb the programme under its regular budget, thus bringing it under closer scrutiny by the World Health Assembly. Even if the WHO Assistant Director-General could claim in his progress report to the Assembly that the whole of continental Europe and Zone I of the Americas had reached the maintenance phase of the campaign, the programme was extensively discussed. There were comments such as "It was clear that the campaign had reached the crossroads, and the time had come to take stock of the situation" (Dr Evang, Norway); "the WHO secretariat had no long-term plan for an expensive campaign that had been started without an adequate scientific basis ... By 1965 it would be ten years since the Health Assembly had taken its decision to eradicate malaria .. His delegation therefore suggested that a committee should be set up, composed of Secretariat members and malariologists from various countries to inquire into the defects of the

campaign and to assess the results achieved" (Professor Zdanov, Soviet Union). The Assembly resolution included a request to the Director-General "to study the present position in regard to the implementation of the malaria eradication programme, its achievements, shortcomings and prospects" (WHO, 1963; WHO, 1973).

The Expert Committee had considered the question of the minimum requirements for feasibility of an eradication campaign. On this subject it is interesting to note the evolution of the opinion of the Committee:

- in 1956 (WHO, 1957) it promoted the policy of global eradication, although it recognized in a footnote that "the problem of finding an effective and economical method of eradicating malaria in tropical Africa has not yet been solved".
- in 1960 (WHO, 1961) it recognized that deficiencies in social structure, educational status, economic conditions and communications, administrative system and health organization could hamper the feasibility of malaria eradication. The proposed solution for these problems was the implementation, with the assistance of an international team, of pre-eradication programmes to study the problems, promote the parallel development of rural health services, and design, test and implement an adequate approach to malaria eradication.
- in 1962 (WHO, 1962a) it developed rather extensively the "minimum requirements of health services to support a malaria eradication programme", thus focusing the problem of feasibility of malaria eradication on a certain degree of development of health services needed to sustain the epidemiological surveillance thought to be required for the consolidation phase of the eradication campaign, thereby neglecting the main issues of socio-economic development. It also set the rather utopian requirement that countries should adjust the development of their health services to the needs of malaria eradication.
- in 1967 (WHO, 1968) it finally set the "conditions to be met before initiating a malaria eradication programme", which were of a much broader social, administrative and political nature. Unfortunately these conditions came 12 years after the launching of the global campaign, and only after the Twentieth World Health Assembly had requested a re-examination of the global strategy of malaria eradication. That Assembly, in 1969, recognized that there were areas where eradication was not yet feasible and where malaria control activities should be undertaken instead.

2.7. Research

The Expert Committee had recognized from the beginning of the campaign the need to support research, particularly in entomology, and recommended linking the programme to existing scientific institutions, although it discouraged programmes from diverting resources to research to the detriment of operational management. Nevertheless, the expectation of global eradication and the operational emphasis of the programme tended to exclude malaria from the plans of research institutions. McGregor (1982) commented on that exclusion, which lasted until the war in Viet Nam forced the United States army to establish an accelerated programme of malaria research: "Throughout the world support for further research into malaria, even that concerned with insecticides and chemotherapeutics, contracted swiftly. Worse still, the apparent imminent

demise of a once important disease removed the necessity for training scientists in malariology. It took 10 years and a war to halt this tragic trend".

The main source of support for malaria research during the 1960s was the programme coordinated by the Walter Reed Institute of Research , whose first priority was the development of new drugs to serve the potential needs of the United States Army. The programme, nevertheless, supported a wide range of research into pathology, immunology, entomology, parasite biology and experimental models. Unfortunately, the programme funding was considerably reduced at the end of the Vietnam war, in 1975. WHO had maintained a research programme, mainly consisting of the allocation of small grants to scientists studying problems of potential relevance to malaria epidemiology or control, thus indicating the interest of the Organization and expecting to serve a catalytic function to attract substantial funding from other agencies.

Active research had been maintained, nevertheless, into the development of new insecticides and, as mentioned above, WHO established a programme for the evaluation and testing of new insecticides for potential applications in public health, particularly for malaria eradication (see § 2.3). Unfortunately the main stimulus for insecticide development came from agriculture and, by the time testing for public health was completed, most insecticides had been widely used in agriculture for years and insecticide resistance was emerging.

In 1975 WHO, in collaboration with the UNDP and the World Bank, established a Special Programme for Research and Training in Tropical Diseases (TDR) with the objective of supporting the search for new or improved tools to control those diseases and of developing the research capabilities of endemic countries. In malaria it gave special priority to chemotherapy, immunology, and the field research needed to make the new tools operational, to improve epidemiological knowledge and to solve major control problems.

2.8. The re-examination of the malaria eradication strategy

The WHA continued to be concerned with the fact that "the advance towards malaria eradication has been slower than had been hoped for" (Resolution WHA19.13) and finally, in 1967, requested the Director-General "to study how best to carry out a re-examination of the global strategy of malaria eradication" (Resolution WHA20.14: WHO, 1973).

A contrast became increasingly obvious between the near-absence of resurgences in countries which had achieved eradication as a result of control programmes with a long history, begun before 1955, and the high frequency with which they followed after the apparent success of the newly established vertical programmes. Resurgences became more frequent and, in 1968, a massive epidemic spread across Sri Lanka, whose programme had been considered a model programme a few years earlier but which had experienced several years of escalating resurgences (Bruce-Chwatt, 1974).

The report on the re-examination of the strategy was submitted to the WHA, meeting in Boston in July 1969. While reaffirming that complete eradication was the ultimate goal, it recognized that, in the regions where eradication did not yet seem feasible, control of malaria with the means

available should be encouraged and regarded as a necessary and valid step towards that goal (WHO, 1969).

WHO, in collaboration with UNICEF and the USAID, set up multidisciplinary teams to assist countries in the evaluation of their antimalarial programmes, to determine their potential to achieve eradication in the short term or otherwise to be considered "control programmes". Such classification was confronted with enormous difficulties and subjected to strong political pressures, as it was seen more as a judgement on the quality of the programme than on the scale of the problem ahead.

2.9. Problems of adapting malaria eradication programmes to the objective of control

As discussed above, the "global eradication campaign", which started as a highly political, insufficiently funded enterprise in 1956, was a bold extrapolation of limited experience to the global scale and lacked the scientific resources to adapt to the great variety of epidemiological situations of the real world and to understand the interaction of multiple geo-epidemiological and socioeconomic factors existing in different malaria-endemic areas. Moreover, its operational capacity was seriously weakened by 1960 and became practically starved of financial support by 1963. The global campaign was, nevertheless, very successful in organizing throughout the world, outside tropical Africa, "malaria eradication programmes" with an almost exclusively operational orientation.

After 1969, many countries tried to convert their ineffective malaria eradication into control programmes. Nevertheless, most of those programmes, after more than a decade of persisting problems and insufficient technical and financial support, suffered of some degree of inadequacy for malaria control, having become, particularly during the 1970s:

- overloaded with an unskilled labour force (spraymen and house visitors), for whom the programme often lacked resources to buy the materials and equipment required for their work, and/or
- unattractive to the professional cadres who could have critically reviewed the programme and reoriented it towards realistic objectives, and/or
- ineffective in controlling malaria transmission, which in many countries did not change significantly or returned to original levels during the consolidation phase, and/or
- incapable of coping with new malaria problems, such as those stemming from new frontiers of economic development, and/or
- ineffective in managing malaria as a disease, since established routines placed all the emphasis on the detection of malaria parasites and neglected the care of the patient and even the diagnosis of his or her disease if it was not a patent malaria infection, and/or
- wasteful in the use of insecticides, whose supply was seldom sufficient or continuous while their purchase was difficult and called for hard currency, and spraying was often late and did not achieve sufficient coverage; wasteful in the use of laboratory facilities, since the emphasis on detecting infection insisted on peripheral deployment, resulting in their being mainly used to examine first-contact ambulatory fever patients (who were often

negative – the global positive rate was 3-5%), while general health services, dealing with severe cases and peripheral treatment failures, often lacked microscopic diagnostic facilities; wasteful in the use of antimalarial drugs which were mainly used for the symptomatic treatment of fever, possibly contributing to the spread of drug resistance, and/or

- dangerous in the way they collected blood specimens which, in spite of recommendations for the exclusive use of properly sterilized or disposable lancets, continued to be done in unhygienic conditions as long as it was insisted that large numbers of slides should be collected at the periphery, and/or
- ineffective in the opportune detection and control of epidemics, and particularly in preventing them.

Most antimalaria programmes in endemic countries suffered from one or more of the problems listed above, which were a source of criticism from scientists and general public health workers and contributed to the erosion of the prestige of the programmes and their isolation. Furthermore, the maintenance of large unskilled labour forces in many countries created labour problems, which most general health services were unprepared or unwilling to handle, thus delaying integration efforts.

In any case, the lifting of the time target for malaria eradication resulted in important withdrawals of support by both international sources (UNICEF withdrew in 1971) and by national ones. At the same time the oil crisis of the early 1970s, which raised the costs of insecticides and transport, resulted in serious cuts in the operational capacity of programmes, poor performance and lowered morale. Even those programmes which had made satisfactory progress were faced with the need to attack the most difficult areas in the light of diminishing programme priority, lack of adequate or continuous financial support and unattractive career prospects for professional and technical staff. This set up a vicious circle in which lack of support prevented progress, lack of progress eroded confidence, and lack of confidence led to further lack of support (Nájera, 1979). The problem was defined as one of "near-success in an environment with an excess of problems clamoring for attention. As malaria recedes to a low level other pressing health and social problems exert irresistible demands for available resources" (Scholtens et al., 1972). Gramiccia & Beales (1988) comment that "In WHO alone, malaria advisory staff decreased progressively from 444 in 1967 to 155 in 1977. International and bilateral support for malaria in terms of commodities and services decreased from US$ 16.4 million to $ 6.3 million annually during the same period. Considering the devaluation of the dollar, this represents a drop of 80%".

Moreover, there was no clear concept of malaria control; the fact that eradication had been defined as perfect control suggested that imperfect eradication was somehow equivalent to acceptable control; unfortunately, in most instances ineffective eradication programmes were expensive and wasteful and achieved poor or no control. WHO called on programmes to plan for feasible actions: "We have to admit that between 'everything' (eradication) and 'nothing' (as in Africa south of the Sahara) there is quite a range of 'something' which, translated into epidemiological language, means diversified control methods applied to various extents" (Lepes, 1974). Nevertheless, few countries recognized the need to plan control activities *de novo*, fixing attainable objectives and selecting appropriate approaches (Nájera, 1979). The re-examined strategy reaffirmed the ultimate goal of malaria eradication, and the

Expert Committee (WHO, 1974) insisted on the need to consolidate the gains so far achieved. However, most programmes considered that the only way to consolidate those gains was to maintain as much of the current routines as could be afforded in the areas in advanced phases, thus creating a paradoxically inverse relation between the intensity of the problem and the amount of resources devoted to it.

A most serious problem was the lack of professional staff and general malaria expertise; malariology, as Russell said (see Foreword), was not an attractive field for young professionals, as it was considered that malaria would disappear. Moreover, most programmes lacked the epidemiological information for planning malaria control, since planning for eradication had been based only on the classification of areas into malarious and non-malarious. Epidemiological information systems were concerned only with laboratory-confirmed cases, while considerable delays occurred before blood slides reached a laboratory and most laboratories worked with backlogs of slides of several weeks or even months. As a consequence the antimalarial services lacked the capacity for timely detection of resurgences or true epidemics; in many cases, when reported by the general health services or by the press, were unable to make an appropriate response.

Human resources development was a constant concern and several studies were made to ascertain the requirements of countries to address current problems and to reorient their malaria control strategy. These reviews were consolidated by a WHO Consultation Group on Training of Malaria Staff (WHO, 1972a), which recommended the establishment of courses leading to a master's degree in public health with specialization in malaria and other parasitic diseases and similar courses for medical entomology, in order to make training in malaria attractive once more and to ensure career prospects. Universities in malarious countries were encouraged to create such courses and WHO, with the support of collaborating agencies, tried to establish international courses in selected universities to serve the needs of countries which could not organize national training for professional personnel.

In collaboration with WHO, public health schools in endemic countries organized courses leading to a master's degree in public health with specialization in malaria (e.g. Teheran and Mexico City). Master's degree courses in medical entomology were similarly organized (e.g. Baghdad, Bouaké, Jog-Jakarta, Jos, Nairobi, Sao Paulo). In spite of these efforts, human resources continued to decline as the general status and financial resources of antimalaria programmes did not improve and they could not offer attractive career prospects.

The report to the 25th WHA (WHO, 1972b) expressed these problems as follows: "It has to be realised that, following the revised strategy of malaria eradication adopted by the Twenty-second World Health Assembly, a number of governments were faced with difficult decisions regarding their malaria eradication programmes, i.e., whether (1) to pursue eradication to a successful termination, (2) to limit intensified eradication to areas with a high malariogenic potential, while holding the gains achieved in other areas through an adequate malaria surveillance mechanism, until such time as governments can muster the required means to effect full eradication, or (3) to convert the whole programme, or a large part of it, to long-term malaria control that can eventually be transformed into a fully-fledged, time-limited eradication programme. Making a choice between these courses of action was difficult, particularly when it had to be borne in mind that any relaxation in antimalarial activities due to the conversion of resources might lead to full

re-establishment of malaria endemicity and that, even before this happened, increased morbidity and mortality would occur".

In spite of WHO's efforts at regional and country level to develop a viable malaria control strategy, the 1970s witnessed a general weakening of antimalaria programmes throughout the world. Countries waited for clear and authoritative guidance from WHO, and adopted an attitude of "watch and wait", while resisting as much as possible any organizational change (van der Kaay, 1991).

2.10. Overall evaluation of the malaria eradication programmes

> *It must be remembered that there are only two classifications for eradication programs: successes and failures. The entire investment in eradication work draws rich dividends only after the last individual of the species has been eliminated.*
>
> **Soper (1949)**

Although, according to Soper's criteria, the global malaria eradication campaign has to be considered a failure in relation to the stated objectives and planned time-frame (10 years), nevertheless, quite apart from local successes or failures in eliminating malaria endemicity, it made important contributions beyond its specific impact on malaria. These include indirect effects on the general improvement of health and contributions to the understanding of malaria epidemiology worldwide, to the planning, implementation and management of health programmes and to the development of peripheral health services.

In addition to the clear benefits obtained by countries which did succeed in eradicating malaria, there was a very significant reduction in the malaria mortality rate even in countries where the programme was not advancing satisfactorily. For example, in countries of Central America, the general mortality rate in the period 1955-1968 declined by 30-40%. However, the reduction in the malaria death-rate for the same period ranged between 71% and 100%. A reduction of the same order in the malaria death-rate was achieved in countries of Asia. In the Philippines, for example, the general mortality rate was reduced from 9% in 1955 to 7.9% in 1968, and at the same time the malaria death-rate dropped from 15.6% to 2.9%. In Thailand the corresponding reductions were from 8.3% to 7.3% and from 63.2% to 10.4%. While the life-saving effect of malaria eradication programmes complies with one of the ethical principles of the health service, the much-reduced malaria morbidity also results in an increase in the economic potential of the areas previously affected by the disease (Gramiccia & Hempel, 1972).

The main **contributions of the malaria eradication campaign** to public health and socioeconomic development include the following:

- The campaign drastically altered the global distribution of malaria, which in the 1950s was widely prevalent in Asia and the Americas; India alone suffered a third of the global load of malaria. The campaign eliminated malaria endemicity from most areas of relative socioeconomic stability in Asia and the Americas, where there are no longer wide areas of high endemicity. The disease is now concentrated at the frontiers of socioeconomic development; unfortunately in many of these areas it has shown an explosive increase. Today

80-90% of the problem lies in tropical Africa, which, as indicated above, remained outside of the eradication campaign and where the problem has changed markedly with the spread of drug resistance and the increase in epidemic risk in many areas, due to socio-political unrest, the spread of agriculture to high-lying and arid areas, and the increase in refugee and displaced populations.

- The campaign represented the first public health programme to address the whole of a problem and to plan for its solution everywhere from the beginning, instead of the traditional way of starting at some point, often the centre, and expecting it to permeate to the periphery. This general philosophy created some serious operational problems, but nevertheless brought a democratic dimension to public health planning which has been followed by subsequent programmes, since even if they select operational priorities they do so within the perspective of the total problem.

- Concern with coverage brought, as a consequence, an insistence on establishing contact with the periphery, setting up and supporting, in many countries, networks of **community voluntary collaborators**, which could have become the nucleus for the development of community health workers; unfortunately, in many countries the development of primary health care did not take into account existing peripheral resources, but tried instead to build up new, and supposedly better, structures.

- Another contribution stemming from the need for total coverage was the insistence in the use of **maps**, including the elaboration of locality sketch maps indicating the position of every house and the means of communication, as well as the compilation of detailed censuses; in some countries these maps and censuses were the best available and came to be widely used by the survey departments and the smallpox eradication campaign.

- The consolidation and exchange of information provided the basis for understanding the variability of the epidemiological situation in different areas as well as the similarities between some quite widely separated areas, thus permitting the identification of eco-epidemiological types which may guide the planning of control and exchange of experiences in the future.

Today's malariologists may be surprised at the general acceptance of the malaria eradication policy in the 1950s, but this modern retrospective scepticism results from 13 years' experience of attempting eradication and 28 years of attempting to maintain the gains obtained by the campaign, with very variable success. It is true that some malariologists such as Covell (1949) and the "new school" of the 1930s had warned against generalizations based on limited experiences, but the amazing effectiveness of DDT seemed to justify the expectations of its universal applicability. Moreover Macdonald's mathematical model, developed in the early 1950s and presented as the basis for understanding malaria epidemiology, contributed to the feeling that the key element of malaria control was a reduction in the daily probability of survival of the vector, which could be obtained by maintaining total coverage of indoor resting places with an effective dose of insecticide.

2.11. Fallacies of the eradication proposal

With historical hindsight it is possible today to identify a number of fallacies embodied in the eradication proposal, which should be highlighted to prevent similar misconceptions creating difficulties when strategic options are being selected by endemic countries. Those fallacies include:

(a) the principle that "prevention is better than cure", an obvious truism which does not imply that all so-called preventive measures are better than the appropriate deployment of curative services. The former may fail to prevent and thus leave the population defenceless, while the latter may prevent mortality and reduce incapacity and social impact (see the comments of Hackett in § 1.3.10 above, and **Figure 4**);
(b) the idea that "a cheap, effective and safe" measure may be indiscriminately applied everywhere without considering epidemiological variability, since with time the measure may be shown to be neither so safe nor so effective while replacements are far from cheap or safe; moreover, the cost of applying the measure in remote areas may be many times the original cost. This fallacy underlay not only the deployment of indoor insecticide spraying but also the use of chloroquine as a treatment for fever, which in many areas came to be regarded as a commodity and not as a drug, thus creating habits of use which are most unsuitable for potential replacement drugs;
(c) the economic argument that "a one-shot investment is preferable to the indefinite repetition of expenditure", without taking into account the actual availability of resources and the need to apply a discounting rate to the current value of future expenditures (Cohn, 1972);
(d) the implication in the definition of eradication by the 6th Expert Committee (see § 2.1 above) that preventing the resumption of transmission depended mainly on "the degree of perfection" with which the campaign had been conducted, without considering the continuous need to respond to re-established transmission as long as malaria was not eradicated from the world;
(e) the "low cost of surveillance to ensure eradication", which experience showed to be just as high as attack and proved unreliable in preventing resurgence in areas without well-developed health services (i.e. disease care facilities and epidemiological information systems). The actual cost of maintenance has been evaluated in the island of La Réunion, which has maintained an average annual budget of US$ 3.35 million (Denys & Isautier, 1991). Of this, 77% has been devoted exclusively to vector control for a population of 570 000 inhabitants, i.e. US$ 5.9 per person per year. Similarly, the island of Mayotte, which achieved eradication and has continued an active maintenance programme under French administration, reported an annual expenditure of about US$ 6 per person per year (Julvez, 1990);
(f) the global nature of the programme when in fact tropical Africa was never included in the campaign;
(g) the expectation that the risk of epidemic malaria would not recur after the introduction of regular indoor spraying, linked with the belief that unstable malaria was most responsive to attack measures. In fact, since epidemic malaria is the result of an abnormal situation, continuous mosquito control in inter-epidemic periods is mostly wasted and, if the determinants of epidemic risk remain unknown, it is unlikely to prevent the recurrence of epidemics.

3. FINANCING ANTIMALARIAL ACTIVITIES

Throughout history, efforts to control malaria have often mobilized important community and eventually government resources. In fact, in many countries the organized antimalarial programmes developed eventually into rural health services.

The development of scientific malaria control after the late nineteenth century was mainly financed by the local resources of affected areas, particularly those involved in important economic development works, such as irrigation, dams, railway and road construction, or industrial complexes. In tropical areas, the main source of financial and human resources was the military arm of the colonial powers, before the mobilization of resources from such major economic interests as railways, irrigation, mining, forestry and tea and rubber plantations.

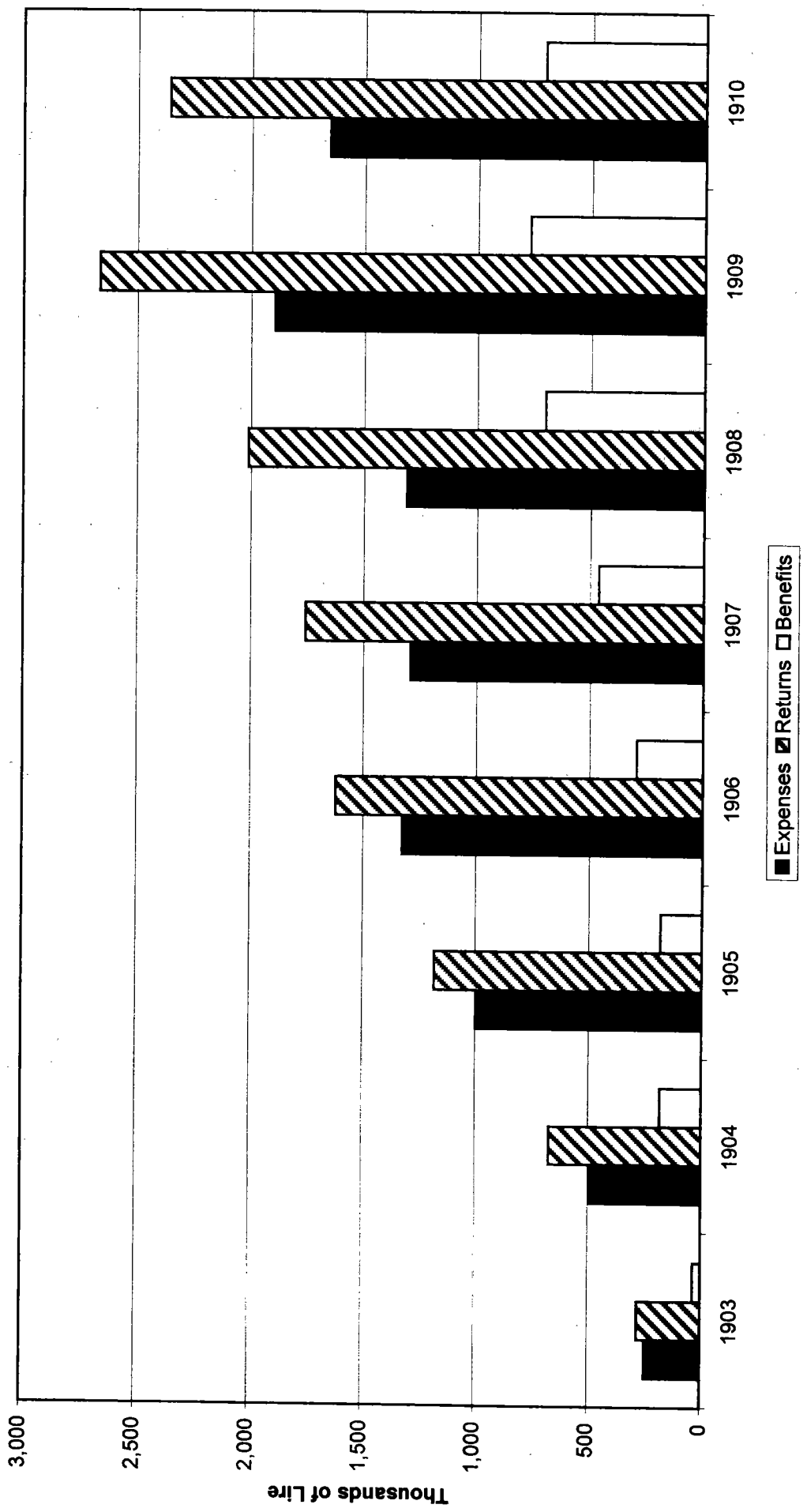
After 1900, the Italian government began to set up a national programme, coordinating and supporting all private and local resources, also establishing and supporting the scientific institutions necessary to promote and guide local resources. Other countries followed this example, and national malaria control programmes developed during the first half of the twentieth century. Central government malaria control activities in Italy were financed from a special account which received all the benefits derived from the sale of quinine plus all the fines imposed for infractions of the law; the accounts of the first ten years of operation of the state quinine programme are shown in **Figure 7**. Sanitation works were carried out by the Ministry of Public Works, provincial and local governments, and major partners such as the railways and the Italian Red Cross.

Similar situations existed before the Second World War in other European countries, where antimalaria activities were usually coordinated by the public health authorities and relied on mobilizing local and private resources. Particularly limited were the resources of the Spanish Malaria Commission; in 1925, it had a budget of 380 000 pesetas, while the budget of the General Directorate of Health was only 8 million and that of the whole State 3 000 million; from this it had to pay personnel (salaries of specialists were less than 300 pesetas), purchase quinine and dispensary equipment, subsidize malaria courses and run all other activities (Malaria Commission, 1926; Editorial, 1927).

Nevertheless, as malaria control became more complex, the antimalarial programmes progressively acquired increased responsibilities in the execution of activities, recruiting specialized staff and developing clear identities within the health services and obtaining some degree of administrative independence.

The adoption of the malaria eradication policy in the 1950s or early 1960s further strengthened the independence of antimalarial services, but was not always accompanied by substantial increases in budgetary allocations. In fact, the malaria eradication strategy was presented to health authorities by calling their attention to their recurrent expenditure in control and stating that the main requirements of a malaria eradication programme were a good organization and strict discipline; countries that needed to increase their programme's financial resources were encouraged to apply for external assistance.

Figure 7. Italian Government Programme "Chinino dello Stato" Financial Results (1903-1910)



Source: Ministero delle Finanze (1911)

Figures 8 and **9** show the national budgets of some American antimalaria programmes as reported by PAHO between 1941 and 1965, indicating the total amounts of the malaria budget as well as the percentage of the health budget devoted to malaria. Comparison of these figures, in spite of the great number of lacunae and some changes in reporting systems, suggest that, before the launching of the malaria eradication campaign in 1955 some countries, e.g. Brazil, Panama and Venezuela, and probably Guatemala and Nicaragua, had substantial malaria budgets. In some of them, such as Panama, malaria control was one of the principal activities of the health services, if not the first one, so that the proportion of the health budget devoted to malaria actually decreased in the 1950s, as other services developed. By contrast, in other countries, e.g. Colombia and Mexico, the malaria budget increased, as did the proportion of the health budget allocated to malaria, indicating that there was mainly an administrative transfer to the malaria eradication campaign, of activities already funded by the health services. Elsewhere, the resources of the national programmes were also the basis for the build-up of the global malaria eradication campaign.

In a similar way, the change from an eradication to a control strategy did not liberate programmes from their operational and staff commitments and as a result most programmes tried to retain their rather large budgets. An effort to collect information on actual expenditures by national malaria control programmes in 1981 reported a total expenditure of US$ 350 million, as shown in **Table 2.** This total did not include data from the African or European Regions and there were some countries with important antimalaria programmes which did not provide information, such as Iran, Iraq and Pakistan, while other sources of information indicate that the expenditures of those three countries amounted to more that US$ 170 million.

Table 2. Reported regional expenditures on malaria programmes, 1981, in US$

WHO Regions	National governments	WHO/PAHO & international	Bilateral sources	TOTAL
Americas	134 843 378	2 398 466	2 927 269	140 169 113
Eastern Mediterranean	21 119 700	1 534 700	2 469 600	25 594 200
		470 200		
South-East Asia	145 781 400	1 542 100	16 003 500	163 392 900
		65 900		
Western Pacific	19 689 200	150 600	1 016 000	20 892 700
		36 900		
TOTAL	321 433 678	6 198 866	22 416 369	350 048 913

Source: Howard (1986).

Correcting for the missing countries brings the total estimate of programme expenditure to over US$ 500 million, of which more than 90% came from national resources. Furthermore, national expenditures for malaria within the general health services were not included, nor were those of state, provincial and local governments, nor those of economic development projects. Also, international assistance for projects not specifically designated as malaria control often included funds for antimalaria activities. If all sources were to be included, the estimate for national expenditure on antimalarial activities could plausibly be doubled (Howard, 1986).

Figure 8a. ANTIMALARIA ALLOCATIONS AS PERCENTAGE OF THE HEALTH BUDGETS LARGE COUNTRIES (1943-1957)

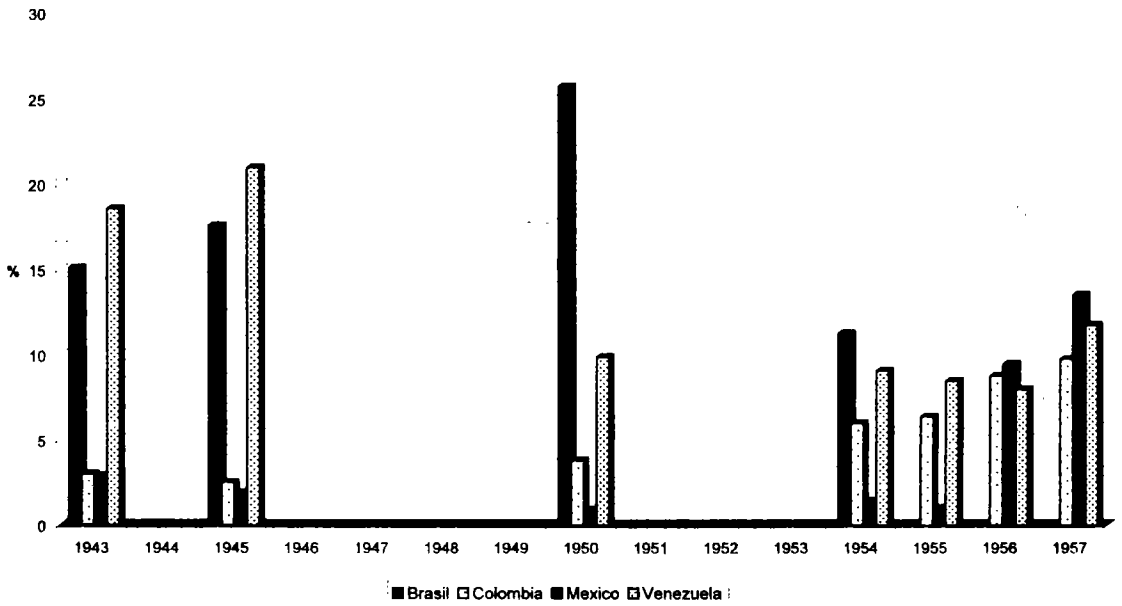


Figure 8b. NATIONAL BUDGETS FOR ANTIMALARIAL PROGRAMMES LARGE COUNTRIES (1941-1967)

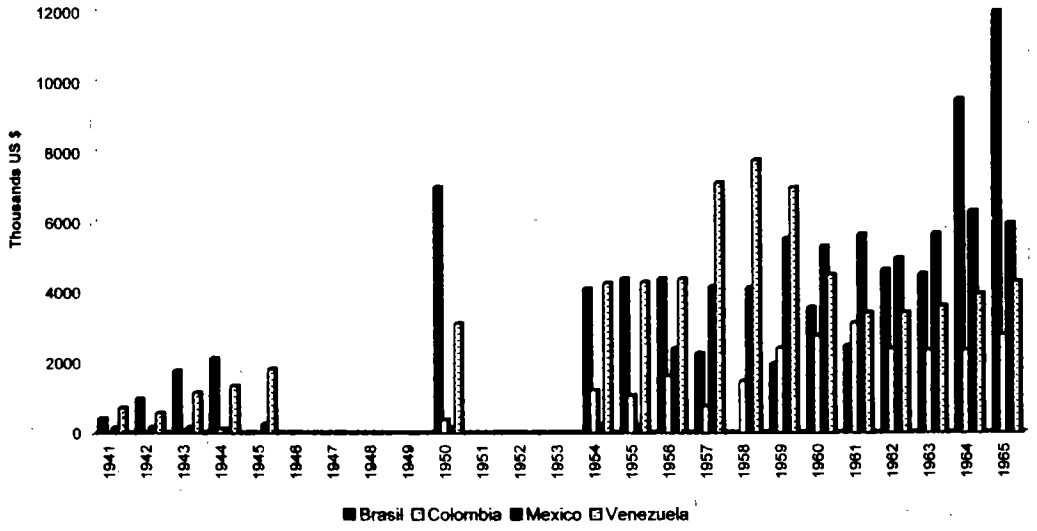


Figure 9a. ANTIMALARIA ALLOCATIONS AS PERCENTAGE OF HEALTH BUDGET CENTRAL AMERICA (1943-1957)

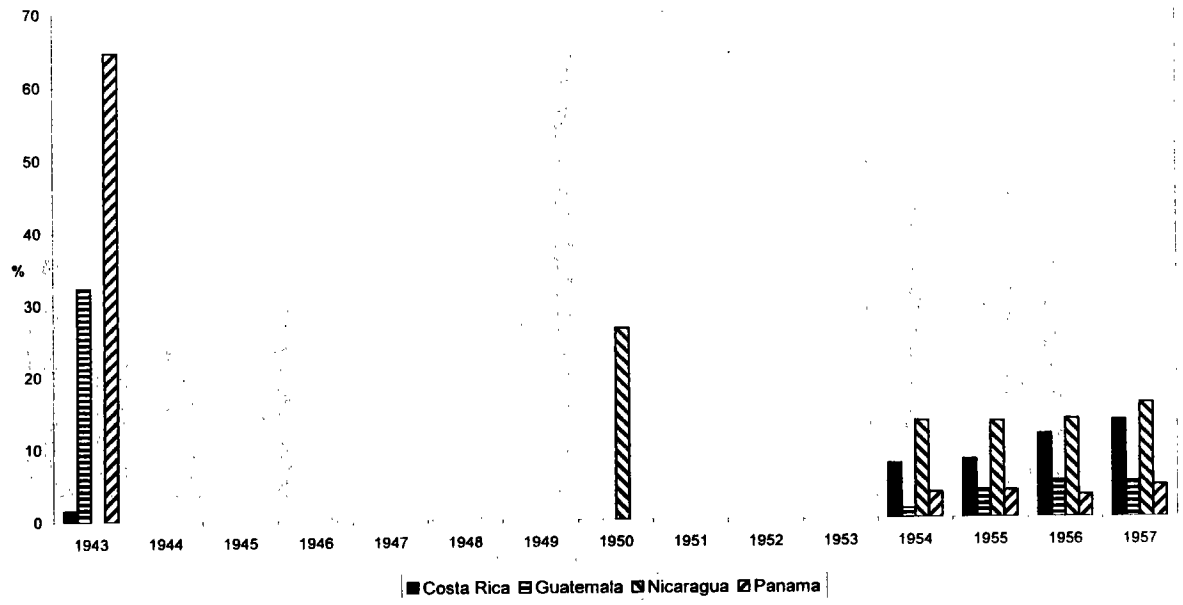


Figure 9b. NATIONAL BUDGETS FOR ANTIMALARIAL PROGRAMMES IN CENTRAL AMERICA (1941-1965)

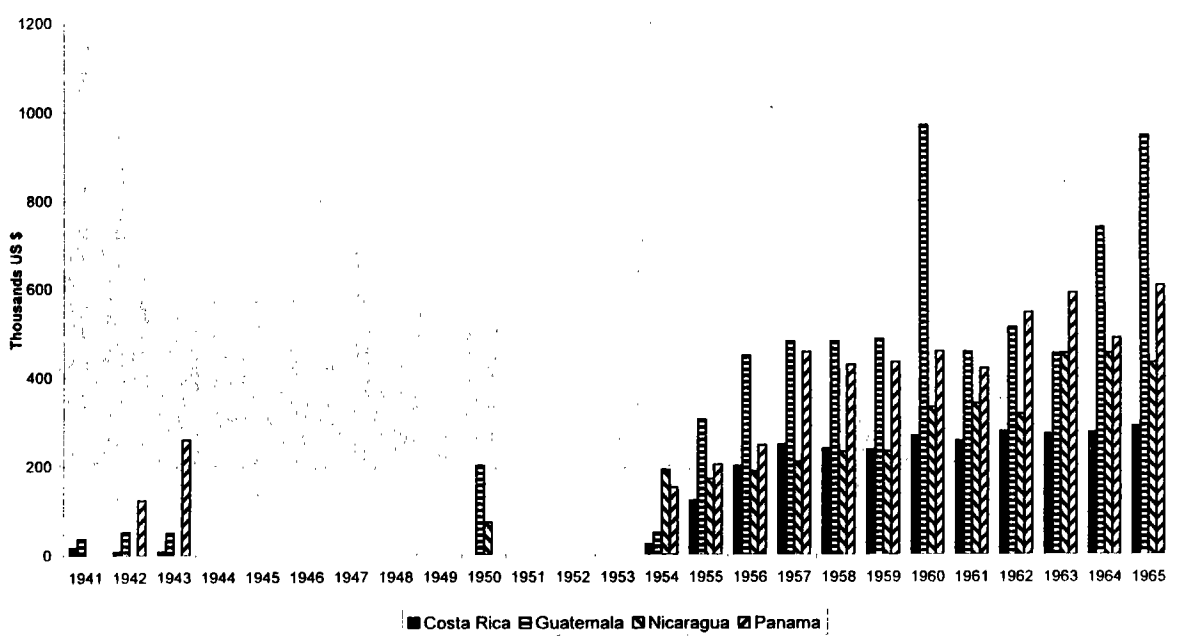


Figure 10 shows the evolution of antimalaria budgets of the countries of the Americas between 1957 and 1995, indicating the continuous increase in national allocations to try to cope with the increase in the costs of personnel and commodities, while at the same time international and bilateral collaboration stagnated and declined, except for the input of the World Bank, mainly to Brazil, during the last few years. The absence of data between 1986 and 1995 and the apparent decline from 1984 should be noted, mainly due to the increasing tendency to account for antimalaria activities under primary health care programmes.

The apparent increase in budgets shown in Figure 10 were mainly the result of general inflation and the even greater increase in the costs of insecticides, transport and wages. The eighteenth report of the Expert Committee on Malaria (WHO, 1986) commented: "The perpetuation of vertical programmes involving a large labour force results in a constant increase in the proportion of the health budget devoted to maintaining this labour force when budgetary constraints are accompanied by increases in wages and salaries. Increased employment opportunities for professionals and skilled staff both within and outside their country have contributed to their leaving the programme, resulting in a decrease in the operational capacity of the programme and a gradual reduction in the number of professional and supervisory staff able to plan and execute its reorientation". The report illustrates the contrast between the rather slow decline in personnel with the rapid drop in operational capability **(Figure 11)**, where the number of house sprayings is used as an indicator of the programme operations.

Figure 12 shows the comparative evolution of human resources for the antimalarial programmes in the Region of the Americas between 1957 and 1981, indicating the considerable reduction in professional staff and particularly, since the mid-1970s, in the proportion of professional staff in the programmes and that of international collaborating staff. This decline, which also occurred at the same time in all other regions, coincided with an increased effort to support international and national training throughout the world, as shown in **Table 3.**

3.1. International collaboration and support

> *... no gift of money however large, and no outside agency however wise or good, can render a service of permanent value except insofar as the gift or the agency offers the means or the occasion for evoking from the community its own recognition of the need to be met, its own will to meet that need, and its own resources, both material and spiritual, wherewith to meet it.*
>
> **The Trustees of the Rockefeller Foundation, 1913, quoted by Russell, (1955)**

Malaria control was one of the first public health programmes seen as requiring some form of international coordination, demanding the early attention of the emerging international health organizations, which became promoters of government action and financial supporters of the development of such actions. Malaria control had been on the agenda of every Pan American Sanitary Conference, since 1907.

Table 3. Training of malaria eradication workers (1957-1967)

Years	Courses at international centres		Courses at WHO-assisted national centres		Fellowships	Exchange of malaria workers
	N° of courses	N° of national participants	N° of courses	N° of national participants		
1957	-		1	26	50	3
1958	6	68	2	30	52	6
1959	5	67	1	22	78	3
1960	4	57	3	44	82	6
1961	9	144	15	404	145	18
1962	10	160	19	528	172	17
1963	10	162	22	574	186	16
1964	7	174	24	572	187	22
1965	9	255	29	811	203	22
1966	10	234	32	930	207	18
1967	9	171	43	1214	142	26
TOTAL	79	1492	191	5155	1504	157

Source: WHO Chronicle (1969) 23: 234.

Figure 10. ANTIMALARIA PROGRAMMES IN THE AMERICAS
ANNUAL EXPENDITURES IN THOUSANDS OF US DOLLARS (1957 - 1995)

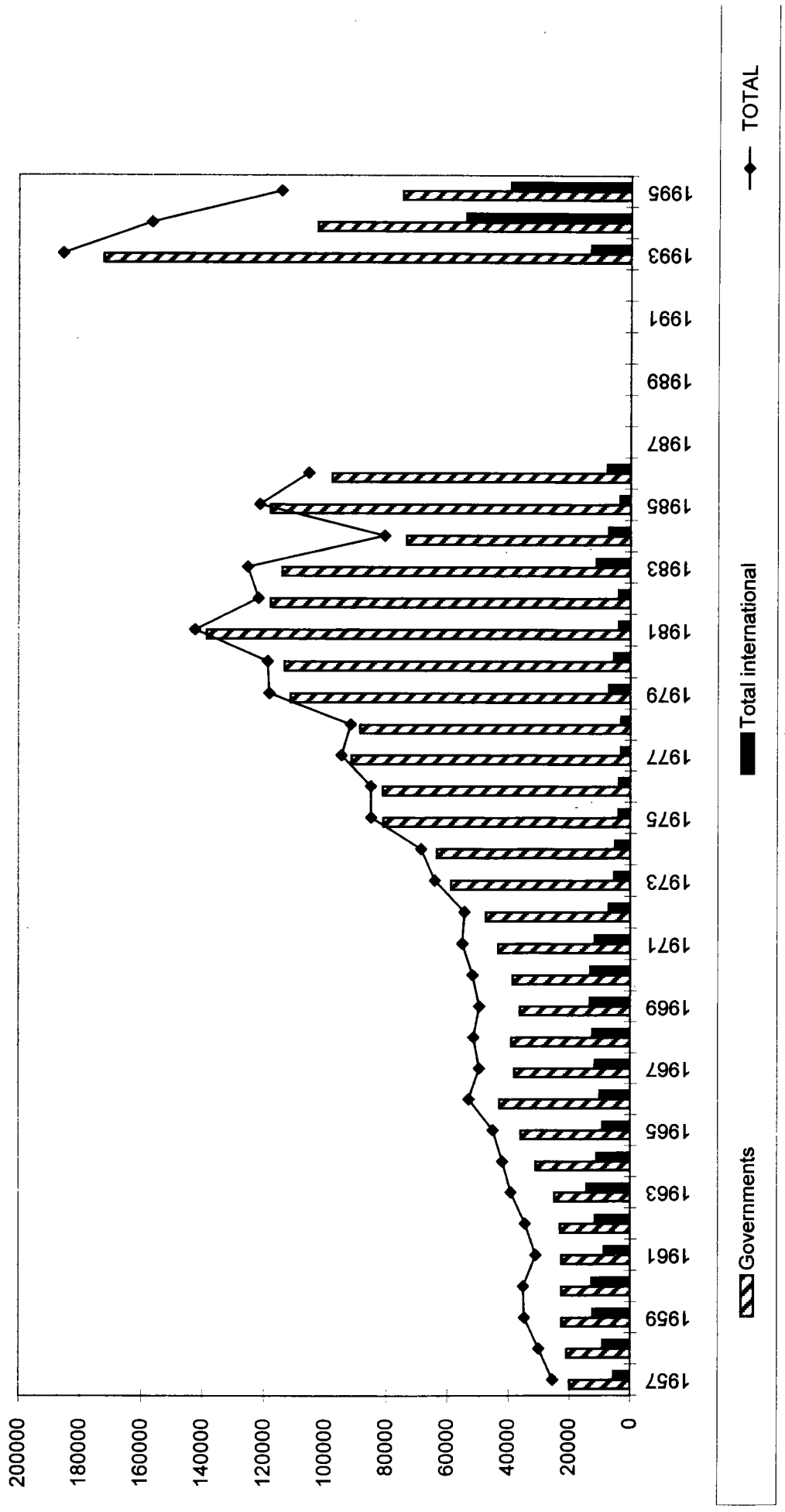


Fig. 11 Insecticide spraying in the originally malarious areas and numbers of malaria personnel in areas in the attack and consolidation phases in the Region of the Americas, 1972-82

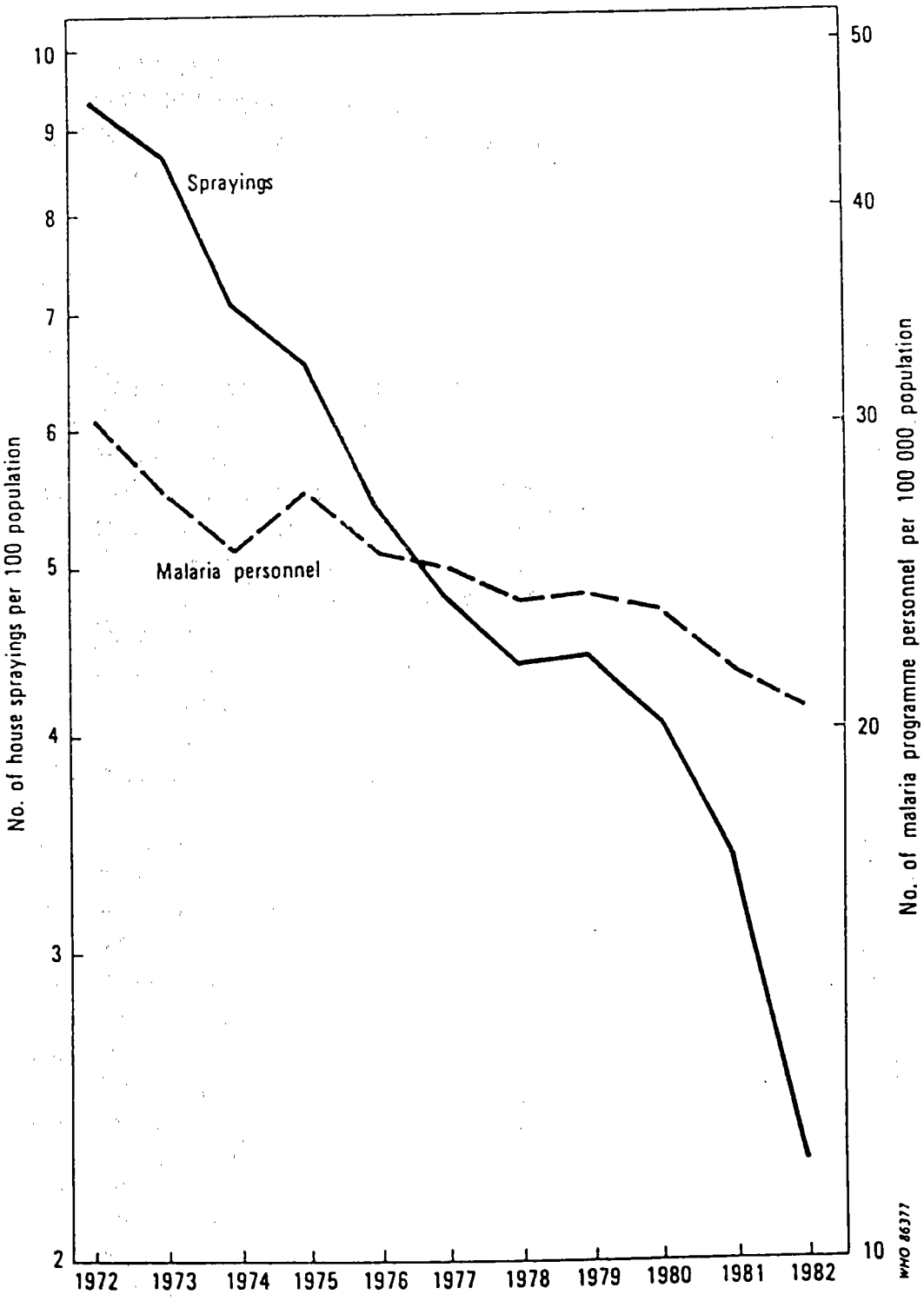
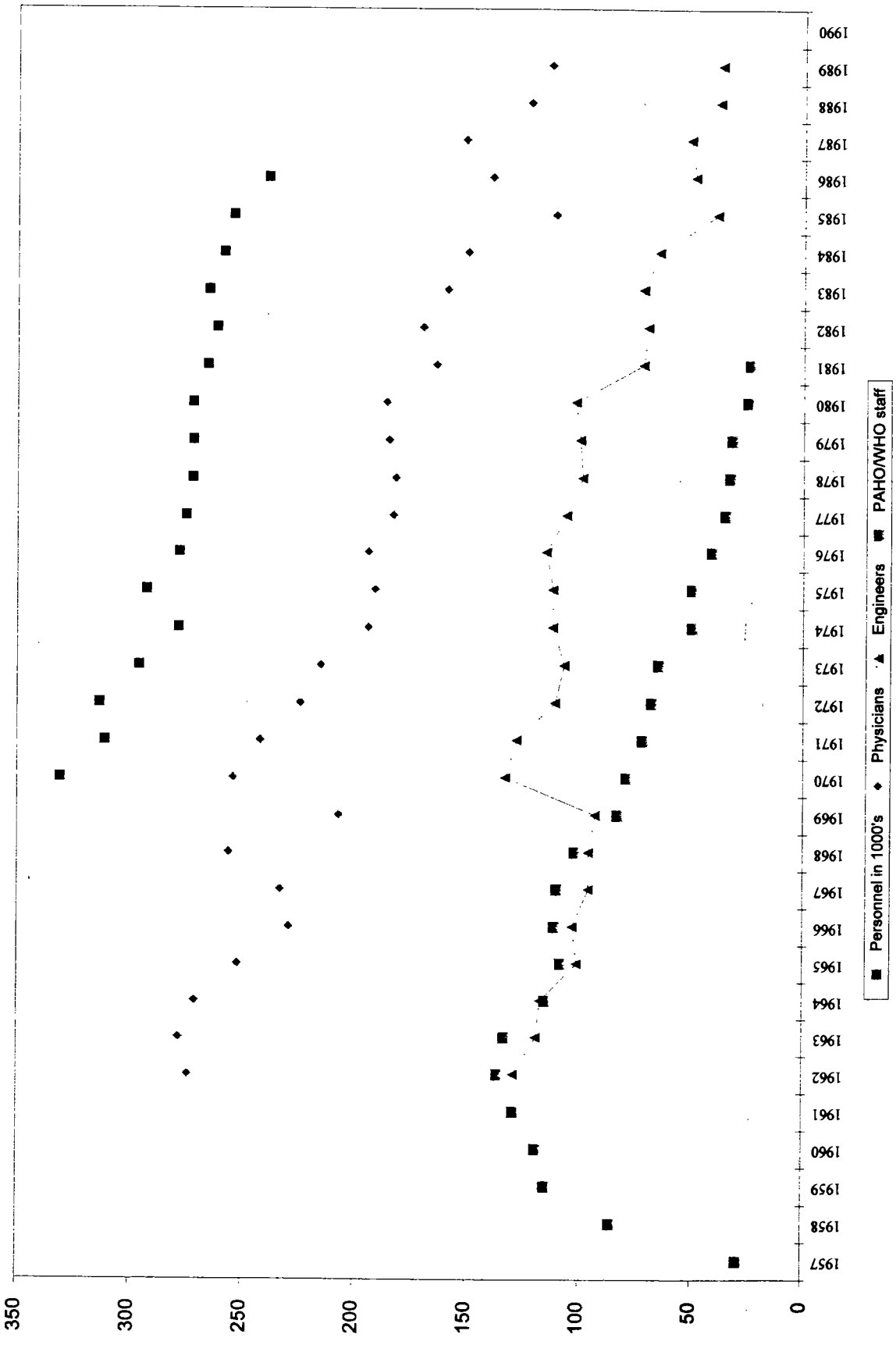


Figure 12. TOTAL AND PROFESSIONAL PERSONNEL ASSIGNED TO MALARIA CONTROL, PAHO/AMRO



The internationalization of the malaria problem may be traced to the spread of malaria epidemics throughout Europe in the early 1920s, which prompted a conference in England in 1923, at the request of several countries trying to devise a continuous public health policy to cope with the situation. "Doctors who had received a training in public health were few and far between and there was a great lack of subordinate personnel. Malaria was everywhere prevalent and severe and it was a question whether the public health policy should be based primarily on efforts to deal with this disease, or whether primary attention should be given to general medical and public health requirements which were equally of pressing importance ... The situation was new to European experience and it was thought that useful advice about it might perhaps be given by a group of workers who had had experience of similar conditions in the tropics. In May 1923 a proposal to this effect was presented to the Health Committee of the League of Nations ... The Health Committee appointed a small Malaria Sub-Committee, and later (in 1924) the Malaria Commission" (James, 1937). The Commission organized tours by experts to study country situations. In 1925 it had the benefit of the participation of an expert from the United States, Dr Samuel Darling, a young collaborator of Gorgas in Panama, on a tour to study the situation in Palestine and Asia Minor; at the end of the tour he and the Secretary of the Commission, Dr Norman Lotian, were killed in an accident; the United States established the Darling medal and prize in memory of Dr Darling. The Rockefeller Foundation funded the work of the Malaria Commission, thus permitting a considerable increase in its activities, after 1925 and up to the Second World War.

After the Second World War malaria control was an important component of the programme of the Institute of Inter-American Affairs, established in 1942. Up to June 1951 it had spent US$ 9.5 million on malaria control projects in 18 Latin American countries out of a total health assistance of $ 92.4 million. Malaria control was also included in Point Four of President Truman's Inaugural Address, implemented under the Marshall Plan.

Malaria control was included among the priority concerns of the Interim Commission of the World Health Organization, and a Malaria Expert Committee was established whose first meeting actually preceded the official creation of WHO.

The Rockefeller Foundation which, as mentioned above, had supported malaria control in the United States from 1915, started cooperative studies with governments in 1921, first in Latin America but promptly extended to Europe and the Philippines, to test experimentally on a small scale in the field particular methods for reducing the incidence of malaria, and to collect field and laboratory observations. These studies, conducted by antimalarial stations under the direction of members of the Foundation's International Health Division, were aimed at discovering affordable control methods, as had been recommended in the 1915 Annual Report: "In the case of malaria, while methods of treatment and control can be effectively applied under ideal conditions, it is still necessary to discover whether the various known measures, such as quinine treatment, screening and drainage operations, can be effectively employed, separately or in combination, at a cost which will not be prohibitive in those communities which suffer most from the disease". The Foundation sought to develop local capabilities and training was therefore an important component of its programme, particularly through the granting of fellowships for medical graduates to become malariologists and for malaria workers to observe what was being done in other countries.

The field stations of the Foundation were often called "stations for the demonstration of methods of control" but, according to James (1937) they could have been called "research stations", since there was hardly any item of malaria research, except perhaps chemotherapy, which had not received attention. Besides the support of field stations, which in Europe alone numbered 38 in the mid-1930s, the Foundation supported the coordination of international work in malaria control and, as mentioned above, funded the work of the Malaria Commission of the League of Nations from 1925. The total malaria expenditure of the Rockefeller Foundation (1916-1954) is presented in **Table 4.**

Table 4. Malaria expenditures by the Rockefeller Foundation, 1916-1954

Early field studies	125 962
Leesburg (Georgia)	30 270
Edenton (N. Carolina)	40 822
Tallahassee (Florida)	241 050
Brazil (*Anopheles gambiae* eradication)	395 419
Italy	802 502
Albania	135 032
Sardinia	411 185
TOTAL	4 903 236

Total yearly expenditures reached four peaks:

1929	200 000
1936-38	195 000
1940	300 000
1948	190 000

3.2. The WHO Malaria Eradication Special Account (MESA)

This special account was created by the WHA in 1955 by the same resolution WHA 8.30 that established the global malaria eradication campaign. Contributions were rather meagre: 44 countries supplied, between 1956 and 1963, US$ 20.33 million, of which the United States paid $ 17.5 (86.1%), but contributions practically stopped after 1963, when that country ceased its contributions. **Figure 13** shows the yearly contributions to MESA as from its establishment, with the potential use of the funds classified as "unspecified" and "specified". It should be noted that: (a) originally there were some important contributions and all were unspecified, that is, they could be used for any need of the programme; (b) between 1963 and 1975 there were practically no contributions; and (c) between 1975 and 1984 there were some important contributions but

practically all of them were specified, that is, were funds given through WHO for specific activities in specified countries, being actually complementary to bilateral assistance. After 1984 there were a few contributors who recognized the importance of supporting the general activities of the malaria programme of WHO and made some unspecified contributions, although most of the funds still continued being specified.

Figure 14 presents the same contributions to MESA, showing how the special account was originally dependent, between 1956 and 1963 on the contributions of the United States. Once that country, the main promoter of the global eradication programme from its inception, stopped contributing in 1963, there was a gap of more than ten years in MESA funding, until in the mid-1970s funds for "specified purposes" were accepted in the account.

In 1958, President Eisenhower in his State of the Union address included, among the "Works for Peace" on which the United States was embarking, with other nations, an all-out campaign against malaria "to blot out this curse for ever", and invited the Soviet Union to join in. Support from the United States to the campaign included direct bilateral assistance and voluntary contributions to the malaria eradication programmes PAHO, UNICEF and WHO. By the early 1960s it was considered that the United States "could not much longer carry a disproportionately large responsibility for the well-being of the world's people", and that it should not be the only international supporter of the global campaign, and that other malaria-free countries should join in the effort. In 1963, as mentioned above, that country discontinued its voluntary contribution to the WHO malaria eradication special account.

In 1966, President Johnson, in his State of the Union Address, declared that "we can eliminate malaria in this hemisphere and large parts of Africa and Asia. We can end yellow fever in this hemisphere and we can find new controls for cholera, rabies and other epidemic diseases".

Nevertheless, the erosion of international confidence in the global eradication campaign, as discussed in § 2.5 above, prevented the mobilization of financial support. The international concern aroused by the massive resurgences of the mid-1970s and European concern about the epidemic in south-east Turkey, brought about a renewal of contributions to MESA but, as shown in **Figure 13**, only for the support of specified activities. It was not until after the mid-1980s that some countries were ready to support WHO's efforts to coordinate the development of a revised, realistic strategy of malaria control, and started to make unspecified contributions to MESA.

The drastic drop in contributions to MESA had to be compensated for by WHO's regular budget in order to maintain the international assistance needed by endemic countries, but this did not prevent a continuous erosion of that assistance, since WHO funds were increasingly required for other activities and budget growth became progressively reduced. **Figure 15** shows the proportion of the WHO total budget devoted to antimalarial activities since 1951. The decline in WHO assistance was reflected, as mentioned in § 2.7, by the reduction in WHO malaria advisory staff from 444 in 1967 to 155 in 1977. This is also illustrated by **Figure 16**, showing the numbers of PAHO/WHO international staff in the malaria programme of the Americas between 1957 and 1981, which reveals a decline parallel to that of the global programme. This figure shows the great demand for technical and field staff following the initiation of the global eradication campaign and its rapid decline from 1963, following financial difficulties.

Figure 13. CONTRIBUTIONS TO THE WHO MALARIA SPECIAL ACCOUNT BY DESTINATION OF FUNDS (1956-1996)

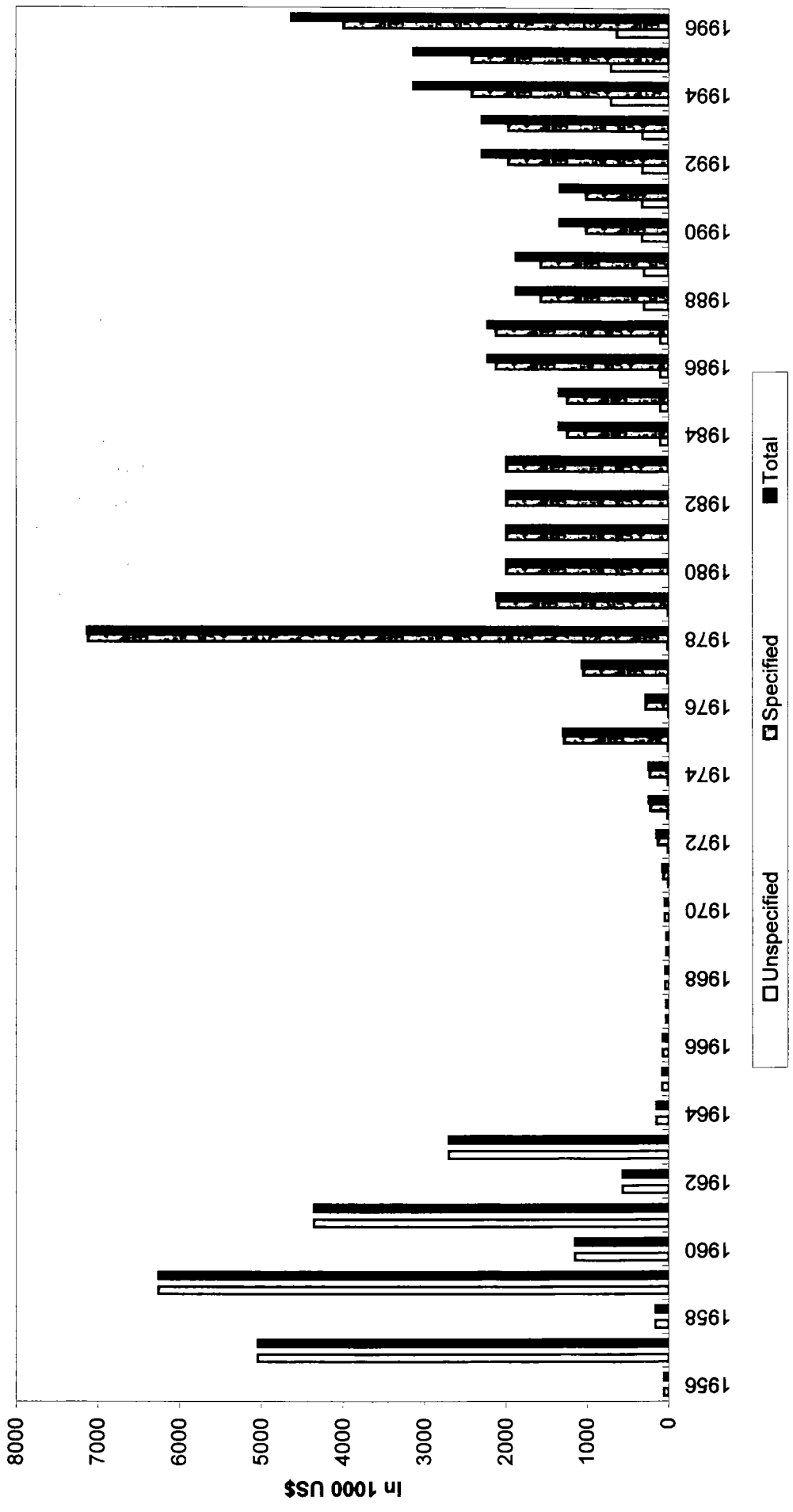


Figure 14. WHO ANTIMALARIA SPECIAL ACCOUNT AND U.S.A. CONTRIBUTIONS

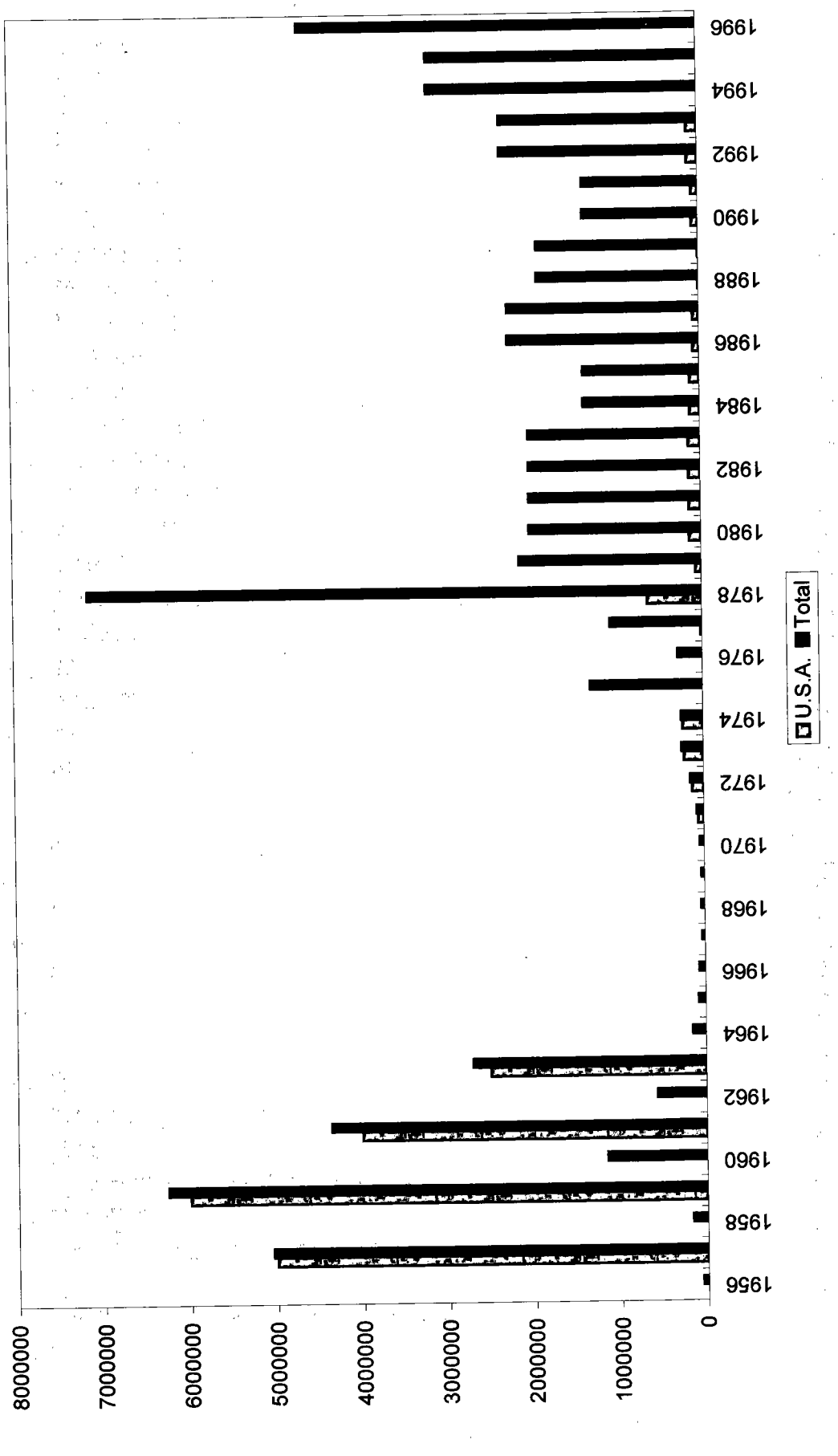


Figure 15. PERCENTAGE OF TOTAL WHO FINANCIAL RESOURCES (REGULAR & EXTRABUDGETARY) ALLOCATED TO MALARIA CONTROL (1958-1993)

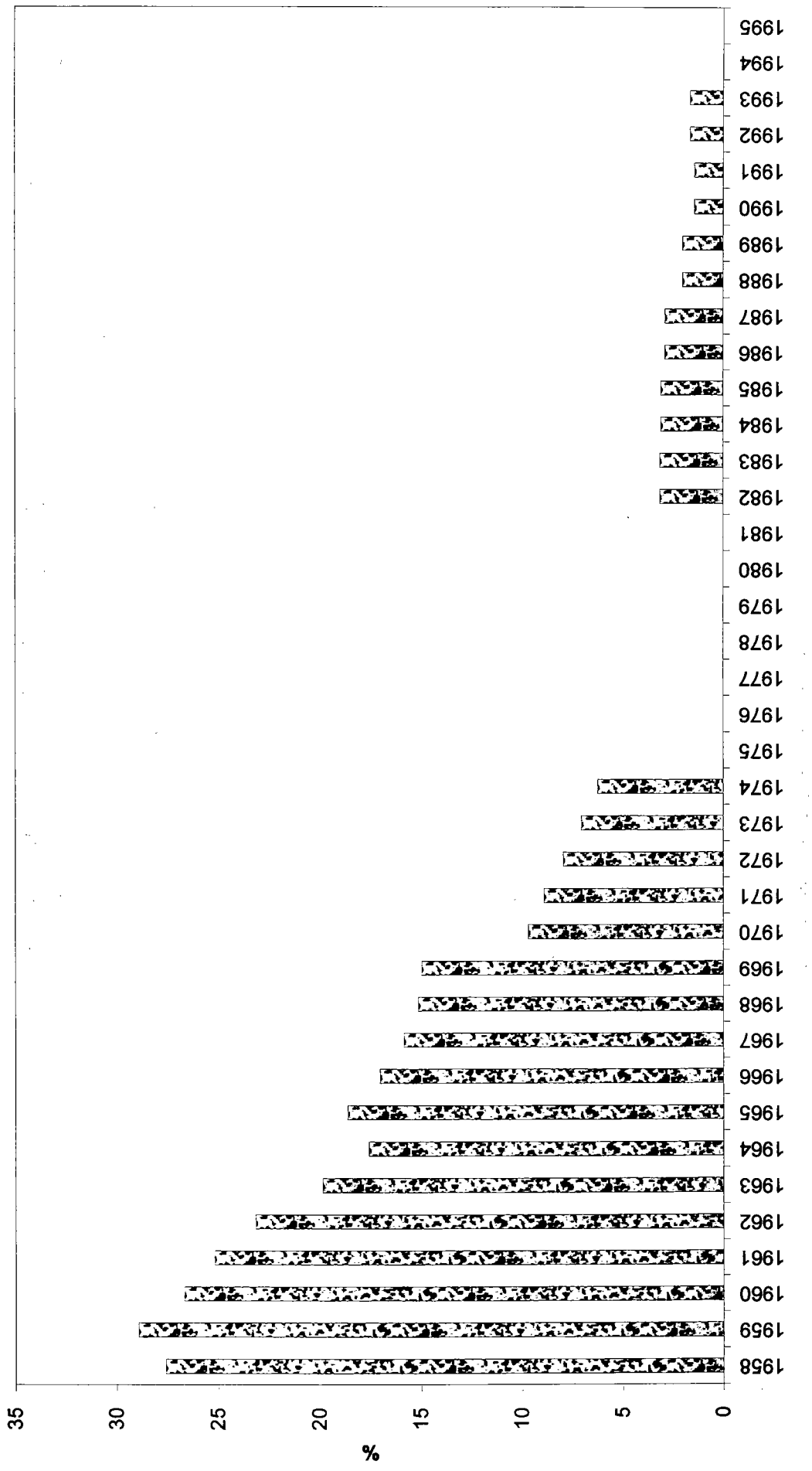
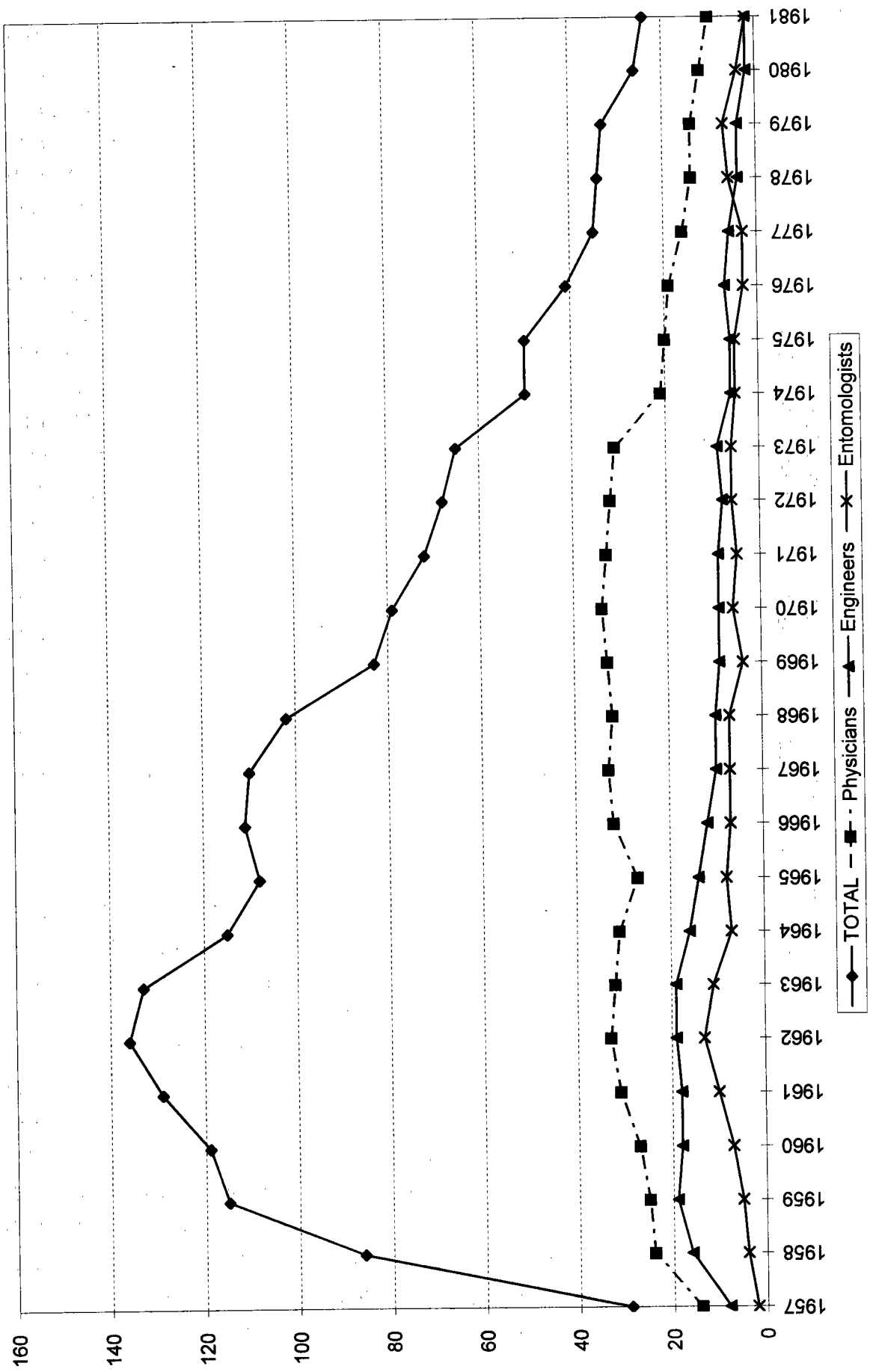


Figure 16. INTERNATIONAL STAFF ASSIGNED TO MALARIA CONTROL, PAHO/AMRO (1957-1981)



4. THE REVISED GLOBAL STRATEGY FOR MALARIA CONTROL

In the study of malaria problems and in the formulation of control programmes, action based on generalisations is likely to be followed by the most disastrous consequences. It has been well said that the most hazardous of human tendencies is the drawing of general conclusions from limited experience, and in no instance it is more applicable than in the planning of malaria control measures.

Sir Gordon Covell (1949)

Everything about malaria is so moulded and altered by local conditions that it becomes a thousand different diseases and epidemiological puzzles. Like chess, it is played with a few pieces, but is capable of an infinite variety of situations.

Hackett (1937)

4.1 Evolution of the problem and revision of the malaria control strategy

The fast deteriorating malaria situation during the 1970s became a serious concern of the governing bodies of WHO; this concern was particularly provoked by the massive epidemics in the Indian subcontinent between 1973 and 1976, and in Turkey in 1977. It was accompanied by a general mistrust in the capacity of vertical programmes and the global antimalarial programme to deal with the problem; new contributions were made to the WHO Malaria Special Account, but they were "specified contributions" to be used exclusively for countries and purposes defined by the donors (see Figure 13, § 3.2).

Although the great epidemics of the mid-1970s were controlled by the re-establishment of attack measures and the reorganization of antimalaria campaigns, which in India, for example, consumed more than half the resources of the central government's health budget, the new equilibrium reached in the mid-1980s represented a morbidity about twice as high as that of the early 1970s. From the late 1980s, efforts to improve case management in tropical Africa were hampered by the rapid spread of chloroquine resistance, the problems of infrastructure building and the chronic limitations of resources.

The formulation during the mid-1970s of the primary health care strategy for the development of health infrastructure guided the elaboration of a malaria control strategy which was adopted by the Thirty-first World Health Assembly in 1978 (WHO, 1978). The strategy aimed at least at the reduction of mortality and of the negative social and economic effects of the disease, the prevention and control of epidemics, and the protection of malaria-free areas with the ultimate objective of eradicating the disease whenever feasible. The selection of control methods was to be made following what was defined as the epidemiological approach, i.e. taking into fullest possible consideration the biological, ecological, social and economic determinants of the malaria problem, and those factors which might influence the applicability or effectiveness of individual control measures and their possible combinations. A fundamental element of the strategy was the recognition of the variability of epidemiological situations, of the feasibility of their modification and of the availability of resources, and therefore of the need to adapt malaria control planning to local conditions. Mapping the distribution of these different conditions was

defined as the "stratification" of the malaria problem, which was to be the basis for the selection of control interventions (see § 1.3.9 above).

Many of the problems which hampered the transformation of eradication into control programmes continued to prevent the WHO malaria control strategy from being implemented throughout the 1980s. It was recognized that most of the existing antimalarial programmes had all their resources tied up in inadequate efforts to maintain the status quo by a "fire-fighting" strategy, and that progress and the solution of new problems would require: (a) epidemiological redefinition of their situation; (b) redistribution of resources; (c) reorientation of personnel; and (d) redistribution of responsibilities between specialized and general health services.

In 1985, the World Health Assembly urged a review of the malaria situation and current control activities. The Expert Committee (WHO, 1986) analysed the situation and elaborated the epidemiological approach to control, based on the recognition that variability, although due to a multitude of factors, could be studied in relation to the potential effectiveness of available interventions, thus in turn permitting the recognition of a limited number of types of situations characterized by predominantly demographic, parasitological, entomological, ecological or social and politico-administrative factors. The recognition of the geographical distribution of these types provided a means to the practical stratification of the malaria problem and to the selection of appropriate control interventions (WHO, 1986; Nájera et al., 1989).

Two main objectives were recognized:

(a) the provision to the whole population in malarious areas of accessible and appropriate diagnostic and treatment facilities for malaria as a disease, which should be used for health information and education of the population; these facilities should be an integral part of the health infrastructure and, although in some areas they may start as specialized malaria dispensaries or clinics, they should have potential for further development into broader primary health care; and
(b) the control or interruption of malaria transmission, which should be guided by the epidemiological services and selectively applied to the control or prevention of epidemics, and to other problem areas where both feasibility and sustainability could be expected.

An analysis of the malaria situation in 1988 (Nájera et al., 1989) showed a general qualitative deterioration of the malaria situation in the world, reflected by the spread and intensification of parasite resistance to antimalarial drugs, the relative increase in *P. falciparum* in endemic areas outside tropical Africa (from 15% in the early 1970s to 36% in 1988) and the increased frequency of epidemics in recent years. It also highlighted the great focalization of the malaria problem. It could be estimated, based on survey data in the absence of reliable statistics, that over 90% of the world's malaria cases and deaths occurred in tropical Africa. In the rest of the world, most malarious countries had similar reporting systems which allowed some degree of comparability, showing that the seven countries reporting most cases (India, Brazil, Sri Lanka, Afghanistan, Thailand, Philippines and Viet Nam, in decreasing order) -- with only 30% of the population of the world's malarious areas -- had 74% of the cases, and that within these countries malaria was concentrated in certain areas. In India, six states had 66% of the cases; in Brazil, 97% of the cases were in Amazonia, which had only 15% of the country's population. This focalization reflected, on the one hand, the persistence of the problem in tropical Africa and other areas of limited socio-economic development such as the tribal areas of South-east Asia, which had

proved physically or culturally inaccessible to the regular and disciplined interventions which antimalarial programmes continued to try to implement. On the other hand, it also reflected the success of past large-scale efforts for malaria control in many areas of the world and the creation of new high-risk situations, triggered by civil war or socio-political conflict (including illegal drug trade), increased numbers of refugees and displaced populations, and recent efforts to increase the exploitation of natural resources in jungle areas, which thus became points of attraction for settlers and temporary workers. In addition, the commitment of programmes to maintain previous gains, the budgetary limitations, the increased cost of insecticides and second-line drugs, and the need to develop new forms of control prevented most programmes from attacking those new problem areas. The malaria distribution today is reflected in **Map 6.**

The continued monitoring of the way the control strategy was applied led WHO to call for a Ministerial Conference on Malaria Control in Amsterdam, in October 1992. This conference was preceded by three Interregional Meetings on Malaria, for Africa (October 1991), for Asia and the Western Pacific (February 1992) and for the Americas (April 1992). The interregional meetings reviewed the situation in their regions, updated the regional antimalarial strategies and contributed to the formulation of the revised malaria control strategy to be presented at the Amsterdam Conference.

The revised Global Malaria Control Strategy adopted by the Ministers of Health meeting in Amsterdam was endorsed by the World Health Assembly in 1993, reviewed by the Economic and Social Council of the United Nations and endorsed by the UN General Assembly in 1994 (Resolution 49/135: UN, 1994) and by the 33rd ordinary session of the Organization of African Unity (OAU) in June 1997. The latter produced the Harare Declaration on Malaria Prevention and Control in the context of African Economic Recovery and Development (OAU, 1997).

4.2. The elements of the global strategy

> *Malaria is a local disease to be dealt with by local efforts.*
>
> **Swellengrebel (1931)**

> *Malaria control should not be a campaign, it should be a policy, a long term program. It cannot be accomplished or maintained by spasmodic effort. It requires the adoption of a practicable program, the reasonable continuity of which will be sustained for a long term of years.*
>
> **Boyd (1939)**

The revised global malaria control strategy (WHO, 1993a) stresses the paramount importance of responding to the needs of the people of malarious areas by making adequate case management accessible, both physically and culturally, to all populations; this is considered a necessary requisite for the build-up and the sustainability of other measures aimed at the prevention of infection.

The strategy rests on four basic elements:

- to provide early diagnosis and prompt treatment;
- to plan and implement selective and sustainable preventive measures, including vector control;
- to detect early, contain or prevent epidemics; and
- 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.

It recognizes that the effective implementation of the strategy requires:

- sustained political commitment from all levels and sectors of government;
- malaria control to be an integral part of health systems, and to be coordinated with relevant development programmes in non-health sectors;
- communities to be full partners in malaria control activities; and
- the mobilization of adequate human and financial resources.

In summary, "the Global Strategy calls for rational use of existing and future tools to control malaria. It recognizes that malaria problems vary enormously from epidemiological, ecological, social and operational viewpoints, and that sustainable, cost-effective control must therefore be based on local analysis. Based on decades of lessons from practice, the Strategy is firmly rooted in the primary health care approach, and calls for the strengthening of local and national capabilities for disease control, for community partnership and the decentralization of decision-making, for the integration of malaria control activities with related disease programmes, and for the involvement of other sectors, especially those concerned with education, agriculture, social development and the environment. It emphasizes the vital importance of continuing malaria research, locally and internationally, and of international teamwork in both control and research" (WHO, 1993a).

The strategy stresses the indisputable advantage of sustainable, even if slow, progress over spectacular but ephemeral success. Its main goals concern problems that are not only important, but manageable. It recognizes that malaria control is an essential part of health development and, as such, has to contribute to the health system as well as make use of it.

The objective of control is to prevent mortality and reduce morbidity and social and economic loss, through the progressive improvement and strengthening of **local national capabilities**. It is recognized that there is no single technical formula applicable to all situations and that, therefore, interventions should be adapted to local conditions, the key to which is "competent local action" (WHO, 1993b).

From the point of view of malaria control, the existence of two main categories of malarious countries is recognized:

- those, mainly in tropical Africa, which were not included in the global eradication campaign of the 1960s and which therefore never established an antimalarial programme that included all their malarious areas; and

- those, included in the campaign, which had implemented large-scale programmes of vector control, based on indoor insecticide spraying, and surveillance, based on case detection.

The strategy outlines the programme priorities for these two main categories in order for those countries in the first category to establish realistic malaria control programmes, and for those in the second to transform their antimalaria activities so as to provide effective and sustainable protection of their population. In both categories of countries, it is necessary to establish effective and efficient epidemiological information systems to recognize and manage epidemic risk, and to adapt preventive measures to the main epidemiological types existing in the country.

The selection of specific interventions in any area should be guided by the progressive understanding of the ecological and epidemiological characteristics of the area, process which has been designed as "stratification" of the malarious areas (see § 1.3.10 above), on which the effectiveness of the intervention and feasibility of its application would depend (Kondrashin & Rashid, 1987). The eco-epidemiological characterization should be taken in its broader sense, including the socioeconomic condition and the degree of development of the health services, on which the sustainability of achievements may depend. The close relationship between malaria and the ecological and social environment makes it possible to recognize common characteristics of the malaria problem and its amenability to control between areas presenting ecological and social similarities, even if they are in very distant areas of the world. It has, therefore, been proposed as a first step towards stratification, the identification of some major epidemiological patterns or "eco-epidemiological types" (Nájera et al.,1992; WHO, 1993a).

The strategy recognizes that affected countries would need the technical and financial support of the international community and stresses the need to establish partnerships between governments and international or bilateral collaborating agencies for the necessary coordination to ensure continuity of action and unity of purpose.

WHO convened a Study Group on the Implementation of the Global Plan of Action for Malaria Control 1993-2000 (WHO, 1993b) and a Study Group on Selective Vector Control (WHO, 1995) to provide technical guidance on implementing the strategy. In addition WHO and the World Bank organized a consultation to explore the political, managerial and financial problems that antimalarial programmes were experiencing in different parts of the world in putting the global malaria control strategy into effect (WHO/World Bank, 1995).

4.3. The use of impregnated bednets and risks of interfering with the development of immunity

> *I have had experience during many years and in many different countries, and have only once been infected, and that at a time when we did not know how the infection is produced. I always rely upon the possession of four articles, namely, a good bed-net, costing about eight shillings, a small hand-net for catching mosquitoes, costing about one shilling, a palm leaf fan, costing one penny, and a bottle of quinine. With these articles the chances of becoming infected are reduced enormously -- especially if a little common sense and care are added to the stock.*
>
> **Ross, R. (1911) The Prevention of Malaria, p. 287-8**

The impregnation of bednets with residual pyrethroids, which besides their insecticide effect, have an important repellent action, considerably enhances the protection afforded by mosquito nets for periods of three to six months and even more, depending on the conditions of their use (e.g. climate, people's sleeping habits, frequency of washing) and the pyrethroid used (WHO, 1997a). Insecticides recommended for impregnation include permethrin, deltamethrin and lambda-cyhalothrin, although new pyrethroids continue to be developed and evaluated (WHO, 1997b).

The important effect of impregnated mosquito nets on childhood mortality in WHO/TDR-supported trials in the Gambia, Ghana and Kenya has created a new expectation that a relatively simple method of transmission control could afford an overall approach to malaria control in tropical Africa, to the point of making some international and bilateral agencies consider supporting the use of impregnated bednets as the core of a strategy of malaria control.

To be effective, mosquito nets, impregnated or not, need to be accepted by the population, which is normally the case in areas with high density of nuisance mosquitoes, particularly early biters that interfere with people's sleep; the nets are less likely to be acceptable in areas or periods of high humidity and little air movement. Also, vector biting habits and people's activities after dusk must not coincide and thus result in important transmission before people retire under the net. The Afrotropical vectors *A. gambiae* and *A. funestus* bite predominantly in the central hours of the night; nevertheless, trials have shown that the main protection is afforded to young children who retire early.

Essential factors influencing the use of bednets as a collective preventive measure are affordability and accessibility, with all the associated production and distribution problems. In the Gambia between 1992 and 1994 a very successful project in which bednets and impregnation were provided free of charge failed when a charge of about US$ 0.50 was claimed for bednet re-impregnation. Even government subsidies may not be able to ensure that bednets can be afforded by the poor, who are most likely at greatest risk.

Even if the problems of affordability and accessibility were resolved, serious doubts have been expressed on the long-term benefit of a bednet programme. Observations in Congo, Kenya, Senegal and the United Republic of Tanzania indicate that merely reducing transmission in endemic areas may reduce severe morbidity and mortality in young children but places them at a higher risk at older ages, without a net cohort benefit (Snow & Marsh, 1995; Trape & Rogier, 1996; Snow et al,1997). Molineaux (1997) argues that delaying specific malaria mortality may still reduce total malaria mortality, as the indirect malaria mortality due to cofactors such as measles, respiratory infections, diarrhoeal disease and malnutrition (which some studies suggest may be as high as or higher than specific mortality), may be concentrated in early life.

The importance of transmission control being integrated into a solid health care infrastructure is shown by the fact that the majority of endemic countries have found it very difficult to maintain effective transmission control activities without it. Often such activities were instituted with an original dependence on external aid or the development of vector, nuisance insects or people resistance, required adjustments that the programme could not afford. In any case, the discontinuation or weakening of control activities resulted in a transmission resurgence of often epidemic proportions, which when caused by *P. falciparum* resulted in high mortality. Already in the late 1940s, Wilson suggested "that a major control scheme in a hyperendemic area in Africa

might be followed by malaria of a different character, and of much more serious import, than that to which we are accustomed, *if control measures slackened*" (Wilson et al., 1950).

There should not be an open choice between case management and prevention of infection. The malaria control strategy considers case management as the backbone of control. On the other hand, the prevention of infection requires that the selection of interventions should be based on adequate understanding of the epidemiological and social determinants of the problem to guarantee the sustainability of the results. Many countries have epidemic-prone areas where it should be desirable to establish mechanisms for either "early epidemic detection and control" or "epidemic forecasting and prevention", which should require organized vector control. In addition, in most endemic countries, people spend considerable amounts on protection against mosquitos and there exists some organized vector control activities in urban areas and in certain development projects.

4.4. Human resources development

As had already been recognized in the 1980s, most malarious countries suffer from a shortage of professional and technical personnel knowledgeable in epidemiology and in malaria control, and even those with national antimalaria programmes required reorientation of their personnel and redistribution of responsibilities between the specialized and the general health services, particularly in regard to disease management and epidemiological information. It is therefore necessary to ensure the training and retraining of specialized and general health services personnel, and to provide the mechanisms and instruments for recruiting and guiding intersectoral collaboration and community participation.

Training is an essential part of capacity building. Training activities should not be considered as an end in themselves but as a part of human resources and service development, and should therefore be adapted to the needs of reorientation of staff and the setting up of new services or programme activities.

The strategy therefore considers essential the strengthening of training facilities and their financing, including not only the costs of training centres and initial courses but also in-service follow-up and adequate equipment and other support, so that people can progressively apply what they have learnt. Training should take place at levels relevant to the learning requirements and where the required teaching resources may exist or can be made available; courses or other training activities may take place at international, intercountry, national or local levels, but the training environment should reflect working conditions as closely as possible. Re-training will be needed to reorient existing personnel in new tasks, and in-service training should enhance skills and help workers to adjust their activities to changing epidemiological situations.

WHO, with the collaboration of the World Bank, is strengthening its programme for the elaboration of teaching aids, training modules and guidelines for the development of training courses, as well as continuing its collaboration with training institutions in endemic countries.

4.5. Support of research in malaria

> *All scientific work is incomplete -- whether it be observational or experimental.*
> *All scientific work is liable to be upset or modified by advancing knowledge.*
> *That does not confer upon us a freedom to ignore the knowledge we already have,*
> *or to postpone the action that it appears to demand at a given time.*
>
> **Sir A. Bradford Hill (1965)**

Malaria control, as the fourth element of the strategy indicates, should be based on the best available knowledge of the epidemiological problem and its determinants, and should be guided by a continuous re-evaluation of their variation.

It is essential to build national capabilities in order to plan, execute and evaluate antimalarial activities adapted to local situations, making the best possible use of existing resources.

Research in malaria has been substantially strengthened since the 1970s. However, it has occurred to some extent independently of established malaria control programmes. Scientific malaria control and research had developed jointly, as mutually supportive and interacting activities, until the advent of DDT, when less attention was paid to malaria research. The new emphasis on malaria research came out at a time of declining support to control. Much more attention was therefore paid to the development of new tools than to epidemiological research or to the solution of problems arising in control programmes.

The description, in 1985, of the rift between research and control, by the in-depth evaluation of the Malaria Control Programme of India, could easily apply to most control programmes at the time and, unfortunately, of many programmes today. It found "a curious rivalry between the malaria programme and outside research bodies, with the former being almost defensively entrenched in earlier techniques (e.g. residual spraying) and the research workers uncritically proclaiming as alternatives what should have been complementary techniques"; most research projects had little operational bearing on the control programme, while the latter lacked "the capacity either to carry out research, to guide it, to generate issues for research based on analysis of incoming information, or to translate into operational use research carried out by other institutions" (Evaluation Committee, 1985).

The WHO/World Bank/UNDP Special Programme for Research and Training in Tropical Diseases (TDR) has, since 1975, supported the search for new or improved tools for control and the development of research capabilities in endemic countries. Its main contributions have included its support for the development of new antimalarial drugs, particularly mefloquine and artemisinin derivatives, the development and field evaluation of candidate antimalarial vaccines, and evaluation of the impact of the use of impregnated mosquito nets.

The WHO malaria control programme, currently integrated into the Division of Control of Tropical Diseases, has continuously reviewed the results of laboratory and field research, promoting and supporting their field validation, and developing guidelines for the management of control problems. These cover the use of antimalarial drugs, the parasitological diagnosis of malaria, the monitoring of drug resistance, the development of national drug policies, the management of severe and complicated malaria, and the use and evaluation of selective vector control. TDR and the relevant normative programmes of WHO have actively collaborated in

these developments, which have recently included the development of guidelines for the management of uncomplicated malaria, norms for the use of artemisinin and its derivatives, a common approach to the treatment of a sick child at the peripheral level, evaluation of new diagnostic techniques, including the use of dipstick tests, and support for operational research in the field to solve control problems. WHO has continued to support research on pesticides that are of potential use in public health and has adapted its Programme for the Evaluation and Testing of Pesticides (WHOPES) the needs of to control programmes (Chavasse & Yap, 1997).

Recent contributions of malaria research include the development of new drugs, one of which, atovaquone, has a novel mode of action (Oliaro & Trigg, 1995), and improved use of drug combinations; new insecticides and improved formulations; and new diagnostic tests which may be suitable for field use if cost and availability could be improved. Important advances are also being made in the development of potential antimalarial vaccines; the study of parasite populations where there may be a possibility of extending epidemiological studies to the molecular level; and the potential development of biological control of vectors. In addition, the careful analysis of the results of the use of antimalarial drugs in the field has led to the identification of an effect of artemisinin derivatives in reducing post-treatment gametocytaemia, which may explain, at least in part, the rapid reduction in *P. falciparum* incidence in both Thailand and Viet Nam in the last few years (Price et al., 1996).

Research may provide new and improved techniques needed to extend the feasibility of control, it may provide epidemiological tools to improve the guidance, and therefore the efficiency, of control, and it may show better ways to combine interventions in more effective and efficient strategies. But it is equally necessary that any new tool be validated in the field and field-tested to determine its applicability in disease control; operational research should be undertaken to find better ways of integrating the new and the old tools. Health systems research may find better ways to incorporate new control approaches into the ways in which the health infrastructure interacts with communities and individuals to improve malaria control.

The renewal of interest in malaria research created a certain imbalance in the relative importance and prestige given to research and control activities. Nevertheless, during the 1990s there has been a serious concern on the part of the health authorities of endemic countries and of the international community to redress that imbalance, not only by increasing the support of control programmes but, even more importantly, by promoting, facilitating and supporting the collaboration and interaction between research institutions and control programmes. For this purpose it is necessary to continue and strengthen efforts:

- to recognize the value of field epidemiological studies, upgrading when necessary the scientific and technical competence of control staff, and to ensure the best possible communication and exchange between research and control;
- to formulate national research policies oriented to the solution of national problems and not only to follow research leads or to support the completion of registration requirements of products of potential commercialization in developed countries;
- to incorporate the participation of scientific and research institutions in the planning, guidance and evaluation of control programmes, as well as in the formulation of relevant policies, such as drug or pesticide policies.

4.6. Control and prevention of malaria epidemics

During the eradication campaign it was expected that the country interruption of transmission, and the eventual eradication, would eliminate the risk of epidemics. Interest shifted from the forecasting, prevention and control of epidemics towards a uniform attack on malaria, based on the qualitative (yes or no) delimitation of malarious areas, followed by a system of surveillance to detect reintroduction or resurgence. Some epidemiologists studied the "epidemiology of disappearing malaria" (Macdonald, 1956; Yekutiel, 1960; Soper, 1960; Russell et al., 1963) and the potential development of malaria outbreaks originating from one or a few residual imported cases in areas free from the disease. Such descriptions were mainly based on theoretical considerations since there were very few observations of such types of situation.

Macdonald (1956) emphasized the importance of the expected timing and scale of epidemics arising from a small origin in a part of the countryside otherwise free from the disease. Analyzing the factors affecting the ***basic reproduction rate*** in such epidemics, he concluded that the great majority of naturally occurring epidemics seem to be "attributable to relatively low reproduction rates, and if they arose from small origins should be sufficiently slow in early development to make recognition by an efficient surveillance system simple". He recognized that past epidemics had occurred in areas where some obstacle to transmission existed, while eradication was to be achieved in areas having a very high basic reproduction rate, where a "surveillance system should be established which could without any doubt detect recrudescence within, at most, a couple of weeks of the occurrence of secondary cases".

Unfortunately, as mentioned above the "developed mechanisms" for such efficient surveillance (case detection) were heavy, slow and costly, and were imposed on malarious countries long before they even approached malaria-free status, so that from the very beginning, both laboratories and surveillance workers became overloaded with work which was consequently delayed and skimped. In fact, the traditional health care systems, even if their development had been neglected, proved to be much more effective and efficient in detecting epidemics than the specialized case detection services (Sharma et al., 1985; Fonseku & Mendis, 1987).

The abandonment of malaria eradication and the formulation of a malaria control strategy (WHO, 1978) formally called for the control of epidemics to become a major component of the strategy. Nevertheless, the concept persisted that all malaria situations were equivalent, all would succumb to the proper application of standard attack measures, and could be characterized by quantifying the actual and potential transmission in terms of the incidence of infection (API) and the *vectorial capacity,* the *reproduction rate* or the *inoculation rate*. Onori & Grab (1980) attempted to develop practical applications of the general theoretical model by proposing the ***entomological inoculation rate*** as a comprehensive indicator of malaria transmission and therefore as an indicator of epidemic risk; they recognized that epidemics could have a variety of determining factors, that could give an indication of developing risk, but actual forecasting should be based on the determination of the proposed indicator. The extensive review of malariology edited by Wernsdorfer & McGregor (1988) limited its consideration of malaria epidemics to a cursory listing of recognized and potential precipitating factors, without suggesting any system of forecasting, prevention or control.

The eighteenth and nineteenth reports of the WHO Expert Committee on Malaria, in 1985 and 1989 respectively, tried to reawaken interest in the study, forecasting and control of epidemics, as an essential component of modern malaria control. Kouznetsov (1989) reviewed the main determinants of epidemics after the end of the global eradication campaign, and Nájera & Beales (1989) tried to analyse variability in the causal factors of epidemics and the need to organize appropriate emergency preparedness so as to be able to respond in useful time.

The Global Malaria Control Strategy adopted by the Amsterdam Conference in 1992 has epidemic prevention and control as one of its basic elements. Unfortunately, as described above, the work of the Malaria Commission of the League of Nations was not followed up after the launching of the malaria eradication campaign; as a result the study of epidemics has to restart and to adapt to the present situation.

As the Malaria Commission fully understood, study cannot be limited to the detection of an epidemic situation and the study of the epidemic itself, but has to be extended to the understanding of the characteristics of each epidemic area, which would be crucial to a decision on what kind of response to mobilize.

The concept of **early detection** is to be expressed in terms of the *real time* available for implementing an appropriate response. It is therefore necessary to establish both a monitoring system capable of detecting the earliest indicators that might trigger the chain of determinant events, as well as **emergency preparedness** to respond to a potential or actual epidemic. As recommended by the Commission, it is most important to determine the **epidemic potential** and its distribution within each area, as well as the timing when particular indicators are relevant. A comparison of the relative value of the time for action after different indicators have been used, suggests the following:

- the detection of an increase in reported malaria incidence gives little or no time for action since, in most cases it will only be noticed when the epidemic is fully established; this is particularly the case in the routine surveillance services, still maintained by many antimalaria programmes, which consider only parasitologically confirmed cases, have large backlogs in their laboratories and retain a highly bureaucratic system of consolidation and reporting of data. The sensitivity of the system could be improved by requiring peripheral services to report, by emergency channels, *abnormal* increases (an agreed definition will be needed for each area) in fever cases and/or severe malaria cases, thus providing the earliest information on the increase of incidence and, if emergency preparedness is in place, the possibility of strengthening case management capabilities or, in very serious situations, instituting mass treatments; it will usually be too late to do much about vector control, since intense transmission would have been going on for more than two or three weeks, and may already be declining;
- the use of endemo-epidemic indices of malaria cases (Cullen et al.,1984), of fever cases or of any other indicator is a method that provides a criterion of normality (provided no changes are introduced in the system of data collection) and it may therefore be used as a procedure for recognizing deviations from normality of any indicator;

- entomological indicators, such as increased vector density or longevity would, in theory, allow enough time to introduce transmission control measures, such as house-spraying, re-impregnation of bednets or, if affordable, space-spraying, but the difficulties and cost of obtaining representative and relevant entomological information are often prohibitive;
- monitoring periods of temperature-humidity favourable for vector survival, as would be required for *oasis malaria epidemics* (Daggy, 1959), also offers a short time for action as it detects the period when longevity is increased and therefore transmission is occurring; depending on the type of preparedness, it may permit some form of emergency control;
- monitoring rainfall, in areas such as the Punjab, where the pattern of rainfall in specific periods may give an indication of increased breeding and therefore allow over a month of real time to mobilize vector control;
- monitoring periods of excess dryness when rivers will form pools and provide more vector breeding places, would give a similar time for action;
- monitoring river levels in areas, such as Khartoum, subject to direct flooding or increased water-logging at times of excessive rise of water level; in such areas, increased vector breeding occurs in the pools resulting from the withdrawal of flood waters and therefore may give an additional period of one or two weeks. Moreover if, as with most desert rivers, their levels originate at very distant upstream areas, the alarm signal could be obtained several weeks earlier;
- even earlier warning may be obtained by monitoring weather satellite information when local indicators of risk have been defined by the analysis of remotely sensed vegetation and weather data, integrated with ecological and all available epidemiological information into an accessible geographical information system (Thomson et al., 1997; Connor et al., 1998);
- in many areas (north-western India, Sri Lanka, Colombia, Venezuela) it has been shown that there is a historical association between malaria epidemic years and the meteorological disturbances linked to the El Niño-Southern Oscillation, thus providing a very early warning which will permit general preparation and the careful monitoring of the pertinent indicators so that preventive measures can be implemented in time (Bouma & van der Kaay, 1996; Bouma et al., 1997).

The correlation between the local epidemic risk and the El Niño or the opposite La Niña years may correspond to excessive wet or dry weather spells. For example, the well-documented malaria history of the Punjab shows that, in that area, the El Niño years are particularly warm and dry and malaria epidemics tend to occur in the following year, which frequently has heavy rain. In contrast, the malaria epidemics of southern-central Sri Lanka are associated with La Niña years, when the south-west monsoon fails.

Historical research has a major role, not only in helping to provide the most solid thread to link with the studies and the tested hypotheses of the past, but also to provide specific areas with historical data which could help to identify associations of past epidemics with certain ecological or social variables. This approach may suggest hypotheses of possible etiological associations and can therefore play a role in the search for useful indicators of epidemic risk.

One of the most important ideas to retain is that **not all epidemics are equal** -- in their dynamics, in the way they end, in the desirability of investing great efforts to control them.

As the Malaria Commission already recognized, an epidemic is a **rupture of equilibrium,** not necessarily limited to the population's herd immunity. It is therefore essential to understand what was the basis for the previous equilibrium and what was its resilience, as well as what is the potential stability of the current situation.

An epidemiological problem is the result of some change in an ecological niche and one important characteristic to evaluate in ecological niches is their **resilience**, that is, their ability to return to their previous state of equilibrium after being disturbed. Of course, if the disturbance is sufficiently strong to break the resilience of the system, that system will tend to find a new state of equilibrium with or without some period of oscillation. The classical example is a spring, which requires constant pressure to be depressed, unless the pressure is strong enough to break it or make it lose its elasticity. These potential states of relatively stable equilibrium will determine the **sustainability** of a change that has occurred in an epidemiological situation.

There is clearly considerable variation in the degree of stability of different epidemiological *equilibria* and, similarly, in the degree of sustainability of malaria control. In some cases the table situation is that of absence of malaria transmission, and in others that of more or less high endemicity. An essential question in dealing with an epidemic situation is, therefore, to distinguish whether it is:

- an abnormal disturbance of a stable non-malarious equilibrium, in which case the epidemic will end by itself; or
- a return to a more stable endemic situation after interruption of unsustainable control, in which case the problem to be considered is how to adapt to the new endemicity and implement a control strategy similar to that of other endemic areas; or
- the result of a new ecological disturbance which will not disappear spontaneously, in which case the possibility should be considered of correcting that disturbance or otherwise of adapting to it, by devising some form of malaria control within the new situation.

Similarly, the choice and timing of control activities should be based on that assessment; unfortunately, a common response to malaria epidemics has been to mobilize all resources to introduce standard measures of transmission control, such as insecticide spraying or mass drug administration. Often the time required for such mobilization is so long that the epidemic is already over when vector control becomes operational; moreover, due to the general attrition of standard control measures, they gradually lose their effectiveness before the periodic return of conditions favourable for a new epidemic.

4.7. Intersectoral collaboration and community participation

> *La quadruplice invincibile alleanza del medico igienista, dell'idraulico, dell'agricoltore e del maestro conduce viribus unitis ai successi, ormai confermati, della nuova colonizzazione.*
>
> **Celli (1925)**

The inability of the Global Malaria Eradication Campaign to achieve its objective globally, was one of the causes of disappointment with vertical health campaigns which led to the birth of the primary health care strategy for health development in the mid 1970s and its adoption as global health policy in the Alma-Ata Conference in 1978.

Primary health care included intersectoral collaboration and community participation as two of the main elements of the strategy and ministries of health started to organize, as from the mid-1970s, elaborate programmes of community participation with missionary zeal, based mainly on two false assumptions: (1) the belief that the traditional values of the poor were the main obstacle for development and for health improvement, and (2) the idea that the poor were incapable of organizing themselves (Ugalde, 1985).

The return to a strategy of malaria control after that of malaria eradication did not and could not re-establish the collaborative spirit which existed between malariologists and health authorities, or between them and the people of endemic areas, in the early days of control. Nor could it mobilize the full participation of industry and private enterprise, after having liberated them from their responsibility for malaria control. As a matter of fact, early efforts of malaria control had started, in most instances, at the demand, either of:

- public works, industry or private enterprise, which found that malaria was a serious obstacle to their activities, and were fully prepared to provide for the necessary expenses, requiring from health authorities technical guidance, supervision and evaluation; collaboration even extended to such instances as the funding of the Ross Institute in London by the Tea Plantations of Ceylon;
- communities aspiring to be delivered from epidemic malaria or increased mosquito nuisance, generally in relatively well-developed areas in temperate climates and with not very high endemicity.

Malariologists provided advice and tried to study the local problems, establishing collaborative links with authorities, institutions and people; in most instances, the combination of the effectiveness of the control measures, socioeconomic development and the collaborative control programme, resulted in the impressive success which led to the expectations of global eradication.

The eradication campaign, instead of encouraging community participation, insisted on imposing the obligation of accepting insecticide spraying and provided free antimalarial treatment which, in many places, soon became also discredited as malaria accounted for only a small proportion of the fevers suffered by the population.

Many health planners in the 1970s felt that "community control of the systems that provide human services to the poor is a concept that is here to stay. Community participation is here, more of it is coming, and programs aren't going to work without it" (Geiger, 1969, quoted by Paul & Demarest, 1984). But health workers in the field encountered serious difficulties, as expressed by the UNICEF/WHO Joint Committee on Health Care, because "efforts by nongovernmental organizations, which may be genuinely motivated to help the poor improve their health situation and their socioeconomic position, are faced with considerable obstacles. If the hostility of the local elite is aroused, it is likely to be backed up by the machinery of the state, and the community-involving activities will be neutralized or prescribed as subversive" (WHO, 1981).

In a review of community participation programmes for the control of vector-borne diseases, Service (1993) concludes that community participation in malaria control programmes has suffered a chequered history, primarily because of cultural barriers and misconceptions; as Agyepong (1992) commented, there can be no meaningful involvement of local communities when their medical perceptions and that of biomedical teams who plan and initiate control are so divergent. But, as Werner (1980) noted, the establishment of a meaningful dialogue would require a real mutual understanding since "as many pioneers of health care alternatives will testify, often those whose attitudes and traditional approach are most difficult to modify are not the villagers but the professionals".

An important form of community participation for extending diagnosis and treatment facilities is the networks of voluntary collaborators of Latin American and some Asian countries (see § 2.4, above). An evaluation (Ruebush & Godoy, 1992) in Guatemala of the volunteer collaborator network, established in 1958, showed that there were more than 5 000 collaborators operating throughout the malarious areas of the country; their age ranged from 12 to 76 years, and 61% were men; approximately 15% had no formal education and only 27% had a sixth grade or higher education; the median length of service was 35 months, ranging from 3 months to 26 years, and 33% had worked for five years or more; male volunteers had significantly lower turnover than females, as did married when compared with single ones; an inverse relationship was noted between the level of education and the length of service.

They continued to be considered unpaid volunteers since they received no salary from the health services, which assumed that their motivation was basically altruistic, without exploring the variety of compensatory relationships that could be established between the community and individuals provided with knowledge and logistic support by the health services. Voluntary health workers often relate to the community as private medical practitioners and, as such, may vary from effective providers of community services, which the community appreciates, compensates and demands, to instruments of exploitation of community weakness (Nájera, 1984). Many of them have continued for years, seemingly established as the village doctors, maintaining an important clientele. Even if chloroquine has a general anti-inflammatory action, the success of the voluntary collaborators cannot be based on the effectiveness of their treatment if they use only the chloroquine provided by the antimalarial service.

Ruebush et al. (1994a) have investigated in Guatemala the qualities of an ideal "volunteer malaria worker" from the point of view of the villagers and the antimalaria staff. Both agreed on the importance of the worker being available at all times of the day to take care of patients and of being a responsible person but, while the staff wanted individuals who recognized the importance of their work as a "volunteer collaborator", the villagers considered it very important that they should have a general knowledge of medicine. In the search for a more attractive model of community participation in malaria case management, the Guatemalan antimalaria programme tested various modifications of their methods of work and reporting, among them the recruiting of "Volunteer Medicators", who would provide antimalarial therapy to fever cases without taking a blood smear; these "medicators" identified and treated only a slightly higher percentage of patients than the traditional volunteer collaborators (36% versus 33%); however, the cost of maintaining a network of medicators was estimated as only US$ 0.61 per patient treated, which compares very favourably with that of the traditional collaborator, US$ 2.45 (Ruebush et al., 1994b).

The great efforts to recruit and train "community health workers" for primary health care during the 1980s generally disregarded the existing network of malaria volunteers, and community health workers were seldom given training in malaria diagnosis and treatment; for example the "barangay health workers", the government-trained health volunteers in the rural areas of the Philippines operating since 1981, are not contributing adequately to malaria control because of inadequate training, insufficient logistic support, poorly sustained motivational schemes and lack of community support (Lariosa, 1992).

A realistic approach to community participation is, nevertheless, seen as the main approach to the development of rural health infrastructure in many countries and to the necessary projection to the periphery of accessible diagnosis and treatment of malaria, as prescribed by the malaria control strategy.

The proclaimed commitment to intersectoral collaboration would require a broadening of the interests and competence of malariologists and the constitution of multidisciplinary teams either within the programme itself or by establishing linkages with other institutions, as was the case in the early years of malaria control. Antimalaria programmes are generally concerned with the problems associated with economic development projects, although their relations are often incriminatory and defensive, rather than mutually understanding and cooperative. Similarly, local authorities and municipalities undertake sanitation and nuisance mosquito control without reference to the antimalaria programmes.

Similarly, it will be necessary to renew the interest in "man-made malaria" and re-establish the competence in malaria engineering and safe agricultural practices, developed during the 1920s and 1930s, as well as the collaboration with education and information departments and the media, in order to develop malaria-safe habits in the population.

4.8. The programme of support to Africa

The WHO Action Plan for Malaria Control gives clear priority to the endemic countries of Africa south of the Sahara, where 90% of the world's malaria cases occur and where malaria continues to be an important, often the main, cause of childhood mortality. Besides their high malaria endemicity, these countries share a weak peripheral health infrastructure and therefore have urgent need for national malaria control programmes which could guide and support the adequate implementation of the control strategy at the central and district levels. The general health infrastructure needs to be strengthened so as to provide early diagnosis and prompt treatment both at the health services facilities and at the community level, as well as the management of severe and complicated malaria. It is also essential to establish a workable epidemiological information system to guide the development of preventive interventions and, in epidemic-prone areas, the management of epidemics and the formulation of epidemic preparedness.

The Afrotropical region is dramatically characterized by the most powerful malaria vector system in the world, which maintains the extreme dominance of *P. falciparum* infection in holoendemic or hyperendemic conditions, except where undisturbed primary forest, high altitude or desert conditions limit the development of the *A. gambiae* complex / *A. funestus* vector system. In addition, man-made environmental disturbances such as agricultural development and deforestation, extension of irrigation in arid areas and desalinization of coastal areas favour the

progressive extension of the endemicity beyond its present limits, while climatic change may also contribute to its further expansion and anarchic urbanization may also create foci of increased transmission in areas of high population density (Coluzzi, 1994).

The control strategy, as repeatedly mentioned above, has to concentrate on improving diagnosis and treatment facilities and ensuring their physical, financial and cultural accessibility to all the people, supported by health information and education of the population and an epidemiological information system, to promote, guide and support the use of personal and community protection measures in harmony with the socioeconomic development of the communities. It is reasonable to expect that this strategy may produce an improvement in the epidemiological situation similar to that achieved by the Europeans in Africa during the first half of the twentieth century, as illustrated in **Table 5** (Duren, 1951). During that period, even if morbidity did not significantly decrease, mortality dropped to a point where malaria no longer represented an obstacle to the life of Europeans in the tropics.

Table 5. Malaria morbidity and mortality of Europeans in the Belgian Congo (1918-1949)
(Annual averages per period)

Periods		1918-20	1921-30	1931-40	1941-49
Estimated population		3 617	8 570	11 062	19 295
Malaria	Cases	722	1 229	1 638	3 777
	Deaths	9	13.5	5.6	9.8
Haemoglo-binuria	Cases	67	73	43	33
	Deaths	14	13	8	7.7
Total	Cases	789	1 302	1 681	3 810
	Deaths	23	26.5	13.6	17.5
Morbidity per 1 000		220	152	152	197
Mortality per 1 000		6.39	3.1	1.23	0.9

Source: Duren, 1951

It is nevertheless important not to be tempted by the spectacular effect of bednets or other forms of effective transmission control, without ensuring their sustainability, while neglecting the essential development of case management at all levels, against the advice of Wilson et al. (1950), Coluzzi (1961) or the recent ones by Snow & Marsh (1995), Snow et al.(1997) and Trape & Rogier (1996). The dramatic resurgences in Sri Lanka, India and Turkey, have been referred to earlier. A more recent and dramatic African experience is that of the Blue Nile Health Project in the Gezira State of Sudan, an area with a long history of man-made malaria and more or less successful vector control, but subject -- as is most of central and northern Sudan -- to periodic epidemic risk. A malaria epidemic in 1975 generated the necessary support for starting a very efficiently run malaria and schistosomiasis control programme, unfortunately dependent on external funding. The project did not start in full force until 1978-79, when the epidemic had

subsided, but it did prevent potential epidemics in 1980 and 1985 (suggested by rainfall data and the registered levels of the Blue Nile which indicated the risk of extensive flooding). Funding was interrupted in 1989, giving rise to an immediate resurgence of transmission followed by a massive epidemic, more dramatic than that of 1975, following flooding levels of the Blue Nile in 1993-1994 and the prolonged rains of 1994 **(Figure 17)**.

It seems obvious that, in accordance with the global malaria control strategy, transmission control in Africa must be considered as complementary to, or as a spearhead of, the development of a health infrastructure, and that countries should avoid embarking on programmes which are dependent on external funding. When available, such funding should be used to develop local capabilities to identify and solve problems and to strengthen the health infrastructure needed for the application of available control methods and for the development and implementation of new ones.

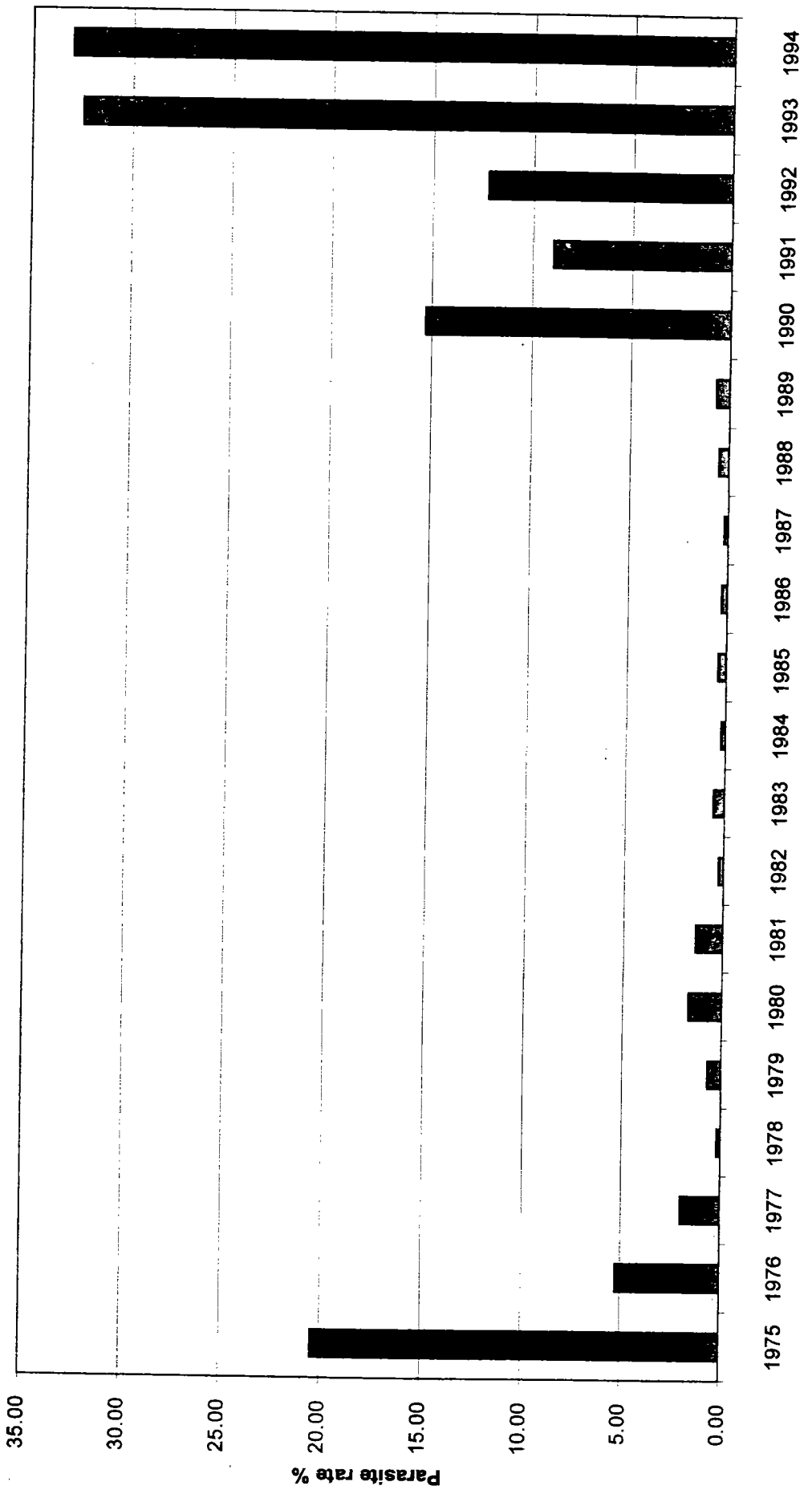
Many countries are exploring ways of making pyrethroid-impregnated bednets accessible to people in endemic areas but, as mentioned above, they are far from being a widely applicable control measure. The development of practical methods of transmission control in holoendemic areas of Africa should remain a global research priority; as Coluzzi (1994) says: "The research for new control tools, considered important for many areas of the world where malaria persists, becomes an absolutely priority and urgent objective in the case of sub-Saharan Africa".

5. MALARIA, ECONOMIC DEVELOPMENT AND SUSTAINABLE DEVELOPMENT

The same diverse experiences and contrasting perceptions of the malaria problem described above gave rise to conflicting opinions about the relation between malaria control and socio-economic development, particularly following the development of malaria control measures which could claim to be effective in almost all situations. Should malaria control precede economic development or wait for it?

The long history of the Pontine Marshes illustrates the close interaction between malaria and socioeconomic development. Celli (1925) described the general evolution of the occupation and agricultural prosperity of the Roman Campagna through the centuries, as shown by historical records which indicate that during a period of more than two thousand years there were contrasting cycles of malaria incidence and agricultural activity in inverse relation (see **Figure 1)**. The decline of agriculture in the late period and the collapse of the Roman empire was followed by a period of prosperity during the Carolingian dynasty and the consolidation of the papal states, particularly through the agricultural policies of Pope Zacharias (741-52), who established rural villages and formed administrative and religious centres, convinced that agriculture was the main remedy for land physically deteriorating and becoming unhealthy. The struggles for the Italian throne and its annexation by the Holy Roman Empire during the tenth century and the protracted Empire-Papacy wars brought about four centuries of depression, despite the attempts of the Cistercian monks, known as the monks of valleys and marshes, to settle there after the tenth century. The prosperity of the Renaissance period was ended by the consolidation of latifundia, the weakening of authority and the development of banditry during the seventeenth and eighteenth centuries.

Figure 17. MALARIA PREVALENCE IN CHILDREN (2-9 YEARS OLD) IN GEZIRA, 1975-1994



Annual surveys in January, in fixed indicator localities in the Blue Nile Health Project area

The relationship of malaria and agricultural activity is reflected in many expressions such as that of Fioravante: "in order to make a malarious area habitable, settle it", or that of Machiavelli: "unhealthy regions become healthy if they are occupied all at once by a large number of people". Nevertheless, no modern society could accept such a form of development.

Although many concerns remained about the possibility of implementing effective malaria control measures in poorly developed areas, most malariologists agreed with Swellengrebel that "it was of little use saying to a country like Albania, for instance: go and get rich".

5.1. Malaria as an obstacle to economic development

> *Now in the labour forces of the Roman Campagna, the objective which we pursue, with quinine prophylaxis, is not only a humanitarian objective but also a utilitarian one, regarding the productivity of agricultural work. In the present situation, quinine prophylaxis aims to maintain, as much as possible, the efficiency of the workers during the harvests.*
>
> **Bini (1925)**

The concept of the *economic loss* due to malaria, as a justification for important expenditures in specific antimalarial activities, goes back at least to the calculation by Bolton (quoted by Ross, 1911) that through malaria, Mauritius lost one million rupees, i.e. 2.6 rupees per head (1 rupee = 1/15 English pounds of 1910). It was the main argument to induce private enterprise to invest in vector control for the protection of workers and was widely used for fund raising **(Figure 18)**. Ross (1911) considered this type of evaluation "the most important question from the preventive point of view". It acquired renewed prominence when, after the Second World War, the dramatic effectiveness of DDT again seemed to justify large-scale specific campaigns.

The image of the vicious circle of *disease - low productivity - poverty - disease* goes back to the debates on the "laziness disease" in the United States and the birth of the Rockefeller Foundation (Garcia, 1981). Malaria soon joined ankylostomiasis as a link in the fatal vicious circle; being the most prevalent disease of the poorest rural areas, producing recurrent chronic infections, with fever attacks in spring and summer, and malignant tertian occurring in the late summer and autumn when most work was required for collecting the crops, it was clearly a classical example of a debilitating disease, impairing productivity. Winslow (1951) expressed this concept as "Men and women were sick because they were poor; they became poorer because they were sick and sicker because they were poorer".

This image is typical of situations where malaria transmission, with strong seasonal exacerbation, affects people often subjected to other infections, malnutrition and lacking medical care, who are not able to develop an early solid immunity. In view of the coincidence of disease and need for intense agricultural work, which makes replacement more difficult, past estimates of the loss of work due to a malaria attack, which range between 5 and 15 days, do not seem too exaggerated. Recent studies in Burkina Faso, Chad, Congo and Rwanda give similar estimates, which are expected to rise due to the spread of drug resistance (Shepard et al., 1991).

Figure 18

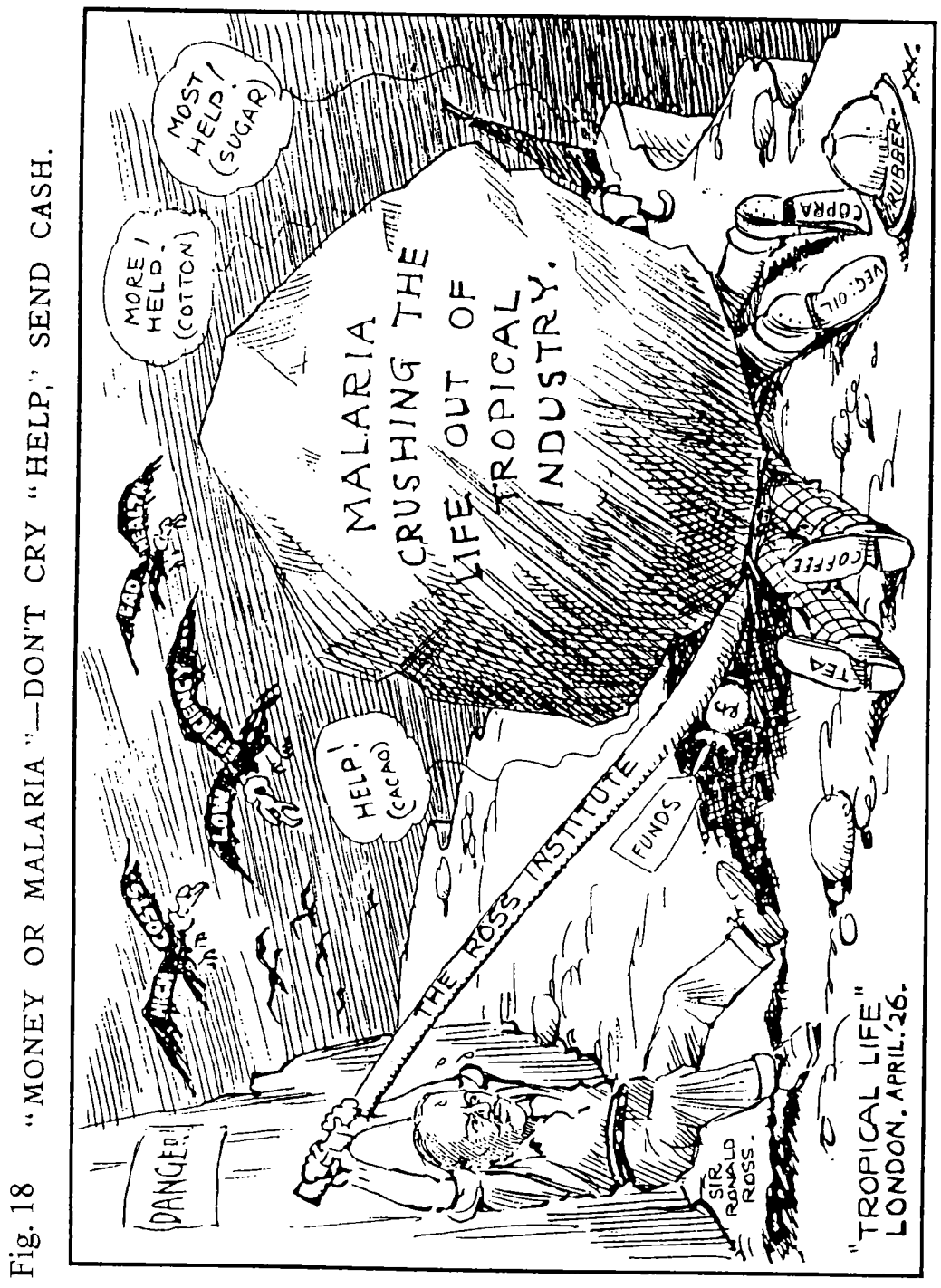


Fig. 18 "MONEY OR MALARIA"—DON'T CRY "HELP," SEND CASH.

Wanted—A Bigger Fulcrum. One Ten Times the Present Size Preferred.

Source: Ross Institute, London School of Hygiene and Tropical Medicine

In places attracting labour from areas of lower endemicity, the impact may be very severe. In Southern Rhodesia, it was estimated that the loss of human resources due to malaria was from 5% to 10% of the total labour force, with the greatest incidence at the peak of agricultural production (Winslow, 1952). Similar problems were observed in other parts of East Africa.

These patterns were implicitly generalized to all malarious situations, creating a model which has been described as "malaria blocks development" and has contributed to the persistent demand to justify as cost-effective any expenditure in publicly funded preventive medicine, in striking contrast to the general practice in clinical medicine (Brown, 1984).

5.2. Malaria control as an instrument for economic development

The recognition that malaria was a serious obstacle to socioeconomic development led to the expectation that widespread agricultural development would follow the important investment in malaria control undertaken in the 1950s and 1960s. These were the views expressed at the time of promotion, justification, launching and implementation of the global malaria eradication programme, with statements like: "Where malaria dies the good earth revives. For the individual, eradication makes savings possible, it improves his output and the quality of his work, it urges him along the path of progress. For the nation, malaria eradication means a healthier and happier people, who can make a greater contribution to the national budget. For the Hemisphere, eradication is not an end in itself but has to be coordinated with all the activities leading to improvement of the well-being of the population" (WHO, 1962b); or the great expectations expressed by General George C. Marshall, US Secretary of State, in his opening address to the 4th International Congresses on Tropical Medicine and Malaria, meeting in Washington, DC, in May 1948: "Little imagination is required to visualize the great increase in the production of food and raw materials, the stimulus to world trade, and above all the improvement in living conditions, with consequent social and cultural advances, that would result from the conquest of tropical diseases".

The expectations that malaria control would improve food production led the WHO Expert Committee on Malaria (WHO, 1948) to work with representatives of FAO on a proposal for collaborative demonstration-area studies to show the potentiality for increased food production of effective malaria control. The aim was to respond to the challenge of General Marshall: "The conquest of diseases which hold millions weak and inefficient, and the maximum production of foodstuffs in lands now yielding little, are tremendously important requirements of the world situation". This proposal received the support of the WHO Executive Board, the UN Economic and Social Council and the Second World Health Assembly, and both organizations worked to select suitable study areas in Asia, the Americas and the Eastern Mediterranean, followed up by the Expert Committee in its third and fourth sessions (WHO, 1950 and 1951). Nevertheless the interests of both organizations were soon diverted from such studies by the growing focalization of malaria control on indoor residual spraying and by the declaration by FAO that its interests were limited to very large projects that could substantially increase food production in the world (Gramiccia & Beales, 1988). The subject of "malaria and agriculture" does not appear on the agenda of subsequent sessions of the Expert Committee.

A subject that further clouded the possible collaboration of both organizations in malaria control was the use of insecticides and the development of anopheline resistance, which presented its most severe manifestations in areas of extensive cotton or rice production subject to very intense aerial applications of a wide range of insecticides. Malariologists blamed the agricultural establishment for the development of anopheline resistance, which threatened malaria eradication, and sometimes even engaged in futile discussions on the relative priorities of food production and disease prevention. It was even proposed to reserve some insecticides, such as malathion, for exclusive use by health campaigns, only to find that malathion resistance could result from the use of other organophosphorus insecticides in agriculture. Such problems had no simple solution since most insecticides were in agricultural use several years before completing the complex evaluation of efficacy and safety required for their use as indoor sprays. Moreover, the phenomenon of cross-resistance, which depends on the resistance mechanisms towards the insecticide operating in a particular vector species, is, even today, only partially understood.

Most national malaria eradication campaigns were justified in terms of the economic loss due to malaria based on calculations similar to those quoted above from the beginning of the century, that is, mainly based on estimating the average number of work-days lost, sometimes including the cost of treatment. Some estimates even assigned a monetary value for the lives lost, by attempting to calculate an actuarial value for a human life; thus, Suarez Torres evaluated a life at 10 000 Mexican pesos, Padua at US$ 2 000. Such estimations have been seriously criticized as they imply that human lives can be reduced to their work capacity, which can be bought for money (Franco Agudelo, 1981), or that man can be considered as an exchange value (Breilh, 1979). Even from the mere methodological point of view, Bruce-Chwatt (1978) criticized narrow attempts to trace the influence of a single factor through all the complexities of the real economic world. Suarez Torres (1973) estimated the economic loss to Mexico due to malaria during the period 1950-54 as more than 600 million Mexican pesos. Pampana (1969), reviewing the literature on the subject, quotes US$ 23 million for Indonesia (1958), $200 million for India (1942), $54 million for Paraguay (1957) and $50 million for Mexico (1955).

A different consideration was made by Russell (1948) to justify external assistance, who estimated that any nation importing the products of a highly malarious country paid the equivalent of a 5% malaria tax and that, in the case of the United States, this represented $ 175 million a year.

5.3. Minimum development required as a prerequisite for malaria control

Although the malaria eradication campaign was launched in the expectation that development would, almost automatically, follow the elimination of malaria, it soon became obvious that the campaign could not succeed without a solid health infrastructure, which was lacking in the majority of endemic countries (Gonzalez, 1965). Such an infrastructure implied a certain socioeconomic development. The protracted recognition of the socioeconomic requirements for the implementation of malaria eradication is presented above, in the discussion of the implementation problems of the global eradication campaign.

The whole experience of the eradication efforts suggests that there exists some kind of threshold in the development process, which must be attained for the sustainability of control to be possible. The characteristics of such a threshold must vary in different ecological areas and different societies, but should generally involve literacy or level of public education, social stability, development of peripheral health infrastructure and, to a lesser degree, general economic indicators.

5.4. The health and ecological impact of economic development projects

> *Improper attention to the overall effects of development projects on health will cause the health of the project inhabitants and workers to deteriorate. Careful, comprehensive planning in advance to control such impacts and to provide for a health care delivery system in the developing area will contribute to the country's continued economic growth by assuring a healthy population and work force.*
>
> **Lee, J.A. (1985)**

While malaria control in specific economic development projects had been a critical input for the viability of the project, the great socioeconomic development that was expected from general malaria control has seldom been observed. Development, when it occurred, far from showing increased local food production, was mainly centred on urban areas, based on industry, tourism or extensive agricultural production of cash crops (Berlinguer, 1991).

It became obvious that malaria control *per se* did not spur development, but that the relationship between malaria and socioeconomic development was complex and quite variable from place to place. As many examples, if not more, could be adduced of "lack of development blocks malaria control" as of the expected "malaria blocks development". In particular, the sustainability of malaria control required functioning health and epidemiological services (i.e. used by the population), which could not be improvised by means of a specialized campaign.

The concept was being born that malaria control should be part of health development and thus part of socioeconomic development, demonstrating that important improvements were possible through a systematic and not a sectoral approach, the aim being a "conflicting cohabitation" with the disease which could progressively reduce its worst effects as much as possible (Berlinguer, 1991).

5.5. Malaria and sustainable development

All the accumulated experience outlined above shows that malaria control cannot be undertaken without careful consideration of its socioeconomic and environmental relationship. As recognized by the current WHO malaria control strategy (WHO, 1993a) and the UN Guide for Agenda 21 of the UN Conference for Environment and Development, it is essential that countries develop coordinated national plans and surveillance mechanisms for controlling malaria and other tropical diseases, as part of the health objectives and instruments of sustainable development.

The Brundtland Commission's report "Our Common Future" made clear that economic growth based on the unlimited exploitation of natural resources can no longer be conceived as feasible for the world's economy, and that the concept of sustainability has to guide any development plan. There is, nevertheless, no doubt that the present inequity in the distribution of the world's resources, as well as the growing misery of the world's poor, cannot be considered as the type of general situation which should be sustained, and that it may no longer be possible for the world's economy to simply grow in the exploitative way it has done until now.

The global nature of the environmental problem cannot be discussed here. But at least a third of the world population live in a hostile natural environment, and they cannot be deprived of the right to modify it to make it hospitable in the name of preserving, or even increasing, the quality of life of the other fraction of humanity, who have developed with total disregard for the global nature of the environment (Prost, 1990).

The control of tropical diseases, recognized as an important factor in the equation of misery and waste in the less developed societies of the world, is one of the testing grounds for the applicability of the principles of sustainable development. Most of the economic activities, entailing greatly increased risks of tropical diseases represent unacceptable exploitation of natural and human resources, and their economic output is not aimed at the socioeconomic development of the people engaged in carrying them out. In these situations, the acceptance by politicians and development agencies of the principles of sustainable development should, by rationalizing those activities, contribute effectively to the control of the major tropical diseases.

The current malaria control strategy places most emphasis on building up local capabilities to understand and solve problems, rather than on the massive use of drugs or insecticides in the hope of reaching every house or every patient. The strategy also seeks to promote all possible intersectoral linkages, as well as community involvement and public education and information. This participatory antimalarial strategy gives a prominent role to the development of "malaria safe habits", including the use of personal protection measures, home improvement, community environmental sanitation and chemoprophylaxis during pregnancy. It appears obvious that the development of such habits cannot be left only to the schools; women should be essential partners, provided that their social status permits their adequate incorporation into the educational process. It has been shown that there is a clear relationship between women's control of wealth and the health of their children (Leslie et al., 1986). In malarious areas of East Africa, it was found that local differentials in infant and child mortality could largely be explained by differences in maternal education (Spencer et al., 1987).

6. PERSPECTIVES OF MALARIA CONTROL

The simplicity in theory of prophylaxis against malaria is only equalled by its difficulty in practice.

Sir Leonard Rogers, quoted by Hackett (1937)

Time more than Money, and Continuity more than Perfection – these must be the mottoes guiding malaria control in the tropics.

Russell (1936)

Local malaria problems must be solved largely on the basis of local data. It is rarely safe to assume that the variables in one area will behave in the same way as they do in another area, however closely the two regions may seem to resemble each other in topography and climate. Large sums of money have been wasted in attempted malaria control when malariologists have forgotten this fundamental fact.

Russell et al. (1946)

The revised malaria control strategy adopted by the malarious countries in 1992 in Amsterdam was the result of a concerted attempt to consolidate all past experiences and a determination to break away from the cycle of enthusiasm and disappointment, which continued to turn whenever a push was made to rally all forces in pursuit of a newly formulated campaign (see § 1.3.7, above).

At first sight, it may appear that the control strategy is the culmination of another swing of the pendulum which has oscillated between an anti-vector and an anti-disease paradigm since the beginning of the twentieth century. The current move towards an anti-disease type of paradigm responds to the lessons learnt from the past.

Nevertheless, the metaphor of a periodic movement between two opposite poles conveys the false image of an overall stationary situation, masking the enormous progress which has been achieved through all those periods of ideological and political oscillations. A more faithful representation would be to consider that in the irregular but continuous progress of malariology, and in the even more hazardous development of public health, there have been periodical pursuits of unattainable dreams followed by disillusioned returns to reality. Actually, the periodic "returns to reality" are not to the original situation; each constitutes a new contact with reality and contributes to the broadening of our understanding.

There are important similarities in philosophy between the current malaria control strategy and the so called "new school of malariology" of the 1930s, particularly in the awareness of the limitations of our knowledge to encompass all the complexities of the real world. Nevertheless, there exists today a much wider range of potential interventions with an awareness of their indications and limitations and a more clear perception of the relations with the processes of socioeconomic development and a less bewildering view of the complexity of local variability, which is now seen as stratifiable and potentially typifiable. The recognition of the complex relations between malaria and development is inducing antimalaria programmes to search for a strong working collaboration with programmes aimed at poverty alleviation and socioeconomic development, at a more fundamental level than the mere protection of project objectives.

In spite of the wide recognition of the dangers of embarking on utopian shortcuts to development, there are frequent expressions of disillusion on the apparent contrast between, on the one hand, the acceptance of the soundness of the control strategy by all countries and their voiced political commitment and, on the other, the few, so far, who have demonstrated that commitment by making adequate budgetary allocations, creating coordination mechanisms and attracting, when needed, intersectoral or external collaboration.

It is unfortunate that some of the attitudes still persist which made Connor say: "The apathy of governments to the devastating effect of malaria on the population is in part due to the insidious nature of the disease ... but in my experience the inaction of governments in the field of prevention is due rather to a profound scepticism induced by lack of permanent results from previous expenditures on malaria control" (Hackett, 1937).

The objectives of the strategy are the prevention of mortality and the reduction of morbidity due to malaria and, when and where feasible and sustainable, the pursuit of reduction or elimination of transmission. It is recognized that the most direct way of approaching the primary objective is by supporting, or developing, mechanisms to reach the most peripheral populations. These efforts should therefore constitute a step in the strengthening, or developing, a functional health infrastructure for primary health care. Another essential element of the strategy is the emphasis on pertinent and timely epidemiological information. This is the basis for the early detection of epidemics and for the planning of specific interventions, based on the identification of different types of malaria problem (stratification) in relation to their suitability for vector control measures. Particular attention is given to the identification of epidemic-prone areas and to the monitoring of epidemic risk indicators.

It is erroneous to identify the global strategy with the promotion of any control intervention or general approach; there is no anathema against the pursuit of local eradication, if feasible and sustainable. As discussed above (§ 4.2 and 4.3) and inspired by the philosophy of the pre-DDT control approaches, all control methods deserve consideration that are potentially suitable to a particular problem. Even the recognition of the dangers of vertical approaches should not prevent some countries from using malaria control as a spearhead of health development when malaria constitutes the most prominent health problem, adopting fairly vertical projections of the health services into the periphery. This could be acceptable, provided that the original priority given to malaria does not prevent the eventual broadening of their scope to incorporate other elements of primary health care, once malaria incidence becomes manageable or it becomes possible to improve the effective capacity of community health workers and their support by the health services. Again, it may be concluded with Hackett (1937) that: "Clearly governments can trust to no formulas devised in Geneva or elsewhere, but must create the simple machinery necessary to define and resolve their own problems, locality by locality".

Even if the Amsterdam declaration did not result in an immediate and enthusiastic rallying of international and bilateral funding for malaria control, the continued interest of endemic countries and their persistent call for attention in all international forums has created a continuously accelerating political and financial support.

Following the endorsement of the global strategy by the UN General Assembly and ECOSOC, mentioned in § 4.1 above, the World Health Assembly adopted in May 1996 a resolution requesting that efforts be made to increase resources in order to intensify WHO's action in

malaria control, to reinforce the malaria training programme at country, regional and global levels and to explore the possibility of establishing a special programme on malaria prevention and control. In 1997 WHO initiated a programme for Accelerated Malaria Control in Africa, strengthened its collaboration with the World Bank for long-term malaria control in Africa and initiated a collaboration with UNESCO on the preparation of teaching materials for schools. At the same time an African Regional Initiative on Malaria (AIM) has been developed by an ad hoc Committee including representatives of the World Bank, WHO, selected countries and other interested partners. In January 1997, groups from public and private sectors, involving the World Bank, the European Commission, WHO, research institutions and funding agencies, joined efforts in a Multilateral Initiative on Malaria (MIM) aimed at strengthening research capabilities in Africa in support of malaria control. In May 1998, the Summit of the Group of Eight industrial countries agreed to support malaria control as part of a larger plan to combat infectious and parasitic diseases.

This revival of international interest is not only the result of national concerns but also a stimulus for its spread and consolidation, as well as a means to speed up action in the field. While international meetings were being held, countries started reviewing their antimalarial policies and, as a result, the number of countries reporting successful implementation of the global strategy is steadily increasing. It was reported at the end of 1997 that at least 90% of affected countries and territories had started the implementation of realistic plans.

While malaria control has to happen at local level and all other levels should be mainly supportive of local action, it is important to review and redefine, if necessary, the role of international (including WHO's) and bilateral bodies in this process.

In view of the rapid evolution of the problem, the consensus on the control strategy and the success already obtained in its implementation, in spite of the limited resources available up to very recently, it is necessary to continue the intensification of support to the malaria control efforts, without abandoning the required support to research. New tools are still needed, but it is essential to ensure that endemic countries have the capacity to select and use, from currently available tools, those that are relevant to their problems; that same capacity would be required to make an adequate use of new tools when they become available, and even to contribute to their development. Hence the emphasis of the strategy on the strengthening of local and national capabilities to analyze the different situations, mobilize and guide partners, plan and implement interventions, monitor and evaluate progress, identify and solve problems, adapt to change and contribute to overall health development in the context of primary health care.

The continuity of effort required for sustainable malaria control should be supported by the establishment of strong working links between control programmes and research institutions at the country level, to develop national research policies which may effectively contribute to the solution of field problems and the optimization of control interventions, and their evaluation and reorientation when required.

Strengthening of national capabilities, training and problem-solving field research have constituted top priorities for WHO support to countries for more than a decade, but the strengthening of national capabilities would require, in many countries, besides training, the solution of serious local problems of selection, maintenance and conditions of work. Solutions have to be found locally, instead of trying to impose imported models of well-organized

health services. WHO and other health development partners have endeavoured to fulfil the requirements for technical support; but in general, the most effective technical support has occurred where financial support from an interested party has been available in the country for financing long-term monitoring of strategy implementation (which brings to mind the role played by the Rockefeller Foundation in southern Europe in the second quarter of this century); even penetration to local levels has been also largely dependent on financed technical cooperation. The challenge remains to use external funding to build local capabilities without creating a dependence on an unassured continuity of support.

In addition to the emphasis given to the development of human resources in general, WHO has given a specific priority to the development of national antimalarial drug policies and the monitoring of the therapeutic efficacy of antimalarial drugs, developing standard protocols and organizing intercountry training courses and supporting national workshops and courses, as well as collaborating in surveys, the organization of monitoring activities and the review and interchange of experiences and information.

Economic realities suggest that many endemic countries will continue to require external support but, in many instances, there is a need to improve the cooperation between all agencies, international, bilateral and NGOs, interested in malaria control and also to search for new partners. Existing plans of work emphasize the normative function of WHO, aiming at ensuring the best possible quality of technical support to countries. There persist, nevertheless, numerous problems of organization and functioning of services, human resources development and maintenance, coverage and penetration to the periphery, sustainability, intersectoral cooperation and coordination. It is felt that:

- without improving programmes ability to overcome the operational problems which are hampering implementation and penetration to the periphery, the best guidelines and technical advice would be ineffective;
- WHO, by its capacity for regional and global overview, has an essential contribution to make to that improvement, by consolidating, validating and disseminating countries' experiences, provided it is given the appropriate means for the task.

It cannot be overemphasized that organizational and operational problems do not normally respond to ready-made solutions derived from the direct application of interventions which were successful elsewhere. While testing interventions and carefully monitoring the quality of application and the results obtained are important, it is the evaluation of the epidemiological, ecological, sociopolitical, cultural and other factors which may have influenced the results or the quality of the intervention. It is the appropriate understanding of these factors, that would permit judgement on the conditions of applicability of specific control measures as well as suggest potential additional interventions to correct some negative factors. Also, the required knowledge of all these factors will come, more than from experimental projects, from the careful monitoring of real control interventions in a wide variety of situations. In fact, important observations may derive from unexpected sources, and the accumulation of knowledge should be a continuous process enriched by both positive and negative experiences.

The development and strengthening of such knowledge would provide the basis to address public health authorities, who may be "much more prone to change policies in the presence of data and guidelines than by a set of well thought-out general principles to be adapted and applied by them to their local situations".

The importance of highlighting the "process" should be emphasized, as opposed to concern only with the "objectives" and "targets", perhaps a residue of the previous pursuit of utopias. It may be worth remembering the philosophical attitudes of the Stoics or the Taoists and the example of the archer who is absolutely concentrated on taking the best possible aim and, when asked: "Do you expect to hit the target?", would answer: "What a strange question! Why should I be concerned with the arrow reaching the target? I do what is in my power, which is to aim, but once the arrow is out of the bow it is no longer my responsibility" ... and he hit a flea in the centre of its heart, while other archers worried and under pressure to hit the target could not fully control some trembling of the hand and never obtained a perfect hit. An exaggerated emphasis on evaluating outcome has produced the tendency, unfortunately rather common, of many programmes to boast of success whenever targets are approached and to attribute failures to external causes, such as natural, social or financial catastrophes. Information about outcome should lead to a critical appraisal of the process of satisfaction or excuses.

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