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WHO Expert Committee on Malaria

Seventeenth Report

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Geneva, 20 February–1 March 1979

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WHO EXPERT COMMITTEE ON MALARIA

Seventeenth Report

INTRODUCTION

The WHO Expert Committee on Malaria met in Geneva from 20 February to 1 March 1979. The meeting was opened on behalf of the Director-General by Dr I. D. Ladnyi, Assistant Director-General, who pointed out that, although in 1978 the general trend was towards a reduction in the number of malaria cases in some countries, the unchanged endemic levels in Africa south of the Sahara, the resurgence of the disease in other parts of the world, the financial difficulties faced by countries in providing health facilities for their populations, and the technical problems such as insecticide and drug resistance, require vigorous action to ensure the implementation of the revised strategy of malaria eradication adopted by the Twenty-second World Health Assembly in 1969 (1).

Those difficulties had resulted in a reorientation of the WHO malaria control strategy and the new strategy (2) thus developed was endorsed by the Thirty-first World Health Assembly in resolution WHA31.45 (3). The new overall strategy stressed the absolute need for political decisions and included a number of basic principles for the implementation of malaria control.

The main task of the Expert Committee was therefore to provide guidelines—particularly for the health administrator and health planner—on how to plan, implement, and evaluate malaria control programmes at the present juncture.

Later, Dr H. Mahler, Director-General, attending the meeting, stressed the significance of the development of the primary health care concept (4) and of the inclusion of curative and preventive services, including control of infectious diseases, in the framework of primary health care.

While eradication of malaria had been reaffirmed in effect by the Thirty-first World Health Assembly (3) as the ultimate goal of the programme, courses of action leading to the achievement of such a goal needed to be determined in each country in accordance with the

prevailing epidemiological, socioeconomic, and other conditions, on which chances of success of national antimalaria programmes primarily depended.

1. APPROACH TO MALARIA CONTROL

1.1 Malaria situation analysis

Although the objective of malaria eradication had not been achieved by all countries, a major reduction of malaria morbidity and mortality had occurred on a global scale. The eradication effort had greatly stimulated developments in the management and implementation of public health programmes, including the total coverage of rural populations and the introduction of evaluation techniques related to epidemiology and control operations. It had involved the recruitment and training of thousands of health workers, who in many instances later formed the backbone of the general health services.

By 1970, the eradication programme had freed 727 million people from the risk of malaria; this number then represented 53% of the population of the originally malarious areas. This progress had helped in saving a great number of lives, and had permitted the economic development of many areas of the world, particularly in Asia, south and south-east Europe, and the Americas. In addition to promoting a general improvement in health, malaria eradication measures in certain countries had reduced the prevalence of other vector-borne diseases, such as leishmaniasis and plague, and had contributed to the success of mass campaigns, such as those against smallpox, which also benefited greatly from the experience gained in operational management.

However, during the past 10 years the malaria situation has progressively deteriorated in several countries. The resurgence of the disease (eventually reaching epidemic proportions) has particularly affected Turkey, several countries in southern Asia, and some countries in Latin America.

According to the information available, the number of reported cases of malaria throughout the world has more than doubled during the past 5 years; although in 1977 there was a decrease of 23% over the previous year (Table 1), mainly owing to improvement in the South-East Asia and Eastern Mediterranean Regions. However, in

spite of the resurgence of malaria, at the end of 1977 there still were at least 600 million people (29% of the population of the originally malarious areas) protected from the disease.

In some countries, nevertheless, the increase has reached dramatic proportions, with the figures showing an increase by a factor of 30–40 compared to 1969–70; thus in some instances, malaria is again endangering not only the health of populations but also their overall socioeconomic development. In countries where malnutrition is a problem, malaria infection may further aggravate it, because with each febrile attack of malaria the patient loses about 21 MJ (or some 5000 kcal_{th}), equivalent to some 3 days of food for an adult (5).

In some countries the progress towards eradication has slackened; a rising wave of imported cases is occurring in other countries from which malaria had either been eradicated or where it was never endemic; and in Africa south of the Sahara, very little is being done for the rural populations suffering from malaria.

It should be underlined, however, that there have been certain developments since 1975 that have softened the impact of the malaria problem in some countries. For example, satisfactory progress has been achieved in Mexico, using classical control methods that offer good prospects. In India—where 250 million people live in areas with a high risk of malaria, another 250 million in areas of moderate risk, and 140 million in areas freed from malaria or naturally free of it—200 000 drug distribution centres have already been established through community participation, which is particularly important in lessening the impact of epidemics.

Questions related to the lack of action, resurgence of the disease, methodology for control, and the need to give a new impetus to the antimalaria programme have been the subject of extensive discussions by politicians, health administrators, scientists, and the mass media. However, even without attempting the arduous analysis of the causes of malaria resurgence, it is clear that all efforts must be concentrated on exploring means of redressing the situation. The WHO Regional Committee for Africa has emphasized the importance of a general plan for malaria control, using antimalarial drugs and other methods (6). While the basic tactical variants for a global strategy were set out in the Director-General's report to the Twenty-eighth World Health Assembly (7), it appears that these were not implemented in most malarious countries and that they were stated in terms too general for their correct application. The policy for reorientation of the programme should therefore be fully

elaborated, taking into account the basic principles of health programming, i.e., technical cooperation, the national will as expressed through government decisions, the programme's social relevance, and the concept of implementing activities with the tools available today and at a cost countries can afford.

It is unacceptable that towards the end of the twentieth century so many people in the world should still be suffering and dying from malaria. New tools and methods for malaria control should be developed, the status of development of health infrastructures should be improved, and the requisite financial and manpower resources should be made available.

1.1.1 *The malaria control situation and its present constraints*

The Expert Committee reviewed the present status of antimalaria programmes in the world. Out of 143 countries or areas where malaria was originally endemic (in part or all of the territory) and for which information is available, 37 countries or areas have been freed from malaria, the malaria risk is minimal in 16 others, and in large areas of the remaining 90 the risk ranges from moderate to high.

An analysis of the malaria situation by region shows that the main constraints to malaria control experienced in the different countries are as follows:

- (1) increased costs of materials and equipment and global inflation;
- (2) inadequacy of administrative and general services to support antimalaria activities;
- (3) shortage of trained manpower and difficulties in attracting and keeping experienced personnel;
- (4) rudimentary health infrastructure in developing countries and limited involvement of rural health services in the antimalaria activities;
- (5) factors of human ecology and ethology that interfere with the application of antimalarial measures (e.g., nomadism, replastering, refusal to accept the spraying of houses) or that increase man-vector contact (makeshift housing, sleeping out of doors);
- (6) difficulty of access to malarious areas for natural or security reasons;

(7) uncontrolled development of irrigation, deforestation, and human settlement in malarious areas, and increased breeding of *Anopheles* vectors subsequent to construction works;

(8) inadequate knowledge of the cost-effectiveness of the various control measures under different local conditions;

(9) resistance of many vectors to insecticides that could be safely used in human dwellings;

(10) vector behaviour leading to avoidance of contact with the indoor insecticide deposit on walls;

(11) development of resistance in malaria parasites, particularly *Plasmodium falciparum*, to certain antimalarial drugs; and

(12) inadequate research support.

The Committee noted that many of the impediments to progress towards malaria eradication have been pointed out in previous Expert Committee reports (8, 9), and it reaffirmed the principles of control measures stated in those documents.

The evolution of the malaria situation in the various WHO regions in terms of the number of autochthonous cases reported is shown in Table 1. These figures, however, are based only on

Table 1. Numbers of malaria cases (in thousands) reported during the past 6 years, by regions (excluding Africa)

WHO region	1972	1973	1974	1975	1976	1977
Americas	284	280	269	356	379	398
South-East Asia	1 920	2 694	4 210	5 992	7 476	5 552
Europe	21	13	8	12	39	116
Eastern Mediterranean	855	883	524	447	344	224
Western Pacific	171 ^a	203 ^b	170 ^c	197 ^d	210 ^d	214 ^e
Total	3 251	4 073	5 181	7 004	8 448	6 504
Change (1972 = 100)	100	125	159	215	260	200

^a Excluding China, Democratic Republic of Viet Nam, and New Hebrides.

^b Excluding China and Democratic Republic of Viet Nam.

^c Excluding Viet Nam.

^d Excluding China, Democratic Kampuchea, and Viet Nam.

^e Excluding China and Democratic Kampuchea.

laboratory-confirmed cases reported by the malaria services. They represent a considerable underestimate of the actual situation, for the following reasons.

(1) There is considerable variation in the accuracy of the reporting, the coverage of the reporting systems, and the efficiency of the laboratory services.

(2) In view of the change from malaria eradication to malaria control, the search for cases has been drastically curtailed, since large-scale case detection is not usually carried out in control programmes. Since in most countries in Africa cases are not reported systematically, the data from this Region have not been included in Table 1.

With regard to the dramatic increase in the number of cases recorded in the European Region, it should be borne in mind that this Region includes Turkey and that malaria became epidemic in eastern Turkey in 1976. The European Region also includes a portion of North Africa.

1.2 Implementation of the revised antimalaria strategy

The Twenty-second World Health Assembly, in its reappraisal of the global strategy of malaria eradication, justified the malaria control programmes and endorsed their basic principles (resolution WHA22.39; 10). The WHO Interregional Conference on Malaria Control in Countries where Time-limited Malaria Eradication is Impracticable at Present (11) and the series of reports of the WHO Expert Committee on Malaria further defined technical and operational approaches to malaria control. A review of the main impediments and problems facing the antimalaria programme and proposals for its development were summarized by the Director-General in his reports to the Twenty-eighth and Twenty-ninth World Health Assemblies (7, 12).

The Thirty-first World Health Assembly, having considered the Director-General's report on the strategy of malaria control (2), adopted resolution WHA31.45 (3), urging Member States to reorient their antimalaria programmes—with the final objective of malaria eradication, where possible—as an integral part of their national health programmes in accordance with the guidelines set out in the Director-General's report.

In the spirit of the constitutional objective of WHO, that is, the attainment by all peoples of the highest possible level of health, and

in the light of resolution WHA30.43 (13), which sets the objective of “the attainment by all citizens of the world by the year 2000 of a level of health that will permit them to lead a socially and economically productive life”, the urgency of the fight against the resurgence of malaria assumes a paramount importance.

The principles that must be observed in implementing antimalaria strategy include the following:

(1) The national will to control the disease should be clearly expressed through a governmental decision to support antimalaria activities on a long-term basis.

(2) Malaria control should be an integral part of the country health programme.

(3) The feasibility and practicability of reducing malaria to a level concordant with the set objectives should be demonstrated.

(4) The participation of the community should be a condition *sine qua non*, and emphasis should be placed on the community's understanding of the effects of the different methods of control, since success will greatly depend on this.

(5) Wherever applicable, permanent measures for the control of malaria should be made an integral part of the relevant development programmes (e.g., irrigation, drainage, hydroelectric schemes, highways) through the collaboration of the government ministries and agencies concerned.

1.3 Definition and justification of objectives of a malaria control programme

A malaria control programme can be defined as an organized effort to institute, carry out, and evaluate such antimalaria measures as are appropriate to the prevailing epidemiological and socio-economic conditions, in order to achieve the greatest possible improvement in the health situation of a population subjected to the burden of this disease or exposed to the risk of its resurgence.

The objectives of any malaria control programme can be classified in chronological terms as ultimate, intermediate, and immediate.

(1) The ultimate objective of any malaria control programme is the eradication of the disease from an area, a country, a continent, and eventually from the globe. While it is becoming apparent that the

achievement of malaria eradication in many areas of the world is often more difficult than previously anticipated owing to technical, operational, administrative, and, frequently, financial factors, there can be no doubt that malaria eradication programmes have contributed to the development of certain methods, introduced a number of successful antimalaria measures, and created a cadre of trained personnel whose experience can be utilized for a wider application of control measures. The gains, often very extensive, derived from these programmes must be protected, and reinvasion by the disease should be prevented by all available means.

(2) Intermediate objectives apply to those areas where malaria eradication does not appear to be feasible. For such areas, the objectives are:

(a) reduction of endemicity to levels not hampering socio-economic development; and

(b) reduction of mortality and morbidity due to malaria to negligible levels.

To achieve these objectives requires:

— assessment of the socioeconomic impact of the disease and its public health importance in the country or area in order to determine the degree of priority to be accorded to it among other health needs;

— development and strengthening of national training capabilities for all echelons of staff involved in the planning and execution of control programmes, including those employed in primary health care;

— development, implementation, and evaluation of more effective and economical methods of control or eradication;

— strengthening of research capabilities, in developing countries especially; and

— improvement of intercountry and regional cooperation and coordination in the control of malaria.

(3) Immediate objectives are:

(a) reduction of the levels of transmission in epidemic areas;

(b) reduction of malaria morbidity and mortality;

(c) prevention of the spread of malaria to areas freed of the disease; and

(d) assistance in the process of social and economic development in affected areas.

1.4 Planning of control programmes and factors conditioning it

The purpose of any disease control programme is to reduce the impact of the disease on the population to the lowest possible level.

Planning applies to the whole range of activities of malaria control. It should therefore cover activities such as: collecting information on the existing epidemiological situation, assessing the operational feasibility of the control measures to be applied and the adequacy of scientific and administrative facilities available in the country, training staff at all levels, selecting appropriate control methods in relation to the needs of different areas, establishing evaluation techniques, assuring the cooperation of other bodies involved directly or indirectly in malaria control, and selecting targets for the programme.

In view of the various methods available for malaria control and the varying results of their application, it is important to choose the most suitable combination of methods. The control measures should be economical and the methods of operation and evaluation must be chosen in relation to the set objectives. In selecting realistic objectives of malaria control and the most appropriate control measures, the use of a stratification system (14, 15) based on the basic factors described below will be of great value.

1.4.1 *Tactical variants*

Antimalaria programme objectives for individual areas depend on national commitment, the prevailing epidemiology of malaria, the effectiveness of technological methods, and the financial capability of each country at any given time.

For practical planning purposes, the objectives vary within a spectrum of control efforts, ranging from the reduction of mortality in limited areas of risk to the implementation of a countrywide malaria eradication programme. Within this spectrum, the definition of goals and approaches gives a framework within which the national planner may design a programme appropriate for his country.

The following sequence of goals and associated antimalaria methodologies, referred to as "tactical variants", is illustrative of the major possibilities of malaria control. No one approach should exclude elements drawn from other approaches. Depending on the epidemiological situation, and in order to reduce malaria to the

lowest level as rapidly as possible, more than one variant could be used within the same country. It must be clearly understood that, while these tactical variants constitute organized lines of approach to malaria control, the adoption of any one or combination of more than one in no way precludes the practice of individual measures of protection by members of the community. These measures include the use of mosquito nets, house screening, space sprays against adult mosquitos in houses, and other measures aimed at reducing man-vector contact. Indeed, such methods of personal malaria prophylaxis should be encouraged by the national health services.

The four principal variants are as follows.

Tactical variant No. 1

Goal: Reduction and prevention of mortality due to malaria.

Typically, this variant may be applied to a country or a part of a country with high malaria prevalence, severe clinical illness, low socioeconomic status, and limited experience in malaria programme administration. While the general health services would principally be responsible for drug distribution, community centres, private clinics, and large industrial and other organizations may also play an important role in the distribution of antimalarial drugs for the prompt treatment of the disease.

Tactical variant No. 2

Goal: Reduction and prevention of mortality and morbidity, with special attention to reduction of morbidity in high-risk groups.

This variant could be applied in situations comparable to those using variant No. 1, but a satisfactory organizational structure will be required for a systematic distribution of antimalarial drugs to selected groups of the population such as infants and young children, expectant mothers, schoolchildren, and special labour groups. Limited protective and vector control measures might be applied by the individuals, whole communities, or employers with the technical guidance of the general health services.

Tactical variant No. 3

Goal: Same as variant No. 2, plus reduction of malaria prevalence.

This variant assumes the existence of an organizational nucleus and a sufficient number of trained personnel to apply the methods

and to undertake an epidemiological evaluation of the results achieved. The government's commitment to recurring expenditure for a long-term programme depends partly on the capability of the malaria organization to define the cost-effectiveness of the proposed programme (16). Essential adjuncts to planning for limited control effort are intersectoral coordination, particularly with agriculture, and the ability to elicit public and local community participation and cooperation over the long term. Countries may opt for this variant when the effectiveness of technological methods, the commitment of the government, and the cooperation of the public do not permit a comprehensive national antimalaria programme.

Tactical variant No. 4

Goal: Countrywide malaria control with the ultimate objective of eradication; keeping countries or areas free from malaria where eradication has been achieved; and vigilance in countries that are naturally malaria-free but are threatened by the introduction of the disease.

This variant applies primarily to countries with long experience of antimalaria programmes, firm political support and public participation, a stable and expanding economic base, and a growing professional capability in technical, operational, and organizational management.

For purposes of planning, basic factors involved in the selection of the appropriate antimalaria measures have been presented in detail in the fifteenth (8) and sixteenth (9) reports of the WHO Expert Committee on Malaria and in other documents (17).

As is indicated in those reports, these factors are related to the epidemiological situation, the local efficacy of the methods employed, the level of national political commitment and public cooperation, the extension of professional training, and also to the administrative, operational, and financial feasibility of programme implementation.

1.4.2 Epidemiological factors

For the sake of convenience, the stratifiable epidemiological variables have been classified in four categories covering the following elements: environment, man, vector, and parasite.

(1) *Environment*

The main environmental factors that can be considered in malaria epidemiology are: temperature, humidity, and rainfall (total and its distribution). In addition, the topography of the area is important because it determines the number of water surfaces favourable to the breeding of vectors.

Temperature and humidity strongly affect the life cycle, behaviour, and survival of the insect vector as well as the development of the plasmodium within it. Temperature also influences mosquito activity as shown by the effects of hibernation and aestivation; high temperatures and humidity generally favour the transmission of the infection.

The relationship between rainfall and mosquito breeding is of fundamental importance. While, for example, very heavy monsoon rains may greatly increase *Anopheles culicifacies* populations in one area (Punjab, India), paradoxically, lesser monsoon rains in another area (Sri Lanka) may result in the formation of pools in river beds which are ideal breeding places for the same species.

On the basis of the above factors, four malaria zones (equatorial, tropical, subtropical, and temperate) have been identified (18). Climatic patterns may be used for stratification, as they have a bearing on the length of the transmission season. Rainfall and physiography are important since they can affect the choice and periodicity of the control measures to be implemented (19). Areas with similar physiographical features provide a rapid method for delineating malarious areas into broad epidemiological types, which are of considerable practical utility in planning (20).

(2) *Man*

The effects of the environment on man also influence malaria epidemiology, chiefly by causing him to modify his clothing, housing, and life-style (21). The main variables of the human element that have an influence on malaria epidemiology and selection of intervention measures are the following.

(a) Housing plays an important role in protection against mosquitos because the site, type of construction, nature of the walls, screening, etc., influence the selection of control measures.

(b) Sleeping habits (e.g., whether indoors or outdoors) have an influence on the degree of man-vector contact and obviously also on the choice of control measures.

(c) Occupation sometimes has a direct bearing on susceptibility to malaria. Throughout the world malaria and agricultural practices appear to be closely related; malaria is a disease with a predominantly rural prevalence.

(d) The amount of local infection has a direct bearing on the immune response of the population.

(3) *Vector*

The importance of an anopheline species as a vector of malaria depends on several characteristics that should be considered together. The density of the *vector* population, its susceptibility to infection, life span, and probability of feeding on man are of obvious significance. These characteristics affect the vectorial capacity of the vector (22, 23), but other variables should also be taken into account in the selection of control measures—for example, the type and number of mosquito breeding places and resting sites. Responsiveness of the vector to insecticides and the behaviour patterns of the vector species are important considerations in the selection of control methods (24).

(4) *Parasite*

Degrees of endemicity and the relative distribution of different parasite species, which permit the establishment of age-specific population profiles of parasite incidence and prevalence, are good guides for epidemiological stratification (25). Control measures must take into account the life span of different parasite species, their relapse pattern, and the sensitivity of different strains to the available drugs.

In addition to these epidemiological factors it is advisable to consider also the degree of stability of the disease, which influences other important aspects such as immunity status, severity of the infection, and its seasonal or other patterns.

The stratification process will be effective if it is based on the selection for each variable of levels that have a highly significant effect on the transmission of the infection. For example, whenever a malaria survey indicates that transmission of malaria does not occur above a certain altitude, this factor plays a most important role in the stratification of an area. The same may be said with regard to parts of the country where extensive irrigation for agricultural purposes greatly increases the amount of local transmission.

1.4.3 *Operational factors*

Once the epidemiological factors are understood, the applicability of potential antimalaria measures depends on the following operational factors:

- (1) organizational potential of the health ministry to apply proposed technical methods to target populations under field conditions;
- (2) financial and administrative management capability (including logistics);
- (3) accessibility of the population at risk (location and density of population);
- (4) acceptability of the antimalaria programme to the population and the amount of public support accorded to it;
- (5) availability of trained manpower and the voluntary participation of the members of the community;
- (6) the extent and efficiency of the general public health infrastructure;
- (7) effectiveness of national communication systems;
- (8) provision of a legal basis for programme support;
- (9) expectation of sustained support as determined by past experience in the health sector; and
- (10) level of financial commitment by the government in proportion to external resources.

1.4.4 *Socioeconomic factors*

Socioeconomic factors that influence the design of malaria programmes (26) include:

- (1) risk and severity of malaria among various social and economic groups, particularly those suffering from malnutrition;
- (2) educational levels, including acquaintance with health information regarding protection from malaria and other infections;
- (3) economic status, economic growth, and disparities in income distribution (27);
- (4) occupational pattern, which may increase exposure to malaria as it does in agriculture, forestry, and nomadism;
- (5) potential environmental hazards of development programmes such as irrigation, public works, and hydroelectric schemes;

(6) degree of social organization, which determines the support that can be mobilized for malaria control.

1.4.5 *Use of antimalaria measures in different situations*

The practical antimalaria measures that may be adopted will necessarily vary with the overall programme objective and the related tactical variant. For all four tactical variants, the reduction of mortality due to malaria remains a common goal. Furthermore, the reduction and eventual prevention of malaria morbidity is also an inherent aim of the second, third, and fourth tactical variants as well as the aim of a malaria eradication programme, which may be expected to follow as a logical development of sustained malaria control. In all these circumstances, reliance will be placed on the antimalarial drugs that are effective under local conditions. Other antimalaria measures will be incorporated in accordance with the comprehensiveness of the targets. The measures currently available for use in malaria control programmes are described below for each of the four tactical variants.

(1) *Reduction and prevention of mortality due to malaria.* This represents the most elementary form of malaria control programme, applicable to areas where malaria eradication programmes have not yet been undertaken (perhaps because it is impracticable to do so) or where they have encountered setbacks and cannot rapidly succeed. For such a programme the only practical measure available is the administration of curative doses of an effective schizontocidal drug. For the semi-immune populations of tropical Africa, the curative dose of the 4-aminoquinolines may be less than the recommended standard 3-day, 1.5-g base regimen used for nonimmunes (28).

In the first stage, the availability of the drug treatment may be limited to hospitals only. Later, it may be extended to the peripheral health units and, if the resources permit, to the community level. The scope of this programme is determined by the set targets, which depend on the allocated resources.

The impact of such a programme will vary with its extent and its efficacy. For the patient, it will shorten the duration of each episode of malaria fever, reduce absenteeism from school and work, and, in areas where *Plasmodium falciparum* is prevalent, contribute to an improvement in general health. However, travellers or migrants, who cannot be easily brought within the control programme, will require special consideration.

The community to which this simple programme is successfully applied will appreciate the reduction in deaths attributable to fatal attacks of *P. falciparum* malaria, and this fact should be exploited to the maximum in the national health education programme.

(2) *Reduction and prevention of mortality and morbidity, with special attention to reduction of morbidity in high-risk groups.* This constitutes an advance over the programme described above, and may be developed either as a second phase in the national campaign, or at the outset when and if the level of economic development permits. In this variant, it is necessary not only to provide effective antimalarial drugs in sufficient quantities for the early treatment of acute malaria cases, but also to pay special attention to certain selected groups. These may be, for example, infants and children below the age of 3 or 5 years, nursing and expectant mothers after the fifth month of pregnancy, the labour force working on high-priority economic development projects, school-age children, or units of the armed forces. The deciding factors are the programme objectives and targets set by the national planning authorities.

Whatever its scope, the implementation of this component of the programme will, at the present stage of technology, need to rely mainly on the use of antimalarial drugs of proven efficacy under local conditions. A combination of curative and sporontocidal drugs (e.g., chloroquine and primaquine) may be considered (29). Incorporation of a monitoring system to ensure continued drug efficacy is essential.

Since this activity of drug distribution is directed to specific groups of the population (e.g., nomadic tribes), it is especially important that every effort be made to encourage active community participation (30).

In association with this drug distribution programme, steps should be taken to prevent the further creation of man-made malaria hazards (e.g., pools of water) owing to agricultural irrigation, untidy road building, and other construction work. Even at an early stage in the implementation of a malaria control programme, priority must be given to environmental considerations in all development projects. This will entail the establishment of an effective mechanism for inter-sectoral coordination to ensure full utilization of the necessary professional expertise in the field of environmental management, from whatever discipline it may conveniently be obtained.

The benefits to the individual of the implementation of such a programme are reflected in the reduction in the frequency of acute malaria attacks, improved growth curves in children up to the age of 3 years (31), reduction in the frequency of abortions and stillbirths in women of reproductive age (32), reduction in school absenteeism and improved scholastic performance (33, 34), and improved work attendance by adults.

The community as a whole benefits from the improved wellbeing of the individuals protected by antimalarial drugs and the increased productivity of those at work. The community's awareness of the value of this preventive health measure should be exploited by the national health service. Additional benefits can be derived from the reduced risk of malaria by those sections of the community that reside in the vicinity of development projects in which rational environmental management practices have been adopted as part of the programme.

(3) *Reduction of prevalence and endemicity of malaria.* It is evident that the limited "holding operations" of the control programmes described under variants 1 and 2 cannot be expected to have much influence on malaria prevalence and endemicity. For any further progress to be made against the disease, it will be necessary to take additional measures with the object of reducing malaria prevalence. The list of antimalaria measures available for use in malaria control programmes is lengthy (8, 35, 36, 37) and may be summarized in two categories:

- (a) measures to be applied by the individual, including
 - prevention of man-vector contact using repellents, protective clothing, bed nets, and house screening;
 - killing adult mosquitos by pyrethrum spraying and the use of aerosols;
 - reduction of mosquito breeding sites using water management methods such as draining pools, filling pot-holes, and preventing collection of water around the house; and
 - chemotherapy and chemoprophylaxis;
- (b) measures to be applied by the community, including
 - prevention of man-vector contact by careful selection of building sites and house screening;
 - destruction of adult mosquitos by space spraying or residual spraying of insecticides;

- destruction of mosquito larvae using larvicides (chemical and biological);
- reduction of mosquito breeding sites using water management techniques such as filling up ponds, draining pools, planting trees, and intermittent drying and sluicing methods; and
- mass drug administration.

In making a choice of antimalaria methods, the national authorities may be faced with the problem of determining the level of malaria control that the country can afford in relation to other health priorities.

Among measures directed against the vector, antilarval operations will have greatest value in areas of high population density, but, whenever practicable, measures for the improvement of the environment by the permanent reduction of sources should be instituted, particularly in towns and in areas of new development projects.

(4) *Countrywide malaria control aiming at the ultimate objective of eradication.* The type of programme to be mounted in conformity with tactical variant No. 4 was described by a previous Expert Committee as, "a special public health programme whose objectives are the ending of transmission of malaria, the elimination of infective cases, and the prevention of re-establishment of malaria endemicity or even of endemic foci" (8).

In a number of countries that have the necessary manpower and other resources for further developing their current operations against malaria, little change in the established timetable will be necessary in adopting variant 4. For others, where the situation is less favourable, this variant constitutes, in the context of the malaria control strategy presented by the Director-General to the Thirty-first World Health Assembly (2) a long-term malaria control programme with specific time targets for attaining the interim objectives described (under variants 1, 2 and 3) above, and leading ultimately to eradication.

1.5 Programme implementation

1.5.1 Definition of targets

In order to assess the progress of a national malaria control programme, it is necessary to carry out periodic evaluations, using set indicators (see section 1.6.2); to determine whether or not the targets have been attained. The time-phased targets may be defined as immediate, intermediate, and final. The progress or setbacks of a

programme that has pre-set time limits for reaching the targets should be considered in the light of operational criteria.

1.5.2 *Interrelationship of the malaria services, the general health services, and the community*

The implementation of a planned malaria control strategy based on the four tactical variants described above is the task of the authorities responsible for providing health services and those responsible for community welfare. Needless to say, the coordinated activities of these bodies, as well as other relevant sectors outside the health field, are fundamental in attaining the pre-set operational or epidemiological targets of the antimalaria programme.

It is of utmost importance that in each malarious country, particularly in the tropical and subtropical belts, undertaking organized malaria control there should be a permanent central antimalaria service composed of trained malaria workers, intimately acquainted with the local conditions; they should be in close touch with the general health services, and with other relevant bodies outside the health sector who could contribute to the antimalaria campaign (public works, agriculture, irrigation, economic development, education). Such an antimalaria service apart from its planning, implementation, and evaluation efforts will also act as the best guard against the adoption and introduction of antimalaria policies or measures that are not suited to the local conditions or to the evolution of the country's health programme. Malaria control requires a deeper and wider knowledge of malaria epidemiology than does eradication. Moreover, malaria control calls for continuous and imaginative investigation and appraisal.

1.5.3 *Programme implementation in relation to the tactical variants*

The whole array of antimalaria activities, starting from the simplest attempts to reduce malaria mortality and morbidity through administration of antimalarial drugs up to the final eradication of the disease, is a responsibility shared by the health services and the respective communities.

Within a national, state, or provincial health department, the personnel assigned to antimalaria work may constitute a unit, a section, or a full malaria eradication service, depending on the magnitude of the problem and the evolutionary stage of the health structure and health programme. Two factors important to the efficiency of programme implementation are: (1) the organization

and contribution of the general and community health services (including the primary health care system), and (2) the leadership of the malaria control organization by a team of malaria experts.

(1) *Implementation of variant No. 1.* Evidently, countries opting for this variant will have few resources. To make the best of what is available, it is important to seek maximum community participation. As mentioned earlier, the least that should be done under these circumstances is to provide sufficient antimalarial drugs for the prompt treatment of malaria. Health authorities should make efforts to mobilize community leaders, religious leaders, schoolteachers, shopkeepers, etc. for antimalaria activities.

In the absence of extensive rural health services, the responsibility for distributing antimalarial drugs should be given to a voluntary collaborator from the community. The same person can also be made responsible for the availability of antimalarial drugs at all times to all members of the community.

Health authorities should see that the dosages are clearly marked on the drug containers, either in the local language or pictorially. Adults in the community should be taught to recognize malaria symptoms if they are not already familiar with them. Basic health education on personal protection through the screening of houses and the use of mosquito-nets and on prompt treatment of malaria should be given as widely as possible. Health education should also be given in schools because the awareness created in children will inevitably reach the parents.

In countries where the primary health care system is developed, the role of the community health worker is to give drug treatment to malaria patients and to record every week on a simple form the number of patients in the various age-groups (0-11 months, 1-4 years, 5-9 years, and over 10 years) thus treated.

Staff employed at the peripheral and intermediate level, including the antimalaria staff, are responsible for giving advice, guidance, and in-service training to drug distributors, for providing the logistic support in distributing and replenishing the community's stock of antimalarial drugs, for supervision of the work, and for collecting statistical information on the numbers treated, classified by age-groups.

The central level of the health service, in consultation with its special malaria group, is responsible for the procurement of the antimalarial drugs, for overall supervision of the activities of health

personnel at peripheral and intermediate levels, and for the collation of data on patients treated in the various districts. An attempt should be made to study the impact of the malaria control methods on local vital health statistics and on the trends in morbidity and mortality.

The special malaria group, apart from giving advice and guidance as well as promoting training and health education, may be helpful in collecting information for monitoring the susceptibility of the parasite to the drugs administered and for suggesting improvements in the conduct of drug administration and health education activities.

(2) *Implementation of variant No. 2.* This variant deals with the selection of target groups from the population and the application of epidemiological knowledge (including details about the transmission area and seasonal factors) to reduce morbidity and mortality due to malaria in these groups (see page 22).

The implementation of this variant requires the existence of a primary health care system in the area where the target group lives. A primary health worker or a voluntary collaborator from the community is entrusted with the administration of the weekly suppressive dose of chloroquine and recording the number of people who receive this dose. Health workers from the peripheral or a higher level should visit the target groups to supervise and follow up the treatment. They should also collect basic operational and epidemiological data and educate the group on the benefits of continuing this preventive chloroquine dose as well as on personal protection.

If in large development projects there are foreign technicians and workers recruited from temperate malaria-free countries or from areas with low malaria endemicity, the implementation of the prescribed antimalaria methods would require the establishment of a well equipped malaria control unit annexed to a dispensary having good laboratory diagnostic facilities. The attainment of a reasonable degree of perfection in implementing the antimalaria work in these projects depends on continuous supervision and guidance by the project manager and his staff, particularly as these development projects in malaria endemic areas are subject to explosive and fulminant malaria epidemics.

Staff of the intermediate and central health services must pay greater attention to these development projects. In many instances the serious outbreaks of malaria experienced by countries as a result

of these development projects led to the creation of special malaria units to initiate epidemiological, ecological, and entomological studies. These units had to develop plans to control malaria in the development areas and to advise on the proper implementation of the recommended measures. Negligence in dealing with the malaria problem in these projects, in areas where malaria eradication programmes were initially successful, led to the resurgence of malaria and forced the authorities to adopt long-term malaria control programmes.

Experience gained in the implementation of preventive measures in development projects, apart from exemplifying the value of antimalaria services, has emphasized the importance of intersectoral cooperation between the health services and the authorities (e.g., ministries) responsible for agriculture, irrigation, hydroelectric power, communications, and mining. This has led to the creation of high-level malaria advisory boards or councils embodying representatives from these ministries to help the health authorities in preventing malaria and other hazards connected with these schemes and to protect the labour forces, often through relevant legislation.

(3) *Implementation of variant No. 3.* The introduction of vector control measures in addition to other measures to reduce malaria prevalence in priority areas such as development projects, urban centres, or hyperendemic areas, represents a first step towards organized malaria control. This step has its roots in the previous tactical variant, where the health services attempt to control malaria in development projects.

The choice of this variant indicates that the government has realized the magnitude of the malaria problem and given it a high priority in the overall health plan. At this stage, the first step is to establish a malaria service within the general health services. The role of the primary health care system in areas where malaria prevalence has to be reduced must be emphasized and its full cooperation in the antimalaria effort ensured.

The role of peripheral and intermediate health personnel is to maintain liaison with the village committees and to guide and advise them on vector control measures, whether related to environmental management, biological control (e.g., the introduction of larvivorous fish), or the proper use of residual insecticides or larvicides. Thus, the role of these health personnel should be mainly confined to training, health education, and motivation of the village committees to

maintain the antimalaria effort, although they would also provide technical guidance and supervision and carry out evaluation. These functions call for trained staff such as sanitarians, entomologists, and laboratory technicians. Whether they belong administratively to a malaria service at the central level or to technical units in the general health service is a matter that can be decided by the authorities in conformity with the local circumstances.

At the central level there should be a nucleus of malaria specialists. A malaria coordination body (e.g., a malaria advisory board) with representatives of all departments that can contribute to the antimalaria programme (including health, agriculture, communications, water management, and mining) should exercise a permanent role in the programme. The malaria campaign is a coordinated interdepartmental and intersectoral effort, and the central nucleus of specialists is responsible for justifying the financial and human investments in the programme, making an appraisal of the technical measures to be adopted, training staff, carrying out applied field research (to optimize the cost in relation to the effectiveness of the antimalaria measures), establishing the best methodology to evaluate the progress of the programme, and ensuring intersectoral cooperation at all levels.

(4) *Implementation of variant No. 4.* For the implementation of this variant it is essential to have an extensive knowledge of the epidemiology of malaria, and there must be a high level of coordination between the primary health workers, the higher echelons of the health services, and other government services. It is realized that such an aim can be reached only by stages, and this may take a decade or more, but the most important step is to set up progressive epidemiological targets and to endeavour to attain them year after year until eradication is achieved. Details of the modalities of implementing this tactical variant vary from country to country and have been under continuous elaboration by the Expert Committee on Malaria and other groups since 1956 (8, 9, 11, 38-42).

1.6 Programme evaluation

1.6.1 General principles

There are certain guiding principles to be borne in mind when developing an evaluation methodology for malaria control programmes (21, 43).

The malaria situation in an area may vary constantly. In view of this fact, evaluation must be a permanent feature of any malaria control programme so that it can be revised quickly to meet the changing conditions. Planning, implementation, evaluation, and replanning must be a continuous exercise and an integral part of any antimalaria programme.

The evaluation methods and the relevant data to be collected must be strictly related to the activities, objectives, and expected outputs of the programme. For example, when aiming at the reduction of mortality, morbidity, or the duration of illness, it would be irrelevant and even detrimental to spend time and effort on assessing changes in malaria prevalence, but it would be useful to study hospital and dispensary records or death registrations or to evaluate the effects of the antimalaria measures on school attendance or on agricultural production.

Taking into account the characteristics of the disease and the expected returns from its control, the evaluation variables may be grouped as follows:

(1) those related to the technical and operational assessment of the programme, e.g., malariometric and entomological indices, specific morbidity and mortality rates, population coverage, and cost-effectiveness ratios;

(2) those related to the general health situation, e.g., effects of the programme on general incidence of sickness indices, life expectation at birth, abortion rates, specific morbidity and mortality rates of other diseases directly or indirectly affected by malaria infection, bed occupancy in hospitals, and health service costs; and

(3) those related to socioeconomic factors, e.g., effects of the programme on national income, industrial and (particularly) agricultural productivity, school absenteeism or scholastic results, labour force output, commerce and tourism, and existing development plans.

1.6.2 *Operational and epidemiological criteria*

The indicators that may be used in the operational assessment of *tactical variant No. 1* are:

— the number and distribution of drug distribution centres (as a percentage of the number anticipated at the planning level) and the number of people collecting antimalarial drugs from these centres;

— availability of the necessary quantities of appropriate antimalarial drugs at the drug distribution centres, knowledge of the drug distributors regarding drug dosages in relation to the patient's age; and the distributors' skill in compiling statistical data; and

— capability of the health personnel in diagnosing malaria and managing the treatment of malaria cases.

The epidemiological assessment indicators of this tactical variant are:

- reduction in mortality rates;
- proportion of severe malaria cases among all fever cases recorded by the health institutions;
- number of deaths due to malaria; and
- number of laboratory-confirmed malaria cases.

The operational assessment indicators used for *tactical variant No. 2* are the same as those used for No. 1. The epidemiological assessment of this variant can be made using the following indicators:

- six-monthly spleen and parasite indices;
- case detection expressed as malaria incidence rate;
- parasite density index;
- reduction in absenteeism from work and school; and
- reduction in infant mortality rates.

For *tactical variant No. 3*, the operational assessment indicators are:

- indices showing larval and adult vector densities;
- proportion of vector breeding sites effectively covered by larvicide application; and
- proportion of vector resting sites treated with residual insecticides.

The epidemiological assessment indicators of variant No. 3 include those listed for variant No. 2 and in addition the following indicators:

- selective periodic *Anopheles* density indices (assessment of man-vector contact);
- indoor vector mortality; and
- vector susceptibility rates.

For *variant No. 4*, the assessment should be carried out on the basis of malaria eradication procedures.

Malariometric indices. As a measure of the effectiveness of malaria control operations, malariometric indices continue to be superior to serological methods. In tactical variants 1 and 2, which aim only at reducing the specific mortality in places where the health infrastructure is not well developed and laboratory facilities are limited (as in parts of Africa and Asia), treatment will be given to all malaria suspects. However, for the evaluation of the effects of malaria control, the Committee strongly recommends the use of information based on microscopically confirmed malaria cases, even though these data are limited in the early stages of a programme and may have to be obtained by sampling.

1.6.3 *Socioeconomic indicators*

In many countries malaria is an important cause of continuing poverty. Successful antimalaria schemes have often been followed by a marked improvement in the social and economic conditions of the community (44, 45). It is, nevertheless, very difficult to quantify the role of any specific endemic disease within the whole complex of underdevelopment. There is a need for more reliable information and improved methods of study.

To measure the impact of malaria on socioeconomic conditions, surveys need to be carried out in order to estimate the demand for and the use of various health facilities. There is also a need to assess the influence on public health of such social factors as disability, working conditions, housing, and food consumption. Useful data can also be obtained by carrying out surveys oriented towards specific problems such as interference caused by seasonal malaria during the harvest, the problem of increased transmission of malaria owing to new irrigation schemes, and the influence of local availability and cost of antimalarial drugs on the morbidity rate. Some examples of the factors for which appropriate assessment methods need to be developed are:

- (1) amount of disease or disability related to the seasonal periodicity of malaria;
- (2) proportion of sickness diagnosed as malaria or as "fever" notified by local dispensaries, and the proportion referred to hospitals;
- (3) mean duration of sickness diagnosed as malaria in men, women, children;

(4) variations in annual or seasonal malaria (or fever) morbidity recorded by different health units at different levels of responsibility;

(5) the effectiveness of the treatment given, judged by the records of the treatment centres;

(6) relationship between malaria and malnutrition or other diseases;

(7) degree of exposure to malaria in various economic groups, and extent of utilization of personal protection measures such as protective clothing, repellents, or antimalarial drugs.

Problems arise when mortality and morbidity statistics are used to measure socioeconomic change. The impact of decreased mortality on economic development may be questioned when it is either limited to a small and unrepresentative portion of society or when it increases the proportion of unhealthy and incapacitated people in a poverty-stricken society and contributes substantially to excessive population pressure. Information on cause-specific morbidity is extremely difficult to obtain, and the relationship between morbidity and socioeconomic development is also particularly difficult to determine quantitatively. One measure that is considered to be of value in areas of endemic malaria is change in birth-weight (46). Since excessive perinatal and infant mortality is related to the high ratio of newborn babies of low birth-weight, the latter may be regarded as an indicator of socioeconomic development (47). However, a number of conditions other than malaria, principally protein-energy malnutrition and nutritional anaemias, also contribute to the frequency of low birth-weight.

The socioeconomic effects of malaria and its reduction need to be studied in the field, and appropriate methods of assessment should be developed for each of the tactical variants.

2. FORECASTING, PREVENTION, AND CONTROL OF EPIDEMICS

2.1 Factors determining malaria epidemics

The term "epidemic of malaria" is used loosely to indicate a rapid and marked increase above the generally low level of mortality and morbidity due to malaria. The term "epidemic outbreak" has been restricted to the occurrence of malaria cases in an area in which the disease was unknown (48). During the past 10–15 years, however,

epidemic outbreaks of malaria were observed mainly in areas where malaria had been previously eradicated or nearly eradicated. The characteristic features of these epidemics include their explosiveness, the predominance of *Plasmodium vivax*, and, as a rule, low fatality. They usually occur in areas of high receptivity¹ and/or vulnerability² with reduction in the level of collective population immunity.

Elimination of post-eradication epidemics is a difficult task, especially when they are detected with some delay. In addition to serious socioeconomic consequences, these explosive epidemics may also lead to the re-establishment of endemicity. Post-eradication epidemics are new phenomena in malariology and require careful attention and study by the national health and malaria services.

Epidemic outbreaks of any intensity or localized epidemics affect all age-groups to almost the same extent. Spleen rate, parasite rate, and parasite density are high in children and adults alike, except that the older adults, with some residual immunity, may show somewhat lower rates. In endemic areas the minor seasonal rises of incidence show more moderate spleen and parasite rates and parasite counts and a more or less marked tendency to spare the adults. The seasonal rises occurring in highly endemic areas usually affect only the lower age-groups, leaving the adults much less affected. This is largely due to a high collective immunity of the population.

The mechanism of a malaria epidemic is complex because it depends on the qualitative and quantitative relationships between the human host, the parasite and its vector, and on physical, biological and economic aspects of the environment. The following modified classification (19, 50) is useful in considering the main points related to the origin of an epidemic.

(1) Human factors

- (a) Decline in collective immunity following a previous epidemic in a nonendemic area.
- (b) Introduction of nonimmune groups into an endemic area.
- (c) Malnutrition or an intercurrent disease causing a decline in human resistance to infection.

¹ Receptivity refers to the abundant presence of anopheline vectors or the existence of other ecological and climatic factors favouring malaria transmission. The epidemiological experience in a country, both before and during the eradication programme, must be used to delimit areas of different receptivity so that the degree and type of vigilance may be appropriately planned and organized (49).

² An area may be referred to as "vulnerable" either when it lies close to malarious areas or when it is liable to the frequent influx of infected individuals or groups and/or infective anophelines (49).

- (2) Parasite factors in the human host
 - (a) Seasonal recurrences or relapses.
 - (b) Importation by human carriers of new parasite species or strains.
 - (c) Shortcomings of mass drug administration or of radical treatment.
 - (d) Development of parasite resistance to a hitherto active drug.
 - (e) Increased gametocyte production in the infected population.
- (3) Mosquito factors
 - (a) Increased vector density and longevity due to meteorological conditions.
 - (b) Decrease of the deviation of *Anopheles* from man due to fewer domestic animals.
 - (c) Greater accessibility of man to *Anopheles* vectors due to change in human habits.
 - (d) Increased preference of local vectors for human blood.
 - (e) Importation of a new effective vector into the area.
- (4) Environmental factors
 - (a) Unusual climatic or meteorological conditions leading to a sharp increase in breeding activity of the vector.
 - (b) Human activities related to development projects and, especially, agriculture, irrigation, or planting of water-holding crops.
 - (c) Sudden deterioration of sanitary conditions, health services, or both, owing to natural disasters, social disturbances, and wars.

The principles underlying the quantitative analysis of the growth of an epidemic are described in the literature (25, 51). The epidemic grows in a series of steps representative of the incubation interval (the period between the occurrence of infective gametocytes in the primary case and their reappearance in a secondary case), which is about 20 days for *P. vivax* malaria and 35 days for *P. falciparum* malaria. The length of the incubation interval and the degree of the reproduction rate determine the rate of multiplication of transmission, which is much faster in *P. vivax* epidemics than in those due to *P. falciparum*.

An epidemic curve may be broken down into a pre-epidemic phase, during which small-scale transmission takes place between the true primary case and susceptible individuals, who will later form the apparent primary reservoir of infection. The epidemic phase that follows can be subdivided into (1) a first period, lasting about 3 weeks in *P. vivax* epidemics, during which a reservoir of cases exists but may not multiply continuously (i.e., it remains much the same size), (2) a second similar period in which cases multiply but with a more or less regular rate of accretion of new cases throughout the period, and (3) a third period in which cases multiply in successive

waves but at an accelerating rate, until the epidemic is brought to an end by a climatic factor, by reduced susceptibility to fresh infections (since most people have already been infected), or by an intensive malaria control campaign.

In *P. falciparum* epidemics these periods are likely to be somewhat longer. This is because the appearance of gametocytes following a fresh infection is delayed in this species and, as a result, malaria cases occur at longer intervals; another reason for this is the slightly longer period of the extrinsic cycle in this species. Commonly the interval is 5 weeks, but it may be longer. It follows that a mixed epidemic is likely to manifest itself first as due to *P. vivax* infections and later as largely due to *P. falciparum* infections.

As mentioned before, the rate of these multiplications would depend on the degree of transmission of the infection, the numbers of susceptible anophelines, their feeding habits and life span, and the length of the extrinsic cycle under prevailing temperature conditions.

2.2 Outbreaks of malaria during eradication or control campaigns

A malaria epidemic in the course of an eradication or control campaign is usually due to one or more of the basic causes of malaria epidemics listed on pages 34–35. However, these epidemics differ from post-eradication epidemics in that they arise from a smaller reservoir of infective cases. It is important that such epidemics be identified at an early stage before a considerable part of the population becomes infected.

In this special situation any unexpected multiplication of cases, on however small a scale, is to be regarded as an epidemic outbreak. The planning of surveillance consists largely in working out means of recognizing such happenings in their early stages.

In malaria epidemics of any size occurring during antimalaria campaigns, the operational deficiencies of the programme play an important part in the origin of the outbreak. Shortcomings of case detection activities are most common, resulting in the accumulation of untreated cases of overt malaria or in a large proportion of gametocyte carriers with mild if any symptoms.

Another major factor is the inadequate coverage by residual insecticide spraying, due to, for instance, defective spraying routine, large numbers of unsprayed houses or undetected changes in the response of *Anopheles* vectors to insecticides.

2.3 Forecasting and detection of malaria epidemics

In considering the question of malaria epidemics, a distinction must be made between epidemics occurring in areas where the malaria endemicity has not been disturbed by man and those occurring in areas where, owing to man's intervention, malaria endemicity no longer exists.

Before the availability of DDT, malaria epidemics occurred mainly in areas with hypo- or mesoendemicity and, in certain circumstances, in areas with hyperendemicity. One of the characteristics of these epidemics was their occurrence in cycles of 5–8 years. In the past, whenever endemic malaria was characterized by a seasonal wave, the forecast of a higher incidence was reasonably easy. These cycles were not fully explained but were related in Asia to excessive rain in the early part of the monsoon in July or August. Some of these events resulted in a high mortality of the population, with subsequent paralysis of the normal life of the area and famines due to virtual cessation of agricultural work.

It is somewhat more difficult to forecast a cyclical epidemic, as the cycles are far from regular. However, if any unusual happening is detected, especially if it is related to the factors mentioned on pages 34–35, there might be a possibility of a sudden increase in the incidence of malaria.

The most obvious pointers were meteorological and environmental factors, but a reasonably good collection of vital statistical data, while not often likely to forecast a malaria epidemic, could detect it at an early stage and facilitate the initiation of appropriate measures.

Thus Christophers' (52) method of mapping points of excessive mortality (ratio of mortality in the epidemic months to normal mortality) permitted the early prediction of incipient epidemics in the Punjab in 1908. This method may still be of value in areas where no other method for the early detection of increasing incidence exists.

Since the initiation of malaria eradication programmes in various countries, the disease has been eradicated or its endemicity has been reduced to a low level, and there is now a risk of malaria epidemics occurring in nonimmune populations. An exception to this is found in areas of Africa south of the Sahara where hyper- and holoendemic malaria is still common. These areas were not included in the malaria eradication programme and there has been no change in endemicity over the years.

Resurgence of malaria has occurred in a number of countries and, in many cases, it has grown to epidemic proportions. Two features connected with malaria resurgence have been recognized. First, if no antimalaria measures are taken, malaria grows from a level of low endemicity to its natural endemic level. This type of resurgence is being observed in many areas. Secondly an epidemic outbreak may occur under particular circumstances in which there is an agglomeration of a large number of persons infected with malaria in an area at a time when the vector density is high. Under the term "particular circumstances" one would have to include two well-defined conditions: (1) areas formerly endemic, and (2) areas still endemic. Consideration must also be given to irrigation schemes employing a large foreign labour force consisting mostly of nonimmune persons, and to areas in which social disturbances or hostilities are taking place.

In both types of area one has to consider the ratio between the indigenous and immigrant populations. Where the recipient area is still endemic and the imported labour force nonimmune, one has to consider the epidemiological features characterizing the autochthonous malaria of the area. For areas that were formerly endemic but are still receptive, malaria epidemics can develop only when a large parasite reservoir is being imported; in this case, one would have to consider the type of "imported" malaria and its epidemiological features. When there is importation of nonimmune persons into an endemic area an epidemic of malaria will develop rapidly, but this is not usually the case when the parasite reservoir is imported. The epidemiologist will have to estimate quantitatively the parasite reservoir and its potential for transmission through the specific vectorial capacity of the species of *Anopheles*. It goes without saying that, in addition to environmental factors, biological factors related to the vector, the behaviour of man, and the species of *Plasmodium* involved will also have to be taken into account.

In certain circumstances, for example, small islands with limited resources that have succeeded in eradicating malaria, the reintroduction of malaria or simple resumption of transmission, for example, of *P. malariae*, may be expected to result in an epidemic outbreak.

The most important practical tool for monitoring the malaria situation remains a sustained surveillance of fever cases by examination of blood films from a manageable proportion of such cases. This must be backed up by a specific policy decision to replenish

annually the stock of equipment (glass slides, Giemsa stain, reagents) maintained for examining blood films in the central laboratory. There is also need for periodic supervision and retraining of the laboratory technicians who identify the species of malaria parasites and the maintenance of adequate amounts of antimalarial drugs (of the kind that have been proved effective under local conditions) for the treatment of any imported and early secondary cases identified. This surveillance mechanism should include advice on individual malaria prophylaxis to residents travelling to known malarious areas and a regular reporting and follow-up system of all cases of transfusion malaria from suspected or identified blood donors.

An approach for determining the warning threshold of a malaria epidemic has been proposed. The basis of this approach is the quantitative evaluation of four epidemiological factors closely related to the entomological inoculation rate, which determines the degree of malaria transmission (53). These individual or combined direct factors are:

- the daily man-biting rate
- the daily vector-survival rate
- the length of the sporogonic cycle, in days
- the gametocyte rate.

Changes in the entomological inoculation rate will result from any change in at least one of these factors.

Although not yet fully quantifiable, relationships exist between the above direct factors and several independent or combined indirect factors (54, 55).

In the table below the direct factors are listed in the order of increasing sensitivity to the entomological inoculation rate, together with the corresponding most sensitive indirect factors that have an influence on them.

<i>Direct factors</i>	<i>Corresponding indirect factors</i>
Man-biting rate	Rainfall, drought, poor maintenance of irrigation systems, changes in feeding habits of mosquitos
Gametocyte rate	Importation of malaria parasites, migration of nonimmune people
Length of sporogonic cycle	Temperature
Daily survival rate of vector(s)	Temperature and relative humidity

Precise knowledge of the relationships between indirect and direct factors of transmission would evidently be of considerable interest in forecasting epidemiological developments in malaria, but changes in the indirect factors, detected through a warning system, would have to be taken into account.

A monitoring system should be established by which the epidemiological variables affected by the indirect factors can be calculated at regular intervals and their values analysed and assessed with the shortest possible delay. The intervals between the observations may vary in different epidemiological situations, and it is left to the epidemiologist to decide when the observations should be repeated.

The establishment of a monitoring system should be based on sound principles. Due consideration should be paid to the statistical procedures relating to the collection, recording, and processing of the data. Good monitoring will also involve the use of various statistical methods such as sampling techniques and decision theory. The main statistical requirements of monitoring and surveillance systems were discussed by a WHO meeting in 1977 (56).

It seems that the proposed approach is of some promise, but it can be fully explored only when the entomological and parasitological data are constantly and reliably monitored. A field trial of this method would be of value.

2.4 Control of epidemics

As pointed out before, *P. falciparum* malaria is relatively slow in multiplying and it reaches its epidemic peak (when about 50% of the population is infected) later than does *P. vivax* malaria, even when transmission is intense. There is, in both cases, a phase of relatively slow growth before a sudden rise. The initial, relatively slow stage is a warning, and towards the end of it, when secondary cases are recognized, there should be an urgent study of their numbers. This will determine the degree to which the emergency insecticidal and mass therapeutic measures should be undertaken (57).

In planning control measures against an actual or a potential malaria epidemic it may be useful to consider two stages:

- (1) first-degree prevention, in which measures are taken against the importation of vectors or suspected sources of infection, and
- (2) second-degree prevention, in which measures are taken against the re-establishment of transmission.

First-degree prevention is applied when the infected vectors arrive from outside the national borders (an event of particular seriousness when these vectors are resistant to the insecticides usually used in the country), or when there is an influx of human sources of infection, whether actual or merely suspected.

If the infected vectors arrive by direct flight across the national frontiers the border areas must be protected by residual insecticide spraying. However, vectors may also be carried in motor vehicles, trains, aeroplanes, and ships. There are no practical defences against this happening and the importation of uninfected vectors (even if they had been eliminated from an area) will not constitute a serious breach in the defence against the re-establishment of malaria. On the other hand, prevention of importation requires a considerable expenditure and the action may be entirely unsuccessful.

Protection against the influx of suspected sources of infection also comes under first-degree prevention. To be effective, the vigilance mechanism must detect all cases of imported malaria and maintain a periodic review of all recorded fever cases. This activity is both difficult and expensive, not only in tropical areas but also in the temperate zone. The importation of drug-resistant strains of *P. falciparum* should not be looked upon as very dangerous in protected areas when insecticides are the means of eliminating foci.

With reference to the second-degree prevention, the WHO Expert Committee on Malaria has emphasized the need for an efficient and alert vigilance system able to detect any reappearance or resurgence of the disease before it re-establishes itself as an endemic condition (40), endemicity being defined as a measurable incidence both of case and of natural transmission over a succession of years. Once the criteria for eradication have been met no area should be reclassified as malarious unless an endemic state has been established or appears likely to be established (58).

Thus, while it is vitally important to discover and to eliminate new foci, the appearance of a few imported or introduced cases does not constitute the re-establishment of endemicity. What is essential is the ability to apply remedial measures efficiently and on time once a focus is found.

The activities required for second-degree prevention are:

- maintenance of up-to-date geographical reconnaissance;
- periodic classification of the different areas of the country according to their vulnerability and receptivity (see footnotes 1 and 2 on page 34);

- study of population movement patterns;
- provision of local and regional diagnostic facilities for the examination of blood slides;
- maintenance of case detection posts, if available;
- investigation of indicator cases;
- epidemiological investigation of active foci that may appear;
- radical cure of all infected persons found;
- maintenance of stores of materials and equipment needed for reintroduction of spraying when necessary.

A force of auxiliary health workers, who can be called upon in case of an epidemic, should be maintained to search for malaria cases and apply the required remedial measures. It is important to follow up the foci from which malaria has been eliminated.

It is doubtful whether any basic health service, unless it is of exceptional competence and has a very wide network of local units, can take appropriate and rapid action in cases of extensive or even localized epidemics. While the local health units are of great help in detecting and reporting the incidence of malaria and administering the necessary drugs, their assistance in carrying out well planned antimosquito measures is usually less than adequate.

It is only during a malaria epidemic that the value of a centrally directed service, specializing in the control of malaria and other vector-borne diseases, is fully appreciated. The tendency to integrate prematurely the malaria control units into the general health services, in countries where the menace of epidemics exists, may have wide-ranging adverse effects.

Whenever possible, the capacity of antimalaria units to control malaria and other vector-borne diseases, and their availability at short notice, must be maintained and if necessary restored.

3. TRAINING IN MALARIA CONTROL

Long-term malaria control programmes require knowledge and skill at all echelons of the health service. Moreover, in the communities oppressed by the disease, the awareness of the nature of malaria and of its prevention is the key to success in overcoming it; thus, health education in this field should be a continuous process.

There is no standard method of malaria control and the tactics have to be worked out for each area in relation to its ecology and socioeconomic situation. Consequently the objectives of training

vary, and each country should develop its own training programme for the various categories of malaria service staff and general health or community workers to meet local requirements. All malaria training programmes should have a built-in evaluation component; therefore, the learning objectives must be specifically and precisely defined. This would be of great help in the development of curricula and the selection of candidates and teaching staff. Career opportunities should be provided for the training staff and the trainees.

The definition of the training objectives should be based on the short- and long-term objectives of the malaria control programme, overall health programmes, and present or future job descriptions of the categories of staff to be trained. In other words, the training should be programme-oriented and should be in relation to the tactical variant or variants adopted by the country.

In malarious countries, appropriate malaria training should be provided not only to the staff who will work in the malaria service, but also to other staff such as the community health workers, nurses, midwives, sanitarians, public health technicians, medical officers, agricultural extension officers, and administrative officers.

Some education about malaria should be begun in primary and secondary schools; this should be continued at the university level for all categories of undergraduate, and especially for students of agriculture and engineering.

In view of the shortage of teaching personnel, there is a need to develop special programmes to train teachers. The development of any teacher-training programme must be preceded by a careful assessment of the training needs of the country in each region; on this basis regional or interregional training programmes may be instituted.

A joint WHO/USAID Task Force on the Malaria Training Programme for Asia emphasized the need for giving support to national training programmes. The present regional training programme for Asia includes training and applied research activities in other vector-borne diseases. It is expected that there will be increased cooperation between the Malaria Training Programme for Asia and the Southeast Asian Ministers of Education Organization Regional Tropical Medicine and Public Health Project, the UNDP/World Bank/WHO Special Programme for Research and Training in Tropical Diseases and other training and research institutions.

In countries from which malaria has been eradicated, personnel of the general health services need to be trained in the detection and

prevention of malaria; this is required to strengthen these countries' defences against the reintroduction of the disease. Malariology should again have a place in the curricula of all medical schools, and in postgraduate courses in public health.

Malaria control requires a much broader entomological expertise than was needed for malaria eradication. In recent years the already scarce professional expertise in entomology has been diverted to programmes for the control of other vector-borne diseases. Therefore there is an urgent need to develop or strengthen institutions for training medical entomologists. The training curriculum of these institutions should cover all entomological aspects of malaria control. The Committee noted, with appreciation, that action was already being taken by the Organization in this field; however, it suggested that this effort be intensified on a subregional or regional basis, in order to adjust the formal curriculum and field training in accordance with the needs of the countries concerned.

To allow long-term planning of regional training programmes, an estimate of the cost for the next five years should be made on a realistic basis so that funding bodies can consider their future financial contributions in advance.

It would be most useful if WHO could prepare a summary of all existing information on practical malariology in the form of teaching aids and make them available to the countries needing such information. Manuals on the planning of malaria control programmes, and on practical malaria epidemiology are particularly urgently needed.

4. RESEARCH IN MALARIA

WHO gives strong support to basic and applied research on malaria and mosquito control (59, 60). In addition to the important research work being carried out under the auspices of the UNDP/World Bank/WHO Special Programme for Research and Training in Tropical Diseases (61-63) and independently by a number of national research institutes, there is ample scope and justification for research work by the malarious countries themselves. For these studies, external assistance is often available and the Committee recommended that WHO should encourage these countries to avail themselves of these opportunities to a far greater extent.

The Committee directed attention to the following research areas.

(1) With respect to tactical variant 1 (see page 16), there is need to develop methods of implementing primary antimalaria measures in rural communities affected by the disease and not adequately covered by a health infrastructure. This type of field research should include sociological and demographic studies, examination of logistic problems, development of health education, and techniques of evaluation.

(2) With respect to the other tactical variants, applied research should be oriented towards surmounting problems encountered in the field and should include studies on:

(a) methods of encouraging communities to accept the prescribed antimalaria measures and to participate in applying them;

(b) the assessment of morbidity and mortality in those areas where the data are at present poorly collected;

(c) the extension of vector resistance to insecticides, and prediction of the time when the applied insecticide must be replaced by an alternative compound;

(d) the rational use of insecticides in control programmes;

(e) the distribution and spread of chloroquine-resistant *P. falciparum* malaria;

(f) the cost-benefit and cost-effectiveness of control programmes under various ecological and socioeconomic conditions; and

(g) finding the most effective communications system to support the programme.

It is apparent that such studies require personnel who are trained in research methodology. The establishment of regional field training and research centres is regarded as the best approach to training workers in that area.

Although field research has been undertaken to overcome local obstacles in malaria control ever since such control work started, it has not been widely systematized. For this reason it represents, for most of today's workers, a new venture in the development of realistic methods for malaria control, and each region must project its field research programme in a sufficiently convincing manner to attract donors to finance it.

Basic research into all aspects of the disease and its transmission (64, 65) forms the backbone of all malaria control programmes.

4.1 Advances in the development of antimalaria measures and their potential value

4.1.1 Antimalarial drugs

The Committee considered that the WHO programme of research into the identification, production, and testing of new antimalarial compounds—a programme to which the Walter Reed Army Institute of Research, Washington, DC, has contributed immensely for many years (66)—could be expanded to include investigation of the pharmacology and efficacy of traditional indigenous herbal remedies and products used empirically in several countries, particularly in Asia.

Some of the more important lines of investigation being pursued in connexion with antimalarial drugs are the following:

(1) *Tissue schizontocides*. Several 8-aminoquinolines, more active than primaquine, are under study, with particular reference to toxicity. Primaquine and its isomers are also being examined with the object of decreasing their toxicity, e.g., by lysosomotropic formulations. A screening system for tissue schizontocides and a liver tissue culture of *Plasmodium* schizonts are being developed.

(2) *Blood schizontocides*. Mefloquine is now being investigated in clinical trials in Brazil, Thailand, and Zambia. Triazines, amino-acridines, and aryl thioquinazolines are being developed outside the WHO programme.

(3) *Gametocytocides*. The Walter Reed Army Institute of Research is developing a screening system for gametocytocidal and sporontocidal drug action, and studies on the action of primaquine in this respect have also been initiated.

(4) *Prolonged drug action*. The sustained release of an injectable formulation of pyrimethamine, using biodegradable polymers, is under study and may lead to the development of a formulation of a combination of pyrimethamine and a sulfonamide or a sulfone. Studies are also being carried out on quinazoline formulations and on pyrimethamine pamoate and its possible combination with acedapsone.

(5) *Combination of tissue and blood schizontocides*. The toxicity of a proposed combination of mefloquine and primaquine is being studied.

(6) *Drug susceptibility*. A global programme for studying the susceptibility of *P. falciparum* to chloroquine has been started, initially in the South-East Asia and Western Pacific Regions. The *in*

vitro macrotest is being used at present. However, a microtest for studying the susceptibility of *P. falciparum* to chloroquine and mefloquine is under development; this test will offer many practical advantages. Ancillary studies include the use of alternative treatments, the management of drug-resistant malaria cases, and the biological characterization and cryopreservation of isolates. Field aspects of the study comprise the training of personnel capable of susceptibility monitoring, development of a mapping system using *in vitro* and *in vivo* testing of carriers, and appropriate selection of remedial measures.

(7) *Studies of special problems including the development of laboratory models.* Models that depend on simian hosts are difficult to maintain, as the supply of monkeys (particularly *Aotus*) is seriously restricted. The Committee expressed its concern at the present situation, and felt that programmes for breeding these monkeys should be established as soon as possible, and that efforts should be made to facilitate the export of *Aotus* from countries in which they are native. Systems have also been proposed for the culture of *P. vivax*, and for animals other than monkeys for the investigation of relapsing malaria.

4.1.2 Immunological methods

(1) *Malaria vaccines.* The Committee noted that, although great strides have been made in recent years in identifying and testing various immunogens in rodent and simian malarias, and while some experimental immunization of man has been achieved, the problems preventing the perfection of a safe and efficacious vaccine against malaria are still formidable (67). Even if the principal remaining problems (i.e., those of the provision of a safe adjuvant for antimalaria vaccines and purification of the antigenic material) are solved, it will be several years before such vaccines become available.

The recently developed methods for continuous cultivation of plasmodia will be invaluable for the production of the large quantities of erythrocytic-stage parasites used as antigen (68). Immunization with merozoites, preschizonts, schizonts, and gametes has been investigated in various parasite/animal models. Since 1972 several humans have been successfully immunized against *P. falciparum* and *P. vivax* with irradiated sporozoites on an experimental and carefully controlled basis. It appears that active immunity

induced by these methods is specific to the parasite species, but protects against all geographical strains within that species. The immunity is stage-specific, with very slight cross-protection with other stages. The induced immunity appears to last up to 5 months with antisporeozoite and up to 9 months with antimerozoite immunization; small booster doses may extend protection in both cases.

Very stringent requirements governing vaccine potency and safety must be met before trials can be envisaged in man (69, 70). It should be realized that such vaccines, regardless of their type and the epidemiological indications for their use, would probably be no more than additional tools in malaria control, and would complement but not replace other antimalaria measures.

(2) *Immunodiagnostic tests.* These are useful tools for research and for epidemiological evaluation and assessment. Serological tests such as the immunofluorescent antibody (IFA), indirect haemagglutination (IHA) and the enzyme-linked immunosorbent assay (ELISA) are being employed for epidemiological studies to determine present or past host/parasite contact. The increasing availability of *P. falciparum* from *in vitro* culture is overcoming the difficulties of antigen supply for these tests. However, the tests are cumbersome and inadequate, and there is a need for a battery of tests simple enough to be undertaken in the field and able to show the existence of an infection, a past host/parasite contact, and the degree of protective immunity.

4.1.3 Antimosquito measures

(1) *Insecticide resistance.* Physiological resistance in *Anopheles* mosquitos to insecticides has become a major obstacle to malaria eradication and control. In 1975 the WHO Expert Committee on Insecticides (71) stated: "It is finally becoming acknowledged that resistance is probably the biggest single obstacle in the struggle against vector-borne diseases and is mainly responsible for preventing successful malaria eradication in many countries." Since then, the situation has deteriorated further with the development of resistance to the organophosphorus insecticides such as malathion and fenitrothion (24, 72-74). Consequently, laboratory and field studies have been carried out on the cross-resistance characteristics of malaria vectors (75).

In the light of these studies it has been found that the development of resistance to DDT can often prevent the subsequent

effective use of synthetic pyrethroids (due to the *Kdr* gene) (76). The development of resistance to malathion may occur without cross-resistance to other organophosphate insecticides, leaving it feasible to use fenitrothion or similar organophosphates. The development of resistance to malathion, fenitrothion, or propoxur might not prevent the subsequent effective use of chlorphoxim. There is also a risk of development of resistance to insect-growth regulators belonging to the methoprene group, but apparently not to diflubenzuron. Studies are therefore being carried out on the cross-resistance spectrum and the speed of development of resistance to new insecticides in WHO collaborating centres and in some instances in the field.

The situation is further complicated by the extensive use of all types of insecticides in agriculture. This has often resulted in the pre-selection of malaria vectors resistant to new insecticides; this problem is being examined by WHO in collaboration with the Food and Agriculture Organization of the United Nations.

In view of the complexity of resistance mechanisms giving rise to a variety of cross-resistance patterns, it is difficult to forecast resistance development and its characteristics when control operations are planned. Therefore investigations are being carried out on the dynamics of resistance development, and the possibility of its retardation or prevention. Standard test kits for monitoring insect resistance, together with guidelines for interpretation of data obtained in the field, are available. However, the Expert Committee noted that these kits were relatively expensive and in some countries difficult to obtain because of currency exchange restrictions. The Committee was gratified to note that WHO has always devoted considerable attention to the problems arising from the development of insecticide resistance in vectors and that these investigations will continue to receive high priority in the future.

(2) *New insecticides.* WHO has pursued for many years a Programme for Evaluating and Testing New Insecticides to find replacements for DDT and other compounds to which vector populations have developed resistance. This programme has yielded several compounds suitable for residual spraying and antilarval treatments, but factors such as cross-resistance within the group of compounds or between the same group of compounds, or toxicity hazard (77) have reduced their potential efficacy. In the organochlorine group of compounds, biodegradable derivatives of DDT were studied but these compounds did not show sufficient activity. The

most promising organophosphate compounds are malathion and fenitrothion. The carbamate compounds, although of interest, have rather short residual activity, as illustrated by propoxur. The most recently studied class of compounds, the pyrethroids, is of interest. The two that are most active are permethrin and decamethrin. These have been tested for residual effect but, because of their irritant and repellent action, they do not seem to reduce the man-mosquito contact to as low a degree as required.

Many organophosphate compounds have been shown to be effective in larval control but the choice depends on the nature of the breeding site and the toxicity of the compound.

Larvicides that affect the growth and development of insects (insect growth regulators) have been tested and may be of promise owing to their low mammalian toxicity.

The indoor spraying of residual insecticides often leads to significant exposure of spraymen and to some degree of exposure of the occupants of the house to these chemicals. WHO has supported research under both laboratory and field conditions to develop alternative compounds and to evaluate their mammalian safety (78, 79). Many authorities have warned of the relatively narrow margin of safety of most of the alternative insecticides when applied as a residual insecticide indoors.

4.1.4 *Biological and genetic approaches to vector control*

(1) *Biological control.* Although larvivorous fish are still the only operational means of biological control (under certain environmental conditions), considerable progress has been made during the past few years in the development of microbial agents based on isolates of spore-forming bacteria, especially *Bacillus sphaericus* and *B. thuringiensis israelensis*. A sample of the latter has been designated as an international standard (Pasteur Institute, Paris) and a standard for the former is now under development. Both will be available in quantity when trials to establish their safety to mammalian and other fauna have been completed.

These agents act as larvicides and have been shown to be very active against mosquitos, particularly *Anopheles*. They can be formulated in various ways and applied with conventional equipment. However, at present there is no certainty that the use of these agents in vector control will prove economic, although in certain agricultural operations they are successfully competing with the chemical pesticides.

The major areas of research on microbial insecticides include the search for the characterization of these agents, new strains that are virulent to the insect vectors, and tests of their environmental safety and efficacy. Recently, industry has shown a keen interest in these agents, and, if they are found to be economically viable, commercial formulations may become available in a few years.

Other categories of microbial agents, such as Microsporidia, Protozoa, fungi, and insect viruses (especially the nuclear polyhedrosis viruses) are less developed, primarily owing to the need for *in vivo* propagation in insects, though *in vitro* methods are being tested. A mermithid nematode, *Romanomermis culicivorax*, has been commercially produced and is available in quantity for field testing. Although highly effective against anophelines, it may present transport and storage problems in large-scale field operations.

The outlook for biological control agents is promising if they can be produced on an economic basis. A commercial formulation of spore-forming bacteria based on fermentation processes will soon be available for field trials. There is also a possibility that bioinsecticides based on these organisms can be produced on a "cottage industry" basis in developing countries—an important consideration as they are not all readily transportable over long distances.

(2) *Genetic control.* Genetic control of insect vectors is a recent development, and was not mentioned in the sixteenth report of the WHO Expert Committee on Malaria (9). The available genetic methods fall into two broad categories—those aiming at direct population suppression and those designed to substitute an innocuous population for the existing ones. However, of the many methods available in each category, only a few have reached the operational stage. Limited experience during recent years has shown that the success of any genetic system depends on a number of requirements, and demands a detailed knowledge of insect ecology (80–82). One major requirement is the mass production of mosquitos for genetic sexing techniques; in this connexion, efforts are being made with a number of anopheline species (83).

(3) *Source reduction and environmental management.* Techniques of source reduction and of elimination of potential breeding sites by drainage, or filling, deepening or flushing ditches; management of water level, changing the salt content of water, and intermittent irrigation are among the classical methods of malaria control to which attention is being paid again. Other forms of environmental

management such as zoophilic deviation, improvement of housing to render insecticides more effective, and reduction of man-vector contact by mosquito screening and impregnated mosquito nets and fumigant mosquito-coils are also being examined.

WHO is closely collaborating with the United Nations Environment Programme in carrying out investigations on environmental methods of malaria control and has, jointly with FAO, reviewed proposals for integrated control of insects of both agricultural and public health importance for consideration by UNEP (84).

5. PROGRAMME COORDINATION

5.1 Cooperation between countries

The Committee examined the several ways in which antimalaria programmes have, under the concept of technical cooperation among developing countries, been coordinated between countries. Its conclusions are summarized in the following paragraphs.

(1) *Training of personnel.* Training of all grades of personnel on an intercountry basis should be organized in different regional centres to avoid problems of language and in order that the training shall be, as far as possible, in an environment similar to that of the eventual place of work. Such training centres are operating in all regions except Africa, where the former Malaria Eradication Training Centres have been converted into Training Centres for Health Service Personnel over the years. There is an urgent need to re-establish these centres. In other regions these centres need to be expanded under the auspices of the local university or government. Alternatively WHO might support this activity.

(2) *Research.* Although information is being increasingly exchanged at bilateral meetings organized by countries themselves or by the WHO regional offices, the coordination of research between countries remains on the whole unsatisfactory. Intercountry coordination is particularly important in the development of field research, and WHO should play a major role in stimulating such coordination.

(3) *Technical services.* Countries should support each other in establishing central diagnostic facilities, particularly for complex and

expensive diagnostic methods such as serological diagnosis. Interchange of technical staff to review and advise on special activities, such as the installation of fish hatcheries, collaboration in the study of vector complexes, planning or establishing operations, exchanging research personnel, or retraining of local staff, should be encouraged by the Organization. The value of a WHO regional epidemiological surveillance team was particularly stressed by the Committee.

(4) *Exchange of experience and information.* Visits by technical staff to programmes in other countries are of considerable value. They may be arranged for individuals or for groups, who may be attending a workshop on a particular problem. It is important to establish coordination between programme directors, whose meetings may be initiated by the Organization.

(5) *Supplies and equipment.* A common form of cooperation between countries is mutual assistance in obtaining materials, especially antimalarial drugs and insecticides, as a donation or on loan. Inter-country assistance has been obtained in establishing the local manufacture of supplies, for example between regions—e.g., India is assisting Viet Nam in establishing a factory for the production of DDT. Collaboration in the production of chloroquine for implementing tactical variant No. 1 in the African Region is a notable example of this kind of cooperation.

However, there is a need for vigilance to protect Member States from receiving faulty equipment and supplies. While WHO maintains an efficient quality supervision of some items, such as insecticides (85-87), this could profitably be extended with respect to equipment (88, 89).

The Committee reviewed these arrangements, and agreed that inter-country cooperation should be promoted and supported to the greatest extent. It was suggested that WHO might develop a revolving fund to assist countries that are experiencing delays in receiving supplies ordered through national channels.

5.2 Coordination at regional and global levels

The adoption of the aim of health for all by the year 2000 has created a new urgency for malaria control programmes, which require much greater multisectoral and multidonor coordination. The Committee drew attention to the long experience of WHO in achieving joint international efforts in malaria programming and its unique position in continuing this essential activity.

The coordinating functions of WHO are seen as follows:

(1) *Programme planning.* This is a national responsibility for which WHO may provide external assistance on request.

(2) *Provision of technical, administrative, and programme guidelines.* Here, the complexity of the programme requires an interregional supervision at the WHO headquarters level. Guidelines should be adopted at regional and country levels.

(3) *Mobilization of multisectoral support for malaria programmes.* This involves the mobilization of agricultural, educational, commercial, and industrial efforts in support of malaria control programmes and should remain a national responsibility, while WHO has the responsibility for developing multisectoral support interregionally. This will require the cooperation of those agencies and organizations that are more directly engaged in socioeconomic programmes, such as the United Nations Development Programme, the World Bank and the Organization for Economic Cooperation and Development. Cooperation should also be sought from countries and organizations giving bilateral assistance.

(4) *Dissemination of information.* WHO has a major role to play in the dissemination of information on malaria in individual countries and geographical regions. This information may be supplied by Member States and the regional offices.

(5) *Programme promotion.* WHO must play an important role in promoting antimalaria activities; in this connexion, WHO should call on political decision-makers to support malaria control and eradication programmes.

(6) *Epidemiological surveillance.* The problems of intercountry migration and the spread of drug-resistant parasites place a major burden on the Organization at central and regional levels.

(7) *Technical cooperation.* The mobilization of appropriate expertise at the interregional and regional levels is a particular concern of the Organization, in addition to strengthening technical cooperation among countries. Bilateral donor agencies should also participate in this.

(8) *Multidonor resources.* In the light of the consultation on extra-budgetary resources, held in Geneva in 1978 (90), a major responsibility for donor resource coordination will continue to be undertaken by WHO. Global priorities of the Organization are thereby more efficiently presented to the donors. WHO's regional offices will have

more specific details of the requirements within the countries in their region. In certain regions, the Organization has played a particularly important role in serving as a broker on behalf of Member States. Ultimately, however, donor resource mobilization is the responsibility of national governments, which must negotiate for such resources on the basis of mutually acceptable plans of action. Apart from WHO, there are other major channels for the mobilization of multidonor resources for health—e.g., UNDP, the World Bank, OECD, and bilateral donors. While WHO is further studying alternatives for the effective mobilization of multidonor resources, the national malaria programme should participate actively in cooperative arrangements to elicit multidonor support.

(9) *Coordination of technical resources.* Subject to the approval of a requesting country, WHO has a major international role in mobilizing technical resources.

(10) *Training.* In the achievement of a malaria control strategy, training is of the utmost importance. Extensive reorientation may be required for the existing malaria personnel, at both national and international levels. Existing training curricula must be oriented towards more comprehensive approaches to control. The need for global reorientation places a responsibility on WHO to prepare training guidelines and to sponsor senior professional training. It would seem appropriate for the regional offices of WHO to sponsor regionally oriented training, taking into account the geographical characteristics of malaria epidemiology specific to the region.

The Committee noted that a common plan for training had not yet been developed in the regions.

(11) *Research.* In addition to the need for the active participation of WHO and Member States at regional and country levels, the coordination of malaria research and the monitoring of new technological development will require the most intense efforts by the Organization.

6. INTERNATIONAL SURVEILLANCE

6.1 Information requirements

WHO is responsible for the collection, tabulation, analysis, and distribution of information on malaria. Surveillance data are collected for the following purposes:

(1) to acquaint national health authorities with the distribution, prevalence, and incidence of malaria, and to provide information on the susceptibility of malaria vectors to insecticides and the sensitivity of the parasite to drugs;

(2) to inform national health services, private practitioners, travel agencies, and other interested bodies about malarious areas so that international travellers can be informed of the risk and of the necessary preventive measures to be followed; and

(3) to enable epidemiologists to measure the risk of importation of malaria cases into malaria-free areas so that the necessary preventive action can be taken in time.

In 1969 the Twenty-second World Health Assembly, in resolution WHA22.48, stressed the fundamental importance of determining the appropriate vigilance measures to be applied and recommended that national health administrations notify the Organization twice a year of the malaria situation in their countries. It requested the Director-General to publish this information twice a year and to publish a map once a year showing areas where there was a risk of infection (91).

In its sixteenth report the WHO Expert Committee on Malaria (9) reviewed WHO's publications on the epidemiological status of malaria, and suggested a format to be used for tabulating the information for publication in the *Weekly Epidemiological Record*, taking into account the needs and requirements of the users. The purpose of this publication is to disseminate information pertaining to international epidemiological surveillance, and it does so in respect of malaria in two regular features entitled "Information on the world malaria situation" and "Information on malaria risk for international travellers". Unforeseen happenings such as epidemic outbreaks and other relevant information are also published in the *Weekly Epidemiological Record*. "Information on malaria risk for international travellers" is based on the reports made available to WHO by governments. The aim of this feature is to assist travel agencies, airlines, tourist information offices, and official and private organizations dealing with international travel, as well as physicians, by providing the fullest possible information on (a) areas where there is a risk, however remote, of contracting malaria, (b) the best methods of protecting individual travellers and groups against that risk, and (c) the steps to be taken if travellers do develop symptoms of a febrile disease after returning home.

The great increase in the occurrence of malaria in tourists and visitors returning to malaria-free areas from endemic areas, particularly in Asia and Africa, was noted by the Committee with some concern. While it was considered mandatory for tourist agencies and other organizations connected with international travel to warn tourists of the potential risks and the necessary precautions, the Committee felt that any legislation to protect the traveller would be difficult to implement and might be prejudicial to the tourist trade that is so vital to some countries. The Committee suggested that governments should nevertheless provide the necessary information and guidance through the distribution of pamphlets and posters to travellers and tourist agencies. Similar information might also be distributed by the International Civil Aviation Organization and by national civil aviation authorities.

6.2 Collection and presentation of data

The Committee noted that the flow of information on antimalaria activities from individual countries to WHO headquarters had diminished considerably since the introduction of the WHO internal reporting system, with the result that the information available at headquarters was not sufficient to provide a precise picture of the malaria situation in many countries. In order to allow the Secretariat to fulfil its mandatory duty in response to resolution WHA31.45 of the Thirty-first World Health Assembly (3), it is of the utmost importance to establish a reliable malaria information service, permitting a rational planning of efforts towards promotion and coordination of a new drive against malaria.

The Committee considered the presentation of the malaria surveillance data appearing in the *Weekly Epidemiological Record* under the title "Information on the world malaria situation". The information contained in this feature is collated by the staff at headquarters from returns sent in, in tabular form, by the regional offices, which obtain it from Member States in the region.

In keeping with the revised strategy of malaria control, the reports on the malaria situation in various countries should reflect the change in the purpose of surveillance, from providing data useful to an eradication programme to communicating the type of information that will enable the epidemiologist to advise his government on the local malaria risk and will tell physicians and travellers of the risk involved in visiting other countries.

The Committee therefore agreed that:

- (1) the initial narrative portion of the report might usefully be expanded;
- (2) the main table of the report should be simplified, and it should also be modified to bring it into line with the tactical variants of malaria control described earlier; and
- (3) the malarious areas listed in this table should be better defined and should be the same as those mentioned in the feature "Information on malaria risk for international travellers".

6.3 Dissemination of information

Although dissemination of information concerning malaria risk to the travelling public is a difficult operation, the Committee felt that the information contained in the WHO publications mentioned in sections 6.1 and 6.2 needed to be popularized through the use of audiovisual publicity techniques such as posters; advice written on tickets, in vaccination booklets, on warning cards, in holiday brochures, and in leaflets in aircraft, buses, and ships; and film strips, slides, or recorded messages at airports and railway stations.

The responsibility for adopting these methods remains with governments. All agencies or commercial and educational institutions involved in contact with travellers also bear much responsibility. The Committee recommended that WHO set up an *ad hoc* group to examine the question of finding better ways of disseminating the information on the subject.

7. REVIEW OF AREAS FOR REGISTRATION OF MALARIA ERADICATION

The Committee considered a request from the Government of France to register the island of Réunion, an overseas department of France, as an area from which malaria has been eradicated.

On the basis of a careful examination of the relevant documentation presented, the Committee concluded that:

- (1) despite careful search during the past nine years and despite the fact that primaquine (a drug employed generally for the

prevention of relapsing malaria) has not been used by the population, there has been no evidence of transmission or of residual endemicity on the island;

(2) there is evidence of adequacy of the vigilance mechanism, and the health services provide ample diagnostic facilities and are in a position to carry out therapeutic and other remedial and preventive measures, if and when necessary;

(3) there are provisions for action against the re-establishment of malaria;

(4) in view of the above, there is every probability that the eradication of malaria on the island of Réunion can be maintained.

The Committee therefore decided to recommend to the Director-General of WHO the inclusion of Réunion in the WHO official register of areas where malaria eradication has been achieved.

8. FOURTEENTH AWARD OF THE DARLING MEDAL AND PRIZE

The Expert Committee examined the various nominations submitted for the award in conformity with Article 5 of the regulations concerned.

Having discussed in private session the relative merits of the candidates nominated, the Committee, in conformity with Article 7, sent its recommendations by letter to the Secretary of the Darling Foundation Committee, the Director-General of WHO.

9. RECOMMENDATIONS

9.1 Approach to malaria control

The WHO Expert Committee on Malaria,

Taking note of the Alma-Ata Declaration, which aims at providing primary health care for all,

Recognizing that this declaration represents a major step forward in achieving international consensus on health for all by the year 2000,

RECOMMENDS that, within the context of primary health care, malaria control be given a high priority, wherever it represents a health problem.

9.2 Planning of control programmes

The WHO Expert Committee on Malaria,

Recognizing the need for each malarious country to have a multi-sectoral malaria advisory body, comprising representatives of various governmental and nongovernmental departments and institutions involved directly or indirectly in malaria control activities, as defined in the sixteenth report of the Expert Committee on Malaria,

RECOMMENDS that WHO urge the responsible authorities to institute such bodies and involve them in all activities related to planning, implementation, and evaluation of malaria control in the countries concerned.

9.3 Review of basic determinants

The WHO Expert Committee on Malaria,

Noting that the definition of basic determinants for planning, implementation, and evaluation of malaria control programmes has not been clearly presented or appreciated in some countries where malaria is a serious public health problem,

Recognizing that there is a great need for comprehensive and practical manuals on planning, implementation, and evaluation of malaria control programmes,

RECOMMENDS that WHO take the necessary action for the preparation and wide dissemination of such documents.

9.4 Outbreaks of malaria during eradication or control campaigns

The WHO Expert Committee on Malaria,

Considering that malaria and other mosquito-borne diseases have now become a serious problem in the urban areas of many countries in the tropics,

Recognizing that many mosquito breeding sites can be dealt with by engineering methods,

Realizing that much of the previous awareness of the relationship between malaria and construction works has been lost,

Noting with appreciation that a manual on engineering methods for mosquito control, with special emphasis on malaria, is under preparation,

RECOMMENDS

(a) that action be taken to accelerate finalization of this manual as well as its translation and distribution;

(b) that courses on the subject of "man-made malaria" for engineers and senior construction workers be given in the countries concerned.

9.5 Programme implementation

The WHO Expert Committee on Malaria,

Recognizing the responsibility of each government to determine the objectives of its own antimalaria programme,

Realizing the need for technical criteria to evaluate the progress in malaria control programmes in relation to the tactical variants adopted,

RECOMMENDS that WHO prepare a comprehensive document on programme implementation, based on the views of countries concerned, for guidance of those responsible for malaria control programmes.

9.6 Role and place of malaria services, general health services, and the community

The WHO Expert Committee on Malaria,

Noting the trend towards the structural and functional integration of health services as a first step towards the delivery of primary health care,

Recognizing the practical difficulties that are being faced in some countries in the delivery of malaria programmes through integrated health services,

RECOMMENDS that WHO evaluate the experiences gained in various countries on the integration of malaria control within basic health services and make this information available to Member countries.

9.7 Control of epidemics

The WHO Expert Committee on Malaria,

Recognizing that *P. falciparum* malaria remains a serious threat to populations in many areas,

Noting that this species of the malaria parasite responds easily to appropriate control measures, especially in countries outside tropical Africa,

Noting that considerable progress has been achieved in the eradication of this species from many parts of the world,

RECOMMENDS

(a) that WHO draw the attention of countries in which the resurgence of *P. falciparum* malaria (and especially its drug-resistant strains) has created a serious situation to the need to counter this growing danger;

(b) that Member States make greater efforts to contain and eradicate *P. falciparum* malaria as an important part of the control programme.

9.8 Training in malaria control

The WHO Expert Committee on Malaria,

Noting that there is an acute shortage of experienced staff for stimulation and promotion of relevant training activities in malaria control at national, regional, and international levels,

Recognizing that the planning and implementation of these training activities must be directly related to the needs of the control programmes of the countries concerned,

RECOMMENDS

(a) that task-oriented educational objectives be formulated for the training of different categories of health personnel and community workers;

(b) that WHO, in cooperation with Member States and multi-lateral and bilateral agencies, undertake an assessment of needs on a regional basis and prepare region-specific proposals for meeting the training needs over the next five years;

(c) that WHO continue to cooperate in the development of training institutions and programmes and the provision of teaching aids and manuals for training in malaria control;

(d) that in malaria-free countries training be oriented towards preventing the introduction or reintroduction of malaria and towards effectively coping with imported malaria, by including malaria in the curricula of medical schools, public health schools, schools of biological sciences, schools for allied health personnel, and postgraduate programmes.

9.9 Antimosquito measures

The WHO Expert Committee on Malaria,

Recognizing that insecticide resistance constitutes the major threat to malaria control and realizing that the prospects of finding new classes of insecticides for malaria control are less promising than they previously appeared to be,

RECOMMENDS

(a) that Member States pursue efforts to encourage scientific institutions and industry in the search for, and the development of, new types of chemical insecticides;

(b) that action be intensified at the international and national levels for ensuring the best possible operational use of available insecticides and that cooperation be strengthened between plant protection and public health services for that purpose;

(c) that insecticide resistance development continue to be monitored and special attention be given to the development of guidelines on the use of insecticides in areas with incipient resistance, and that measures be devised to counter this problem;

(d) that WHO promote intensified studies on the stability of insecticide formulations during their shipment and storage;

(e) that WHO accelerate the preparation of guidelines for the safe use of insecticides in malaria control programmes and periodically update them thereafter and that those responsible for applying insecticide adhere carefully to the guidelines.

9.10 Cooperation between countries

The WHO Expert Committee on Malaria,

Aware of the present difficulties in obtaining adequate funds from international sources for the support of national malaria control programmes in developing countries,

Recognizing that the present uncertainty of resources interferes with the implementation of malaria control programmes in countries where malaria is a major obstacle to socioeconomic development,

RECOMMENDS

(a) that WHO give every consideration to developing and pursuing a more dynamic approach in sensitizing international and bilateral assistance agencies to the need for extending substantial aid for implementing the global malaria strategy;

(b) that international and bilateral agencies give the highest priority to obtaining chloroquine for countries in tropical Africa for the reduction of malaria mortality and to promoting the development of facilities for manufacturing the drug in Africa.

9.11 Coordination at regional and global levels

The WHO Expert Committee on Malaria,

Reaffirming the emphasis given at previous meetings of the Expert Committee since 1958 to technical, operational, and administrative coordination,

Recognizing the new urgency expressed by WHO Member States to improve health for all by the year 2000 and recognizing also the great financial and intersectoral collaboration required to attain such a global objective,

Noting that the resource requirements for the extension of malaria programmes will demand a great deal of external cooperation,

RECOMMENDS

(a) that WHO stimulate the development of multidonor and intersectoral coordination and cooperation mechanisms, on which the global control of malaria will largely depend;

(b) that WHO encourage countries in which there is a risk of malaria to incorporate the planning of antimalaria activities into their health programming within the overall national development plans.

9.12 International surveillance

The WHO Expert Committee on Malaria,

Recognizing the important role of WHO in rapidly collecting

information on the world malaria situation and in disseminating it to all concerned, and particularly to donor countries cooperating with the WHO Malaria Action Programme,

Emphasizing the value of this information for the countries concerned and its usefulness to the international traveller, travel agencies, and airline companies,

Having reviewed the type of documentation at present included in the WHO *Weekly Epidemiological Record* and having agreed with the proposed changes in format,

RECOMMENDS

(a) that WHO improve and further develop the reporting system needed for the implementation of malaria control;

(b) that WHO activate the flow of required data from the countries concerned and continue the publication of this information according to the agreed format in the *Weekly Epidemiological Record*.

9.13 Information requirements

The WHO Expert Committee on Malaria,

Noting the recent rapid increase in the number of cases of imported malaria in several countries from which indigenous malaria had been eradicated,

Recognizing the value of country statistical reports, but

Realizing that reports prepared by certain countries are inadequate, often because malaria is not a notifiable disease or because the notification of malaria cases is neglected,

RECOMMENDS

(a) that WHO stimulate the countries in temperate areas, where imported malaria shows an increasing trend, to introduce or enforce regulations making malaria a notifiable disease and to continue to report the relevant data to WHO;

(b) that WHO encourage the health authorities of these countries to provide accurate and timely information in the form of circulars, pamphlets, and posters warning tourists and tourist agencies of the potential risk.

9.14 Research in malaria

The WHO Expert Committee on Malaria,

Recognizing that the general principles of malaria control are

based on the use of all available methods against the malaria parasite and its mosquito vector as well as on the biological and social response of the human host,

Noting that some of the technical methods previously in wide use have lost a degree of effectiveness owing to the resistance of malaria parasites to drugs and the *Anopheles* vectors to insecticides,

Believing that intensive scientific research on and development of new and improved means of prevention and control of malaria is imperative if the resurgence of malaria is to be contained,

STRONGLY RECOMMENDS

(a) that WHO continue to encourage and support the global effort in basic and applied research with particular attention to insecticides, drugs, environmental methods, and immunological techniques;

(b) that WHO stimulate the study of the socioeconomic effects of malaria and the benefits of its control;

(c) that WHO promote, with a high degree of priority, field research on all aspects of malaria control in developing countries, with the full recognition of the role played by the national scientific organizations;

(d) that WHO support the research and training of nationals in developing countries;

(e) that WHO widely disseminate research information.

9.15 Registration of areas where malaria has been eradicated

The WHO Expert Committee on Malaria,

Having considered the documentation submitted to it in support of a request from a government for registration of an area where malaria has been eradicated,

Noting the recommendations made by the WHO Regional Director concerned and the Director of the Malaria Action Programme,

RECOMMENDS that the name of the French Department of Réunion be entered in the WHO official register of areas where malaria eradication has been achieved.

9.16 Award of the Darling Medal and Prize

The WHO Expert Committee on Malaria,

Having considered the nominations submitted as stipulated in the

Regulations of the Darling Foundation for the Award of the Darling Medal and Prize,

RECOMMENDS that its report on the selection of candidates be submitted by the Director-General of WHO to the Darling Foundation Committee during the next session of the Executive Board.

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