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THE APPLICATION OF INTEGRATED METHODS OF MALARIA CONTROL[1]

1. INTRODUCTION

By malaria control is meant the activities to be implemented to attain fixed objectives under the prevailing local conditions. For this reason, no stereotyped strategy can be described, as the methods to be used must be formulated for each area and will depend on health priorities, technical factors, available resources, as well as on the type of health planning either existing or under consideration.[2]

Account has also to be taken of certain country characteristics, such as: (i) importance of illness due to communicable diseases; (ii) infant and child mortality rates; (iii) expectation of life; (iv) value of the communications system; (v) gross national product and *per capita* expenditure on health; (vi) distribution of population in urban and rural areas; and (vii) amount of qualified manpower and prospects for improvement.

Before selection of the methods to be used preliminary feasibility studies should be carried out to assess their practicability and to define the budgetary allocation for malaria control, the areas to be covered, and the epidemiological target. Once these are known, the malaria specialist will be in a position to offer the best advice, taking into consideration the efficacy and cost/effectiveness of each individual measure and keeping in mind that yearly costs related to material, supplies and equipment, application and evaluation of the measures, and maintenance of the improvement achieved, should be borne for a long period of time.

Countries may, at first, have to restrict their choice of antimalaria measures to a single method of control. However, at a later stage, a combination of methods should be the aim. In view of the variations in local vector bionomics, population ecology and behaviour, as well as the quality and the coverage of any one measure, the use of combined methods offers some insurance against the decrease in efficiency of any measure applied singly and will ensure better overall results.

In fields of national interest, of which health is one, any approach towards the solution of a given problem, proceeds through three stages: (a) political statement of intention; (b) selection of methods according to planned objectives and feasibility factors; and (c) decision on the basis of financial considerations and allotment of funds.

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[1] Dr J.H. Pull and Dr A. Noguer, Division of Malaria and other Parasitic Diseases, WHO, Geneva

[2] For example: (i) inductive planning in which existing services are improved in order to make them more easily available and efficient; and (ii) deductive planning in which objectives, policies and targets are determined and detailed actions carried out, through well-defined administrative and operational channels.

It is not intended to review in toto this procedure, but merely to list the main health targets which could be chosen, and to suggest approaches for the selection of methods of general use.

2. HEALTH TARGETS

According to present strategy, the ultimate objective of antimalaria activities remains the eradication of the disease. Eradication of malaria is therefore a long-term objective for most of the malarious countries, in view of technical, social, cultural, financial and operational constraints. In spite of these constraints, the possibility of action exists in all countries. However, as there are no miraculous technical solutions or any prospects of such solutions being found in the foreseeable future one should propose realistic targets which could be achieved and maintained by countries with their own resources, in terms of funds, expertise and manpower.

Regarding malaria control, four broad targets could be considered, namely:

(i) reduction of specific mortality;
(ii) reduction of specific mortality and morbidity;
(iii) reduction of specific mortality and morbidity, and of malaria prevalence;
(iv) elimination of the disease.

3. APPROACHES FOR THE SELECTION OF METHODS TO BE APPLIED IN A COMMUNITY

Broadly speaking, one could say that the constitution and dynamics of malaria in a population is related to the force of infection h which is a function of four main factors, namely:

(i) the density m of the vector(s);
(ii) the daily survival rate of the vector(s) p;
(iii) the average feeding frequency of the vector on man a;
(iv) the level of parasitaemia x (and of gametocytaemia g, which is a fraction of x).

The relationship of these factors can be expressed mathematically. For instance the force of infection h could be expressed by the equation:

$$h = \frac{ma^2 p^n xg}{axg - \log_e p} \qquad \text{(Equation 1)}$$

where a is the biting frequency of the vector on man. Such mathematical expression indicates that changes in any one of the factors will produce predictable modifications of the force of infection. For example, any reduction of the vector(s) densities m to below the saturation level, will cause a comparable reduction of h; the reduction of the parasite reservoir x will also produce a diminuation of a more or less similar amplitude. On the other hand, if one considers the equation (1) it is easily understood that a modification of the daily survival rate p will cause a much more important change in the force of infection, because the factor p is raised to the power n, with n being the duration of the sporogonic cycle (in general eight to fifteen days according to parasite species and temperature). A marked reduction will also be obtained by any diminuation of the value of a (a is raised to the power two in the equation 1).

It is possible to give examples of expected results according to variations in the value of the parametres; their selected value (unless stated otherwise in the example) is given below:

m = 30, a = 0.33, p = 0.90, n = 14, g = 0.30, x = 0.50.

Examples:

No. 1	If p → 0.90 → 0.70 (22% reduction)	thus: h →	1% of original value 99% reduction
No. 2	If a → 0.33 → 0.257 (22% reduction)	thus: h →	65% of original value 35% reduction
No. 2	If m → 30 → 23.4 (22% reduction)	thus: h →	78% of original value 22% reduction
No. 4	If x → 0.50 → 0.39 (22% reduction)	thus: h →	84% of original value 16% reduction

In reviewing the list of measures[3], including those applicable in a community, it is possible to identify those which would produce an effect on each individual factor, and to measure the impact on the force of infection. For example: (i) the density of the vector m is affected by antilarval measures lato sensu, and/or by insecticidal repetitive spraying; (ii) the daily survival rate of the vector p is affected by residual indoor insecticide spraying; (iii) the feeding frequency on man a is affected by use of mosquito nets, repellents, screening or any other direct protection of man against the bites of mosquitos; and (iv) the level of parasitaemia xg is affected by drugs.

One could therefore conclude that, where the vector is responsive to residual insecticide spraying, this measure should be the method of choice. It is for this reason that residual insecticide spraying was the usual weapon of attack in malaria eradication programmes. For control purposes, however, wide use of this tool should only be recommended with caution in view of its selection pressure on the anopheline population, particularly when it is also employed in agriculture. Consequently, whenever the decision is taken to use a particular insecticide in health programmes, it is indicated to forbid the concurrent utilization of this product (or of related groups) for pest control in agriculture. Alternate use of insecticides of different chemical groups should be explored as this might delay or even prevent early development of vector resistance to current insecticides.

The reduction of the value of a (feeding frequency of the vector on man), will also induce a marked diminution of the force of the infection. However, it is only possible to carry out specific measures (screening of houses, bed nets, etc.) in well organized and motivated communities.

The administration of antimalarial drugs (chemotherapy, chemoprophylaxis) has a place in malaria control, and often, the only practical action is to make drugs widely available, in order to prevent mortality, reduce morbidity and protect the most vulnerable groups of the population. Only schizonticides should be used for clinical cure and prophylaxis, because other types of drugs are neither indicated nor recommended for the radical cure of patients who live in areas where high-level transmission is taking place and who therefore continue to be exposed to the risk of reinoculation of the parasite. Administration of drugs to sick people and to vulnerable

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3 Wld Hlth Org. techn. Rep. Ser., 1971, No. 467, p. 41-48

groups must rely heavily on community participation, and therefore health education of all levels of the community must play a decisive role. Health education efforts have often failed, when they were expected to change the attitude of the population in a short time, without promoting their motivation. Success in this field has been obtained in Senegal, Cameroon and Tanzania. Mass drug distribution is not in general indicated as the main weapon of malaria control for past experience has shown that it is eventually rejected by the population. It is only indicated in the case of malaria outbreaks.

Regarding the reduction of malaria prevalence, a basic problem is the determination of levels of malaria that may be tolerated, in the presence of other important health problems. Generally speaking it is not ethically acceptable to decide which are the levels of malaria tolerable for the population. In practice, however, such levels must be determined to allow the malaria specialist to give, to the best of his knowledge, the relevant advice for attaining the fixed targets.

In the light of the above considerations, it can be seen that each individual control measure has an action on the force of infection h through the modification of the value of one or more of its parameters. The type of measures and the factors liable to change, following the application of these measures, are summarized in Table 1.

TABLE 1 : RELATIONSHIP BETWEEN APPLICATION OF MEASURES AND CHANGES IN THE FACTORS OF THE FORCE OF INFECTION

Type of measures applicable in a community	Factors of the force of infection liable to change according to measures applied
Measures designed to prevent mosquitos from feeding on man (screening of houses and site selection)	a (feeding frequency of the mosquito(s) on man)
Measures designed against adult mosquitos (residual spraying)	p (daily survival rate) and indirectly m (vector density)
Measures designed against larvae (larviciding) or aimed at reducing breeding sites (water management, filling, drainage, etc.)	m (vector density)
Measures against plasmodia (drugs)	gx (parasitaemia)

Indications on the use of these methods according to circumstances have already been outlined. However, it must be realized that each measure applied singly has its limitations depending on the ecology of man and of the vectors and on other local constraints, which frequently prevent the correct application of the measure(s). In defining the objectives of a malaria control and/or eradication programme, it is necessary to determine to what degree the value of h must be reduced. In an eradication programme, h should be reduced to zero, whereas in a malaria control programme, it should be reduced to a value consistent with the expected level of control which expressed in terms of parasite prevalence, L_x in the 2-9 year age-group is:

$$L_x \text{ (limiting value of prevalence)} = \frac{h}{h+r} \qquad \text{(Equation 2)}$$

where r is the daily recovery rate of infection. In order to attain prevalence levels below 10%, for instance, h should be $\leq$ 0.0005, if we assume that r has a constant value of 0.005 in the 2-9 year age-group. It is therefore necessary to test, in the field, the impact of each separate measure on the parameters of infections and to determine the combination of measures which would produce the desired results, expressed in terms of the residual force of infection and taking into account feasibility factors (e.g. resources, manpower, acceptability, practicability, etc.) and cost.

Any selection of methods should therefore be guided by a knowledge of the local epidemiology of malaria; the more detailed this knowledge, the more effective the measures are expected to be. This was already recognized in the early days of malariology in view of the great variability of epidemiological conditions; it is also realized that the acquisition of detailed information on local situations, requires considerable effort, expense, and highly technical human resources. Consequently the extension of malaria control activities throughout the world will require a tremendous global effort with regard to training and field practice.

Following the de facto reversion to control, all available methods should be considered and whenever applicable, used. Moreover wherever malaria control is carried out by attack against the vector(s), then a comprehensive control of all vectors of other human diseases in the area is to be recommended whenever technically and operationally feasible. In the rural areas, this requires a deep penetration of the area by the health services and an efficient administrative structure which is often non-existant. In urban areas the prerequisites for such a comprehensive vector control programme can generally be met.

Antilarval measures, together with classical methods of source reduction, deserve to be considered for application in areas of high population density. In addition, the municipalities and responsible authorities of development projects should be encouraged to apply these methods not only for the control of malaria and of other vector-borne diseases, but also for their own economic advantage ("bonifica integrale").

A sizeable portion of the resources made available for malaria control should be devoted, whenever practicable, to the improvement of the human environment by implementing permanent measures of source reduction; this is particularly true in urban areas and development projects with high population densities. This approach will lead progressively to the permanent reduction of receptivity of the areas to malaria, will contribute to the decrease of malaria endemicity levels and, in some circumstances, might even succeed in eliminating the disease.

Aerial application of insecticides in ultra-low volume (ULV) formulations has two indications:

(i) for epidemic control, both in towns and rural areas;
(ii) for malaria control in towns as a complementary measure to antilarval operations and methods of source reduction.

In addition to availability of drugs, indoor application of residual insecticides is the only other method that has a similarly wide applicability in the majority of rural areas. As stated above, caution is advised regarding its use.

The use of larvivorous fish is attracting attention, although its real value as a method of malaria control in highly endemic areas remains to be determined.

CONCLUSIONS

Progress towards wider and sounder malaria control implies considerable changes in approach, using available methods and resources. The planning and operation of malaria control programmes, and especially of those aiming at prevalence reduction, require a more detailed knowledge of the epidemiology than is generally available at present, and therefore a stronger cadre of professional and technical personnel. As stated by a former Director of the Division of Malaria, it is time to give very high priority to the training and re-training of professional staff, so that the emphasis returns to the scientific study of the biodynamics of malaria, from the managerial ability looked for, almost exclusively, in the training of staff for eradication programmes (Alvarado, 1972)[4].

Training courses have been established in Teheran and in Mexico for a masters degree in public health with specialization in malaria and other parasitic diseases; indeed, the operation of malaria control programmes aiming at the reduction of malaria prevalence requires personnel of such a high calibre that these may be difficult to obtain.

The available methods, together with broad indications regarding their use, have been briefly discussed in the above section. However, the final selection of methods must take into account the particular local situation and should be the result of ad hoc epidemiological and operational field studies. Thus, personnel should also be trained in devising and implementing field research studies.

No mention has yet been made here of the operational set-up responsible for the actual application of malaria control activities. Obviously, regarding prevention of mortality and reduction of morbidity, due to malaria, health services and medical practitioners should be deeply involved in diagnosis and treatment; however, in developing countries these medical facilities are in general lacking in rural areas, where the disease is most prevalent. The distribution of drugs to the sick or even to vulnerable groups should be the responsibility of the community itself, under the overall guidance of administrative and health services.

Regarding the set-up needed for the application of more sophisticated control measures, positions have been taken in favour of the integration of malaria control activities into health services as opposed to others in favour of vertical malaria control services; still no consensus on this point has been reached. It is felt that this is a false problem. In the first place, the personnel charged with malaria activities should, by statute, belong to the health services; and secondly, the degree of polyvalency of this personnel will depend on a number of factors, among which it is possible to list:

(a) original level of malaria endemicity;
(b) targets to be met;
(c) intended coverage of control operations;
(d) malaria control programme versus comprehensive control of vector-borne diseases;
(e) coverage by health services and structure, quality and number of personnel, particularly of the supervisory category;
(f) evaluation of the results;
(g) decision regarding future planning of health component of the country (country health planning/country health programme).

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[4] Alvarado, C. (1972) Some remarks about the spirit of the Inter-American Malaria Research Symposium, Amer.J. trop. Med. Hyg., 21, 839-840