WORLD HEALTH ORGANIZATION

ORGANISATION MONDIALE DE LA SANTE

INF.CONS./WP/85.0
ENGLISH ONLY

INFORMAL CONSULTATION ON STRATIFICATION
FOR PLANNING ANTIMALARIA ACTION

Moscow, USSR, 3-7 June 1985

REPORT OF THE INFORMAL CONSULTATION ON STRATIFICATION FOR PLANNING ANTIMALARIA ACTION

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Introduction

The meeting was opened at 10.00 hrs on Monday 3 June 1985 in the Hotel Belgrad, Moscow, by Dr O.F. Bogatyrev, on behalf of the Ministry of Public Health of the USSR. Dr Bogatyrev welcomed the participants to Moscow and wished them every success in their deliberations.

Professor F.F. Soprunov, Director, Martsinovsky Institute of Tropical Medicine and Medical Parasitology, Moscow, welcomed the participants in the name of the Institute. In his opening address, Professor Soprunov was grateful that the Consultation was taking place in the USSR where the research methodologies on malaria stratification and its practical use has been carried out for a long time and said that the advantage of an informal consultation was that it allowed for free discussion on this important and complex subject. He hoped that the Consultation would be fruitful.

Dr J.A. Najera-Morrondo, Director, Malaria Action Programme, World Health Organization, Geneva, welcomed everybody to the meeting on behalf of the Director-General of the World Health Organization and thanked the authorities of the Soviet Union and especially the Martsinovsky Institute for offering the facilities and opportunity to carry out the work in Moscow. Dr Najera, in his opening address, pointed out that the very name of malaria indicated the recognition from the very beginning that this was a disease of ecological origin. He went on to state that after the availability of the insecticide DDT, a single strategy was adopted, which, if applied properly brought some success. However, one of the main lessons learnt from the attempts at eradication of this disease was the recognition of its local variability not only in the intensity of the problem but in its response to control interventions, and the unexpected diversity and multicausality of this variability. The concept of primary health care opens new opportunities for planning malaria control at the same time requiring new approaches to planning and replanning malaria as a focal problem. It is hoped that this Consultation will contribute significantly to achieving this. Dr V.S. Orlov and Dr J.A. Najera were elected Joint Chairmen and Dr R. Fontaine and Dr A.V. Kondrashin were elected Rapporteurs.

The agenda for the Consultation is attached in Annex 1, and the list of participants in Annex 2. A total of thirteen working papers, listed in Annex 3, were considered by the participants and used as a basis for their deliberations.

1. The conceptualization of stratification and its practical implications

1.1 The concept of stratification

Malaria is a complex disease. Multiple anopheline vectors whose ecology varies profoundly transmit parasites whose biology is far from simple, to a host whose genetic, social and cultural diversities surpass those of the parasite and the vector. This system in turn operates and is further modified by the non-uniformity of the earth and its climate. In response man has devised numerous measures to forestall the perpetuation of this parasite at every point in its cycle. Thus, we have added another layer of complexity in our management of the malaria problem. Recently there has been an attempt to bypass the compexity of using a principal measure conceived to overwhelm the transmission cycle. Furthermore, security was enhanced by covering all areas where malaria might be transmitted. But the response was variable from the beginning. Now we still face a malaria problem of evolving complexity to which rationally planned control activities must be addressed.

Reduction of the complexity can be accomplished by stratification. With the uneven distribution of the various phenomena over the earth and the search for the regularities underlying this unevenness, stratification was and continues to be employed in many branches of science and by many countries, and is applied to very diverse objects. Accordingly, there exist various kinds of stratification, differing from one another in content; these include physiographical, biogeographical, economico-geographical, medicogeographical, etc.

1.2 The definition of stratification

Definitions differ but the substance is universal: to reduce and simplify a complex problem to facilitate its understanding and formulate solutions. Generally defined stratification is the process of uniting areas, populations or situations, which exhibit a relative resemblance by a set of specified relevant characteristics, thereby distinguishing them from other areas, populations or situations dissimilar through the same set of characteristics.

Stratification includes the information, methodology and the end result. It is above all a dynamic process, accommodating to expected and unexpected changes, and subject to periodic revisions.

1.3 The practical implications of stratification

The applied value of stratification is determined by the following five major factors:

- the extent to which the stratification is actually needed;
- the level of accumulated knowledge on the object (i.e. the malaria problem);
- the adequacy of the concepts and methods used for stratification to the state of scientific knowledge;
- the adequacy of stratification objectives to the practical needs; and
- the opportunity for reassessment of stratification results.

The most powerful impetus for a useful stratification is an acute need for it, so acute that practical solutions cannot be met by other means.

Stratification could be performed for any disease as an intellectual interest for solving control problems. With vaccines, preventable disease control can be entirely effective without clarifying the problem through stratification. For some of these diseases, a simple social stratification has been helpful. Furthermore, the distribution of diseases transmitted from person to person exhibits primarily heterogeneity in terms of the human population and will usually not manifest a geographical focalization. Malaria and many other vector-borne diseases are at the opposite extreme. They are not often controllable by a single measure and by their nature they tend to be localized. Indeed, these and other characteristics of malaria indicate the extreme importance and utility of stratification of a malaria problem.

While stratification of other diseases was attempted by individual workers on an occasional basis, the work on stratification of various territories and the entire distribution area of malaria has a long history.

An attempt to relate malaria to particular types of climatic and topographical conditions has been made long before its causative organisms and mode of transmission became known. Even the name of the disease reflects this relationship. Hippocrates, Porcius Cato, Varro, Columella, Aretaeus and many other Greek and Roman physicians, and non-medicals have related the abundance of the disease to low, moist and hot districts and more particularly to those with a swampy terrain. Some of them went even further by providing advice on how to avoid and reduce the risk of acquiring the disease or even advocating drainage as a control measure. Studies on the relationship between malaria occurrence and various climatic and physiographical features have received additional impetus after the discoveries of Laveran and Ross.[1]

While earlier work was aimed at revealing certain regularities in transmission patterns with no reference to controlling malaria (Celli, 1900; Gill, 1938; Klug, 1941), attempts at malariological stratification beginning in 1947 have supported the target of controlling the disease (Beklemishev, 1947; Gabaldon, 1949; Singh, 1952).

The nationwide malaria control campaigns launched during the early 1950s aroused interest in stratification in a number of countries (Brazil, Kenya, Sri Lanka, United Republic of Tanzania, United Kingdom, USSR, and Venezuela) and led to a number of major studies (Lysenko et al., 1956, 1965; Bustamente, 1956; Atlas of Tanganyika, 1956; Macdonald, 1957; Atlas of Kenya, 1959; Karunaratne, 1959; N.K. Shipitsina, 1964). This period ended with a study on malaria distribution and stratification over the entire global area (Lysenko and Semashko, 1968).

The first and the last studies cited above (Celli, 1900; Lysenko and Semashko, 1968) both dealt with the distribution of malaria from the global perspective. Celli's work, however, was undertaken when no means of effective malaria control was available, whereas the latter workers performed stratification of the world malaria situation when the disease was thought to be defeatable.

Till very recently, the rare malariological stratification studies (Bakradze, 1974; EURO, 1979; Alekseyeva, 1982) were mainly concerned with a possible re-establishment of malaria in areas previously freed of this disease and do not deal with stratification of the present-day distribution of malaria.

It is hoped that the present consultations will represent a significant step towards solving this problem.

Malariological stratification at different levels (the world as a whole, the continents, the whole or part of a country) has been performed on the basis of different principles. Generally, two main principles could be distinguished. One of them was stratification based on characteristics not directly related to malaria as such, while the malariological characteristic was associated with already existing natural zones (climatic - Celli, 1900; Gill, 1938; Gabaldon, 1949; Bustamente, 1956; Karunaratne, 1959; or zoogeographical - Macdonald, 1957) or natural districts (landscapes - Klug, 1941). The second principle implied establishing the borderlines between strata according to malaria-related characteristics, taking into account differences in the season of transmission (Atlas of Tanganyika, 1956; Atlas of Kenya, 1959), number of parasite turnovers (Shipitsina, 1964), association of foci with certain landscapes (Lysenko et al., 1956, 1965), incidence/prevalence, endemicity level (Singh, 1952; Lysenko and Semashko, 1968) and risk of incidence (Lysenko and Semashko, 1968).

It can be seen from the above that throughout the history of antimalaria campaigns scientists from many countries were using various approaches in an attempt to stratify malarious areas. In other words, the worldwide experience of malariological stratification indicated the usefulness of the method, although its large-scale application still awaits further development of which the method is capable. Such a situation is primarily due to the fact that these studies were virtually discontinued at the time when malariologists believed they possessed an effective means of controlling the infection and it seemed that humanity would soon celebrate the victory over this ancient disease. Since this notion turned out to be erroneous, the opportunity must not be lost again.

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[1] The pioneer study was performed by A.Celli as early as 1900

It is well known that the antimalaria measures produced different effects upon the disease in various areas, from a complete and stable eradication to an almost complete refractoriness. It became clear that the malarious areas of the world are highly heterogeneous in their responsiveness to the implemented malaria control measures. The experience of the last 20 years in the field of malaria eradication and control has once more underlined the fact that malaria is a focal disease and that there is a need for constant adjustment of existing control measures to local epidemiological, social and economic conditions in the broad context of changes that take place in the process of socioeconomic development (including the health sector). As it stands now, stratification for planning antimalaria action should include identification of malarious areas having similar epidemiological and socioeconomic features, including availability of health services and organized malaria control activities, their characterization in various terms (including response to different control measures) and the development of malaria control strategies which are both appropriate and feasible.

The main advantage of the malariological stratification method under these circumstances consists of providing the basis for revealing this heterogenicity, thereby ensuring adequacy of malaria control measures to the actual situation in an area.

The potential of malariological stratification is rather broad: it makes possible the revision of strategy and tactics adopted by modern malaria control programmes (operational stratification), and, at the same time, provides a basis for outlining a course for research and development of prospective programmes aimed at the eventual complete and stable eradication of the disease.

The results of some current studies on malariological stratification and their practical implication have been presented and discussed by the participants of the meeting. It is hoped that a review of these studies will contribute to a better understanding of the potential of malariological stratification for planning antimalaria action.

2. Current experiences in the practical application of the stratification concept for the control of malaria

2.1 Stratification for malaria control in India

This approach has been developed by the Martsinovsky Institute, Moscow, USSR, in collaboration with the Indian Malaria Research Centre and National Malaria Eradication Programme for the stratification of the malaria problem in India.

If one subdivides the territory of India according to the following characteristics, such as the eradication effort required: the risk of resurgence in malaria freed areas; the attainment of interruption of transmission; a marked reduction in the level of transmission; the level to which the transmission is reduced; the malaria incidence at the peak of resurgence; and duration of the improvement period; it will become clear that the areas differ strikingly from one another and show a varied response to the seemingly logical and absolutely reliable approach of the "everywhere-and-overall" eradication strategy. For the present, therefore, such a strategy seems too expensive as well as not sufficiently justified.

Operational stratification may serve as a base for the development of strategy of long-term control programmes. Operational stratification is the subdivision of malarious areas into strata having a similar present-day and epidemiological conditions, level of incidence/prevalence of various forms of malaria, various vector species, as well as a similar dynamics of incidence/prevalence resulting from antimalaria measures, and is aimed at choosing objectives and targets and at planning the appropriate measures. To do so baseline data are very much needed for stratification, especially standardized ones, relevant socioeconomic, ethnological, anthropological, etc., factors should also be taken into consideration.

2.1.1 Criteria for developing the strategy in India

The following criteria for stratification are proposed; these criteria area based on the experience of eradication and control programmes in India. However, it should be borne in mind that the criteria might be different for each particular case. Such important aspects as administrative, management, financial, etc., should also be taken into account. Amongst the criteria are:

- the initial situation before implementing control and eradication measures (initial endemicity level);
- the situation at the time of the greatest epidemiological improvement period;
- the measures required to attain epidemiological improvement;
- the rate of malaria resurgence; and
- the present situation.

The list of criteria, however, should not be considered as final, but will have also to be the subject of applicability and feasibility.

2.1.2 Stages of operational stratification[1]

The collection, processing and grouping the data needed for stratification by the five criteria cited above are performed at the lowest level that has an epidemiologist or an entomologist available (district or zone, etc.).

Analysis of the district data and stratification of the area are done at the directorate of the national malaria control programme, and are then defined more precisely in each stage or province.

In India it was found that the smallest operational unit for stratification was an area with a population of 40 - 60 000 which should not cause any major problems in collection of information. In smaller countries a smaller unit may be defined for stratification but too small units would complicate the process and might not produce any major advantages.

(1) First stage - Information collection

During the first stage the following information is collected (where applicable, separately for *P. falciparum* and *P. vivax*);

- initial spleen and parasite rates, etc.;
- blood slide examinations;
- data on mortality and on malignant malaria cases;
- monthly and annual incidence by species;
- data on vector distribution;
- resistance of vectors and parasites; and
- antimalaria measures, their type and coverage.

[1] See Annex 4

In order not to lose the basic information, the data of the variables used for stratification should be incorporated at the lowest scale possible. If it demands a very great effort to stratify that way, computer-based mapping could be resorted to.

(2) Second stage - Processing data

During the second stage the data is processed. Indices are calculated, corrections are made, and only after that a series of tables are compiled consisting of:

- results of the initial malariometric surveys;
- the annual parasite index (API) by operational unit at the time of transfer into consolidation phase;
- API and annual falciparum index (AFI) by operational unit of those that always remained in the attack phase;
- total number of spraying rounds for the whole period of reduction of malaria prevalence/incidence;
- consumption of antimalaria drugs per capita for the whole period of reduction of malaria prevalence/incidence;
- the rate of malaria resurgence;
- monthly distribution of P. falciparum incidence;
- monthly distribution of P. vivax incidence;
- API and AFI for the previous year;
- number of malignant falciparum malaria cases and deaths due to malaria for the last five years;
- prevalence of drug-resistant P. falciparum;
- results of susceptibility testing of anopheles to insecticides (data for the last three years); and
- the effect of measures on the incidence level.

(3) Third stage - Grouping of data

The data processed in this way forms the basis for the preparation of maps, i.e. the third stage - grouping of data.

At the end of the third stage, a series of maps with various information incorporated should be prepared. The three stages are carried out at the peripheral level and theory totality is the information base for subsequent analysis.

(4) Fourth stage - Analysis of data

At the central level, the grouped data (maps) are generalized for the whole country. This may be done by hand or by means of computers, depending on the country's facilities and the size of the endemic area, and should be followed by a retrospective epidemiological analysis of the development of the malaria situation within the country. From the onset of the control/eradication programme to the present time and epidemiological analysis of the present-day malaria situation, based on this analysis, a series of maps for the entire country should be drawn.

(5) Fifth stage - Stratification of areas

This is done at the central level for the entire endemic area by means of successive cartographic superposition of maps in order to determine general objectives of the national malaria control programme. Following this exercise, a medium-term plan of malaria control measures for the whole country can be worked out, with regard to the general and specific objectives for each type of area.

The plan should include a section for areas belonging to different administrative units (state/province), listing their specific objectives and indicating the distribution of material resources within each administrative unit.

Management of the programme at the state/province level (intermediate), in cooperation with district epidemiologists, is concerned with implementing the execution of the plan for the state/province on the basis of the data obtained from district and within the framework of the medium-term plan worked out by the national programme directorate, namely:

- the volume of work, the requirements of antimalaria drugs, insecticides and other means, as well as their distribution among administrative units are specified; and

- specific objectives for a 2-3 years period set for each stratum.

As a result, malaria control plans covering a period of 2-3 years are worked out for the state/province as a whole and separately for the administrative units included in the strata.

The activities at this level (peripheral), based on the plan worked out at the state/province level and on the collected, processed and grouped data available in the district include:

- specifying strata boundaries;

- establishing dates for undertaking specific measures in each stratum and in the operational units; and

- assessment of the need for insecticides, antimalarial drugs and other commodities that may be required.

2.2 Use of physiographical stratification in Orissa State, India

2.2.1 Physiographical provinces

The existing stratifications developed for purposes other than malaria may be used as a framework for malariological stratification.

The obvious way is to use physiographical stratification which is well developed and deals with a number of hierarchial levels, i.e. division, subdivision, province, section. Physiographical stratification is the result of integration of a variety of orographic, climatic and other factors, many of which exercise direct or indirect influence on malaria.

The validity of such an approach is supported by the data from the programme in Orissa State, India.

Some 3500 slides were collected from passive cases in 35 primary health care centres (PHC) and examined in a reference laboratory (the standard of which was quite high). As a result, the PHCs were categorized into five groups according to the observed slide falciparum rate (SFR) and slide vivax rate (SVR) as shown in Table I:

Table I:

Group	SFR	SVR	Number of PHC
A	very high (40-53%)	moderate (4-6%)	2
B	high (16-35%)	high (9-14%)	5
C	moderate to high (6-20%)	low to high (1-13%)	19
D	low (1%)	high (21%)	1
E	low (0-2%)	low to moderate (0-6%)	8

The distribution of these categories within the four physiographic provinces of Orissa may be described as follows (Map 1):

- a high SFR never occurred in two provinces (No. 1 and 4, i.e. Utkal Plain and Mahanadi Basin);
- Low AFR never occurred in Eastern Ghats Province (No. 3) and was very uncommon in Garhjat Hills Province (No. 2);
- P.malariae was quite common in Province No. 3 and less common in No. 2, but was found only once in No. 1 and never found in No. 4.

It seems therefore that the physiographical boundaries are of a considerable predictive value for identifying areas with high prevalence of P. falciparum and P. malariae.

Further refinements may be done, by identifying substrata within such physiographical framework, by adding other relevant factors.

2.2.2 Indicator factors

Some factors correlate with malaria, though there is no direct cause/effect relationship between them, e.g. particular crops, particular types of vegetation or prevalence of particular ethnic groups (e.g. tribes in India).

Therefore, the following approaches to malaria stratification may be justified:

(1) selection of factors of high predictive value (indicators), on the basis of experience in limited areas or on conceptual basis;

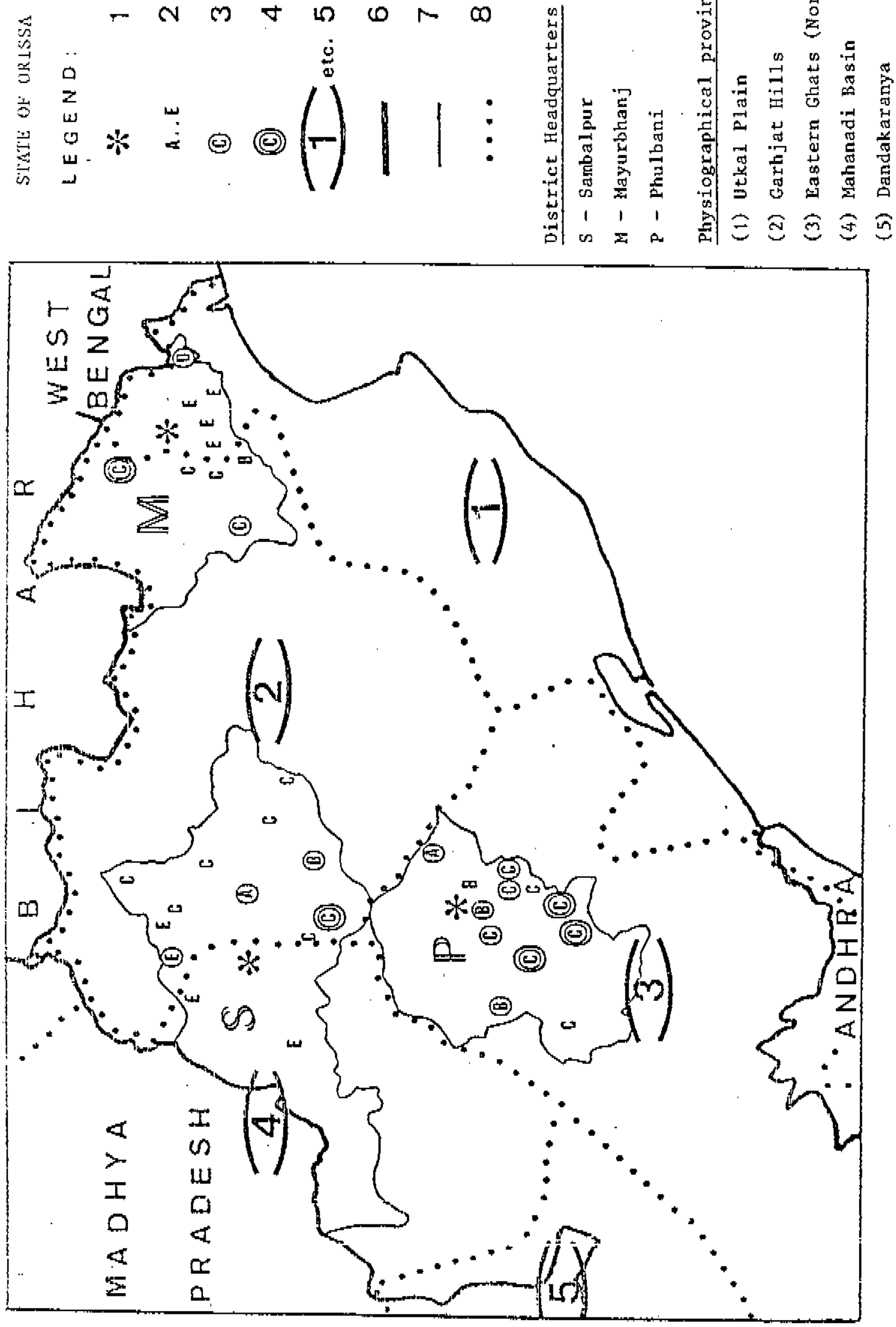
(2) selection of those indicators which may be easily obtained, measured and mapped;

(3) mapping of the indicators and making predictions regarding malaria;

(4) evaluation of the validity of the forecast; and

(5) repetition of the cycle, if needed.

Map 1: State of Orissa



District Headquarters

S - Sambalpur

M - Mayurbhanj

P - Phulbani

Physiographical provinces

(1) Utkal Plain

(2) Garhjat Hills

(3) Eastern Ghats (North)

(4) Mahanadi Basin

(5) Dandakaranya

On these lines, a comparison of P. falciparum surveillance data from Orissa with census data was done. It was found that P. falciparum prevalence strongly and positively correlated with the percentage of "scheduled tribes" in general population. Less strong, but a significant negative correlation with literacy level was also found, the latter is probably of a secondary nature (literacy is low in tribal populations).

2.3 Stratification of malaria in South-East Asia in relation to the rational use of antimalarials

Experience gained in the course of stratification of the territories in the countries of South-East Asia in relation to the rational use of antimalaria drugs, indicated that the first stage of this exercise should be the formulation of its objectives and identification of the priorities, based on whatever available epidemiological data. The consequent stages could be associated with the data processing, grouping, analysis and other related procedures, so that on the basis of these studies appropriate variants of the use of antimalarials has been designed (see Annex 5).

2.4 Epidemiological diversity and malaria control measures in China

The epidemiological approach in malaria control within the strategy of primary health care entails the selection of antimalaria measures appropriate in the natural pattern of transmission and local ecology. As an illustration, early in the 1950s, malarious areas in China were divided into four broad epidemiological zones each with its own characteristic features. Antimalaria strategies based on these features were formulated and implemented. Substratification was made in relation to the epidemiological diversity of the area involved and the antimalaria measures selected were adapted to the local situation.

China's experience also demonstrates that stratification is a continual process. It should be done repeatedly in the course of progress of antimalaria programmes.

2.5 Stratification of malaria in Central America

Stratification should be relevant and respond to acute needs. El Salvador in 1978 was faced with a continued, intransient malaria problem characterized by unacceptable responses to residual spraying and drug administration. Source reduction, larviciding, biological control, space spraying and other expensive measures individually and in combination were contemplated. Reviewing the vast amount of malaria surveillance data by the smallest population unit, a significant heterogenicity of malaria in time and space was obvious. The continuous distribution of malaria incidence indices so derived was empirically divided into strata of graded epidemiological and operational importance. Only 10% of villages consistently produced the majority of the cases in the country. Seasonality was also found to vary dramatically between villages. Four distinct seasonal peaks were identified and those villages with similar seasonal patterns had similar geographical and hydrologic profiles. These results were used by the malaria control programme to focus combined measures in time and space as well as serving for more in-depth evaluation of local epidemiological phenomena.

2.6 Stratification of malaria in rural areas of tropical Africa in relation to dynamics of malaria transmission

Basically four main ecoepidemiological strata may be recognized in rural areas according to the dynamics of transmission: permanent, long-term seasonal (6 months) annually, short-term 'episodic' seasonal (2 months) annually, and sporadic.

(1) Stratum I

Where the transmission is perpetual, occurs almost all the year and is very intense (- 1 infected bites/man/night) being mainly due to Anopheles gambiae s.l.

Malaria prevalence increases until about five years of age, then gradually decreases each year, as does the spleen rate. Seasonal variations of prevalence are relatively few and perceptible only in children. Due to continuous transmission every infant is parasitized, but adults, adolescents, and even schoolboys, have developed a high level of immunity (premunition), so that they are almost free of any severe clinical attacks. Malaria morbidity concerns mainly preschool children and constitutes above 30% of the febrile cases seen by field dispensaries, with very few seasonal variations. Malaria accounts for about 10% of the general infant mortality. Malaria mortality seems to concern mainly infants less than three years old and cerebral malaria is found in less than 1% of all hospitalized cases in paediatric dispensaries. But death from cerebral malaria could be high (up to 25%). Adults and adolescents are usually resistant to external plasmodial strains.

Malaria control by vector control is very difficult to realize and hard to achieve.

This stratum corresponds to degraded forest areas of Central Africa and other areas where rains occur throughout the year.

(2) Stratum II

Where there is a long-term (six months) seasonal transmission which occurs regularly each year relating to the rains, *A. gambiae s.l.* followed by *A. funestus* are the main vectors and inhabitants received above 50 to 150 infected bites per year according to the local conditions. Malaria prevalence increases with age, up to ten years of age, then gradually decreases with age as does the spleen rate, which indicates the acquisition of premunition. But there can be a difference between parasitic and spleen rates according to the transmission season.

Malaria prevalence shows important seasonal variations. It is at its lowest during the dry season (parasite rate - 50% in children; less than half in adults) and greatly increases during the rainy season for children and adults (parasite rate - 80% in children).

Malaria morbidity concerns mainly children under 10 years of age and an average of about 30% of febrile cases reported from field dispensaries are due to malaria. But there are great seasonal variations: from less than 10% during the dry season to more than 50% during the rainy season (and above 80% at the end of the rainy season). Due to the regularity of transmission each year, children develop their immunity so that adolescents and adults are almost completely free of any clinical attacks.

In the paediatric clinics almost a quarter of febrile cases are due to malaria, but with great seasonal variations: 1% during the dry season, to about 50% during and at the end of the rainy season. Cerebral malaria occurs (and in this case mortality could be high (25%)), even if it appears that it is less frequent than usually reported.

This stratum occurs mainly in the savanna (West Africa) and malaria control by vector control only is very hard to achieve.

In strata I and II, 'malaria parasitaemia' must be distinguished from 'malaria disease', to evaluate malaria morbidity in those strata where there is a stable malaria.

(3) Stratum III

Where there is a short-term (two months) episodic seasonal transmission, which occurs each year during the rains and with an almost complete interruption during 10 months, the inoculation rate is relatively low (2-3 infective bites/man/year).

Usual malariometric rates show great seasonal variations, but also from year to year, according to meteorological conditions. Parasite and spleen rates increase during the rainy season for children and adults.

The fact that transmission lasts just two months delays the development of premunition so that not only children but also adolescents or even adults may have clinical malaria. Moreover, the great increase of transmission, when the rains start, can produce outbreaks among populations that have lost part of their immunity. This condition is especially dangerous after a succession of many years without rain, and epidemics often occur.

Control measures have therefore to be taken in the endemo-epidemic stratum. This stratum is represented by the Sahel, circumscribed areas among semi-arid regions such as the Horn of Africa or middle altitude areas. Such an unstable malaria may require antivectorial measures.

(4) Stratum IV

Where the transmission is sporadic, this may occur under special circumstances such as: meteorological, changes in the biotopes, or in special places near temporary rivers. In these foci, malaria is therefore epidemic and severe with a high mortality which could occur in all age groups, even in adults. Between the epidemics episodes there is no obvious evidence either of malaria (spleen rate is low - 10%) or of transmission, even at a low level. Vector and therapeutic measures can control such epidemics. This ecoepidemiological stratum corresponds to high altitude plateaux (Ethiopia) or some desert areas.

2.7 Stratification of malaria in agricultural development areas (the Ruzizi Valley, Burundi)

The endemicity of malaria in Burundi is not only very different in the Ruzizi Valley (altitude 800 m) and in the hills (altitude 1500 - 2500 m), but even in the valley itself various ecotypes may be encountered. The valley has a dry tropical climate: 850-990 mm annual rainfall. The dry season extends from June to September and a long rainy season occupies the rest of the year. The average daily temperature is practically constant, 23-24°C.

The present agricultural development is made up of organized farming in a traditional environment. About 36 000 ha are covered with either rice or cotton cultivation. The rice fields were established alongside the eastern slopes of the valley, where small streams run down the hills towards the Ruzizi river. Elsewhere in the valley wild savanna has been replaced by a new, well-ordered landscape of organized cultivated fields. Maize, Indian millet and cotton are also produced.

Anopheles arabiensis, present in the whole valley has a highly variable aggressivity ranging from 3.9 in Katumba to 56.1 bites/man/night in Gihanga. Gihanga is situated adjacent to ricefields while Katumba, 25 km south-east, has no nearby permanent water collections, but is situated at the edge of Lake Tanganyika and surrounded by cotton fields and cattle breeding areas. The result is a very different type of endemicity. Ricefields induce a stability of the transmission throughout the year, while in arid surroundings the breeding of anophelines mainly depends on rainfall and great differences are observed throughout the year and from one year to another. The incidence rate is on average four times higher in the ricefield areas (0.0120) than in the cotton areas (0.0030) of the valley. The first area is defined as stable, the second as unstable epidemic. The vectorial capacity is 150 times less important in Katumba than in Gihanga, the two villages being located about 20 km from each other.

It is clear that the appropriate control measures could vary from place to place in the Ruzizi valley, according to the local endemicity, stability of transmission and ecological environment; human activities must also be taken into account, like spraying of insecticides for agriculture, cattle breeding, massive immigration and local administrative structures.

2.8 Stratification of malaria in a large town (Kinshasa, Zaire)

The rapid growth of the towns in Central Africa may cause changes in transmission patterns. A study of malaria endemicity within Kinshasa demonstrated sharp differences in prevalence observed between different areas in the city. These are probably the result of different socioeconomic levels, or the presence, or absence of permanent water collections, or the accessibility of the area.

At Livulu with the highest endemicity, there is always water at the bottom of the valley. Steep clay sides of the valley maintain permanent water collections as well as fish breeding ponds. The low economic status of most of the inhabitants does not allow them to buy antimalarial drugs. Drug stores and dispensaries are at a distance. Bad roads make population movements rather infrequent. Barumbu on the contrary presents the lowest endemicity although the zone is a swampy area alongside a stream. However, the situation is peculiar since the area is covered by several transport and commercial estates. The population lives scattered between these factories. Generally the abundant mosquitos are not Anopheles. Mont Ngafula has almost no natural water collection being a hill of sand. However, mosquitos find breeding places in manmade water collections in cultivated gardens where water runs permanently. The University area represents an outstanding situation, where children are regularly examined and all have access to antimalarial drugs. The parents are educated and although no prophylactic treatment is given, fever is treated without delay. Moreover, mosquitos do not find breeding places, because of the absorption of rainwater by the sandy soil.

The important differences in malaria prevalence between places situated a few kilometres apart suggest that the vectorial capacity is a locally determined function. Similarly, anopheline density and female mosquito longevity may vary considerably in each microclimate. Even if it can be assumed that anophelines are present everywhere in Kinshasa, the transmission will nevertheless be influenced by the socioeconomical status of the inhabitants.

2.9 Stratification of malaria in industrial development projects (mining area in Sangaredi, Guinea)

This area is situated on the western slopes of the Fouta Djalon mountains, 120 km from the coast, at less than 500 m altitude. The climate is of the moist tropical type with a long, dry season of about seven months. The population in the whole mining site is about 8000 individuals of which 5000 are employed by the mining company. The others are either an indigenous population existing before the development started, or people attracted by business and trade possibilities.

Epidemiological investigation within the five towns of the area show the influence not only of the vicinity of a dispensary, but also of the organized consultations for the personnel and their families of the mining company. In two towns not directly associated with the mining company, ponds and permanent water collection caused the malaria situation to worsen. A true rural area is in a slightly better position because the malaria situation is not worsened by artificial housing and living conditions.

2.10 A typology of malaria situations in Africa, likely to be meaningful for stratification for malaria control

2.10.1 Stratification according to relatively stable characteristics of transmission

The tentative listing which follows results from an attempt to take into account the experience accumulated by many malariologists in Africa, in control programmes and in research projects. An attempt has been made to define each stratum by a few important characteristics, without trying to be exhaustive or systematic. The characteristics used include some environmental, epidemiological, social, economic, demographic factors. Two characteristics are common to all the strata: the dominant parasite is P. falciparum, the dominant (or exclusive) vectors are very effective fresh-water breeders, depending mainly on rainfall, directly or indirectly. Transitions between strata are likely to be gradual, even though for control purposes a clearcut delimitation may eventually be required.

The proposed typology uses on the one hand the characteristics of transmission or some of its major determinants and, on the other hand, the response of P. falciparum to drugs; with respect to transmission, a primary axis of classification goes from perennial stable malaria to seasonal stable malaria to two varieties of unstable malaria associated respectively with aridity and altitude; to this are added two manmade ecotypes, namely urban areas and irrigation and three special groups; nomadic pastoralists, temporary aggregations of labour, and nonimmune temporary residents.

Furthermore, as already indicated, strata may be geographical areas or population groups, thus allowing for some overlap between strata.

(1) Rural areas with traditional agricultural systems and stable perennial transmission; this is typical of rural areas within the equatorial forest belt; incidence and prevalence of infection are high; morbidity and mortality are concentrated in infants and young (preschool) children; adults are relatively immune clinically; towards coastal areas and estuaries the situation may be modified by the addition of salt-water vector species, although the importance of their contribution to transmission is not well known and may be only minor; towards the savanna this stratum merges into the next (2).

(2) Rural areas with traditional agricultural systems and stable seasonal transmission; this is typical of savanna areas, merging towards the equator into the perennial transmission of the previous stratum (1) incidence and prevalence of infection and disease are similar to those of the previous stratum, with seasonal variation added; vector populations and entomological inoculation rates typically build up very fast to very high peaks in the wet season; away from the equator, this stratum merges into the next (3).

(3) Arid rural areas with traditional agricultural systems and unstable transmission, the instability being due mainly to aridity; morbidity (illness) may extend into adult age groups and may vary greatly from year to year; there is the possibility of recurrent epidemics of malaria when meteorological conditions (rainfall) are favourable for transmission; traditional oases are part of this stratum.

(4) High altitude rural areas with traditional agricultural systems and unstable transmission; in this situation also there is the possibility by recurrent epidemics.

(5) Populations of nomadic pastoralists; they may form (or belong to) more than one stratum: some are fully nomadic pastoralists, moving over wide areas following erratic rainfall; others move in and out of settled areas (e.g. areas included in strata (2), (3) and (6), in which they may be settled and engaged in agriculture part of the year.

(6) Modern irrigation schemes in regular operation; special features: extension of transmission season (increasingly important as one moves away from the equator); frequently use of insecticides for agriculture, which may reduce transmission but also select insecticide resistance; frequently seasonal migration of labour, which may increase the parasite reservoir and the supply of susceptibles, depending on the local risk, the origin of the labourers, the location, shelter and drainage conditions of their settlements, often promoting man/vector contact).

(7) Temporary development projects and the associated aggregations of labour; special risk features: increase in vector breeding and man/vector contact, immigration of nonimmune labourers.

(8) Urban and suburban areas.

(9) Nonimmune visitors or temporary residents (nationals or expatriates) in endemic areas.

2.10.2 Two important qualifying variables: the drug response of P. falciparum and the mortality from malaria

The drug response of *P. falciparum* should modulate policies concerning the use of antimalarials and is therefore of paramount importance for malaria control programmes resting mainly on the use of drugs. It is however not proposed to include drug-response as a variable for stratification, because (i) it may change too fast; and (ii) it leads to adjustment within a given control strategy, rather than to a change of strategy.

Mortality from malaria is important in setting priorities between strata (and in evaluation); it is, however, not proposed explicitly as a variable for the initial stratification because it is too little known. What is suggested is (i) to collect and use whatever information is available on mortality from malaria and (ii) to develop, improve and standardize such measurements of mortality as are feasible with the resources that are or can be made available. The selection and adaptation of different control methods in relation to the different strata, and following the primary health care approach is emphasized (see Annexes 6 and 7).

3. Definition of objectives of stratification and elaboration of an approach

3.1 Objectives of stratification

In many malaria control programmes the same degree of reduction of the disease cannot be achieved simultaneously throughout a national territory due to administrative, operational, technical and financial constraints. Also the same level of effort is not needed throughout a territory to achieve a uniformly lower endemicity. Delineation of homogeneous strata having similar epidemiological, geophysical, socioeconomic and ecological characteristics will allow the formulation of appropriate objectives, targets, and the selection of intervention measures specific to each stratum.

3.2 Essential features of modern control programmes

Modern long-term control programmes are expected to differ from both pre-eradicational control programmes and eradication programmes in their essence.

These control programmes should incorporate the following major principles:

(1) Precise formulation of long and medium-term objectives and targets and operational flexibility appropriate to the local situation and available resources.

(2) Selection of appropriate measures based on stratification of the malaria problem and geographical areas, taking into consideration epidemiological, operational, socioeconomic criteria and administrative and financial capabilities of the country.

(3) Ready access to antimalaria treatment based on total coverage in space and time for every inhabitant of malarious areas.

(4) Methods for monitoring interventions and carrying out impact assessment of the control approaches adopted in relation to the objectives and targets.

(5) Appropriate diagnostic and treatment activities conducted through the primary health care delivery system and preventive activities carried out through the specialized antimalaria epidemiological services within the overall structure of the health services.

(6) The epidemiological services, with applied research and training components should be capable of identifying and defining the problems, planning control activities, monitoring and evaluating operations based on the principle of appropriate selective coverage in time and space. The peripheral structure of epidemiological services should correspond to malaria status and its potential instability including the risk of re-establishment of transmission.

(7) A built-in response capability to meet emergency situations (a reserve for outbreaks).

(8) Community participation in antimalaria operations.

3.3 Criteria of stratification

The specific criteria to be used for stratification will vary depending upon the country or area to be stratified and the perceived nature of the malaria problem thereof. Consequently, this elaboration of the criteria is restricted to general categories and important features to be considered. The general categories for criteria are: (i) epidemiological, (ii) operational, (iii) socioeconomic. The intent of stratification will be to explore the diversity of each selected or relevant criterion and to order the malaria problem according to those perceived to be most relevant.

3.3.1 Epidemiological criteria

- Initial endemicity levels;
- the present situation including current endemicity levels, levels of incidence, morbidity and mortality, seasonal distribution;
- the species of malaria parasite present;
- the distribution of various vector species both primary and secondary with at least a qualitative assessment of density;
- the instability potential which is the tendency of the situation to change or to maintain its endemic level irrespective of the continued presence or absence of control measures;
- the rate of resurgence in situations where malaria had been reduced to a low level (during previous eradication or control campaigns);
- the degree and extent of parasite resistance to antimalarial drugs being used;
- the distribution of insecticide resistance among each of the vector species;
- basic physiographical strata including hydrologic, climatological, topographical and ecological regions; and
- ecological interventions that may result in a change of malariological potential (urbanization, irrigation, deforestation).

3.3.2 Operational criteria

- Coverage in case detection and treatment;
- coverage in antivector measures;
- effect of antivector measures;
- effect of antiparasite measures;
- accessibility to operations;
- cost of various types of measures per 1000 population;
- representation of coverage in terms of density per person or area of general health services, primary health care workers, malaria-specific health workers (both drug and vector control operations);
- the structure of logistic support and administrative services in terms of the probability of logistic constraints and the potential for administrative flexibility; and
- a plan for improvement and expansion of antimalaria operations.

3.3.3 Socioeconomic criteria

- The impact on various socioeconomic groups;
- the seasonality of migration in relation to local transmission;
- the present status of health services and plans for national health development;
- major economic activities, national development plans and priority geographical areas; and
- the resources (including financial, manpower, equipment, infrastructure, communications) available or mobilizable and their geographical distribution.

3.4 The process of stratification

3.4.1 In countries with long-term, well-developed malaria control programmes

- Collection of pertinent data;
- processing of data for each criterion;
- grouping of data should be first done in a matrix format with each basic unit (i.e. village, district, country) united to its set of characteristics;
- interpretation of data;
- setting of the stratum limits, display to express and facilitate understanding of the overall stratification result;
- field testing; and
- performance analysis and restratification if needed.

For more details see section 3.1 above.

3.4.2 In countries in which there have been no large-scale long-term vector control activities (mainly tropical Africa)

The process of stratification of the country for malaria control will include the following:

(1) analysis of available local information with emphasis on geographical distribution;

(2) comparison of that analysis with the general kind of broad malaria typology (or classification system) proposed for Africa (see Section 2.10 above);

(3) on the basis of the above, an interim operational stratification (or re-stratification); this combines the approaches "from below" (the local information) and "from above" (the typology); it includes the identification of relevant strata from among those included in the typology, as well as of other locally relevant subdivisions;

(4) identification and performance of required additional analyses of available information, if any;

(5) planning of the collection of relevant information (i.e. information allowing refinement and updating of the stratification) as part of the control activites; and

(6) identification and collection of required additional data, if any.

3.5 Implementation of the medium-term plan

A medium-term plan of malaria control measures for the whole country should be worked out based on the operational stratification with reference to the general and specific objectives for each type of area. The plan should include a section for areas belonging to different administrative units (state/province), listing their specific objectives and indicating the distribution of material resources among administrative units.

Operational stratification is a process of analysis and synthesis of available information on all aspects mentioned above. This should lead to the selection of homogeneous strata, for which specific objectives, targets and target dates must be established and methods of intervention chosen accordingly.

Annual evaluation of the results obtained in particular areas should allow a more precise determination of the volume of work needed for the next year, depending on the dynamics of malaria. This ensures implementation of the feedback principle, a characteristic feature of the system approach to organizing measures based upon the stratification data.

Stratification for planning malaria control actions needs to be tested first in a few countries. Such field studies would allow its optimization as well as disclosure of all potentials for use in modern long-term control programmes.

4. Logistic aspects of stratification, steps and responsibilities and resource requirements

4.1 Steps and responsibilities

The first step is taken by those responsible for malaria control at the central (national) level and consists of a preliminary stratification (or re-stratification after critical review of the current stratification) on the basis of the information readily available to them.

Information may be found in archives, libraries, academic institutions (including some outside the country), WHO and other international organizations (UN for demography, FAO).

The sources of information may include:

- published literature, including, for example, results of malaria field research;
- unpublished reports, including, for example, consultant reports;
- persons with experience of malaria and its control in the country;
- past and current statistical returns from the health services and from the other relevant services (e.g. agriculture, demography); and
- existing geographical descriptions and maps (e.g. of altitude, rainfall, population).

During this process further needs for information may be identified, as well as the possible sources or ways to collect it if necessary. In addition the need for cooperation with other health programmes and other sectors (e.g. agriculture, education), ways to achieve it, and the need for an interdisciplinary approach to stratification (e.g. public health administration, epidemiology, geography, social sciences, economics, data processing, statistics, management) may become apparent. Multidisciplinary and intersectoral workshops may be necessary.

4.2 Resources requirements for and feasibility of carrying out stratification

An assessment of available resources is necessary to enable implementation of the stratification process. The availability of human resources including technical expertise should be first sought in the internal malaria epidemiological service. However, it is appreciated that at present the national epidemiological services are often labouring under great constraints, and external assistance may be required.

The feasibility of conducting a meaningful stratification will depend to some extent on the availability of records, including operational data, malariometric data and maps, as well as sufficient fund allocation to do the job properly.

5. Methodological and procedural approaches to stratification

5.1 Aspects related to the basic concept

In the following sections dealing with methodological and procedural aspects, stratification is taken in its most general perspective: a way of classifying objects in subjets that are relatively homogeneous with respect to certain criteria. In this context stratification could take place under three basic different forms:

(1) of situations linked to a position in a given area, thus producing stratified maps;

(2) of situations not linked to a position in a given area, thus producing tables of different kinds of groups;

(3) of populations (or other local variables) where the stratification could produce several strata at a given site. They may or may not be presented as maps.

5.2 Aspects related to the level of analysis

Once the different criteria (that is, properties that are attached to the situation being analyzed) are identified and - hopefully - given a certain weight, there are many ways that the actual information about them can be processed in order to perform stratification. What follows does not pretend to be either a presentation of technical possibilities nor a list of all possible procedures available; it is intended to serve only as an indicator of the wide range of potential ways of performing analysis for stratification.

(1) Primary procedures

- Descriptive tables (organized data presentation);
- synthesized tables (with some sort of quantified amalgamation of information);
- descriptive maps (medical cartography by single characteristics);
- superimposed maps (compounding of geographical maps);
- synthesized mapping (cartographic presentation of quantified amalgamation of information).

(2) Statistical procedures

- Simple statistical analysis (statistical dispersion measures, correlation, regression);
- multivariate analysis (numerical taxonomy, principle component analysis);
- exploratory data analysis (EDA).

(3) Mathematical procedures

- Information theory classifications;
- probability distribution analysis;
- Fuzzy-set theory;
- mathematical modelling.

The separation between "statistical" and "primary", as well as between "statistical" and "mathematical" is for convenience. There will be borderline cases, probably sharing two types of procedures. Furthermore data-bases and data banks, used in conjunction with the powerful data-base management programmes available, can also be of help in stratification.

5.3 Aspects related to the tools for analysis

The tools to be utilized are, obviously very much in relation to the level of the analysis presented in (2). However, a certain spectrum of possibilities exists, such as:

- paper and pencil
- calculators
- microcomputers
- minicomputers
- mainframe computers

Table 2 shows a tentative relationship between tools and levels of analysis (this is a very broad and general possible relationship, for there will be many intermediate situations).

5.4 Aspects related to the nature of the analysis

The different levels analysis (see above) provides different degrees of interpretation of the situation. However, for any given degree of interpretation achievable, we can attach to it a static of a dynamic nature. The former implies that we will be inclined to take the results and its interpretation as a mere (but nevertheless useful) description of the situation. The dynamic approach actually involves two types: a time-dynamic representation, and a process-dynamic representation. The former refers to a description of change in historic time, the latter to the structuring of our knowledge in terms of a dynamic model. Only mathematical modelling serves to this last nature of analysis. All the others serve in different degree to either description of the situation or description of the changes.

5.5 Aspects related to disciplinarity

The need for interdisciplinary or multidisciplinary teams of work is commonly stated. However, many times it is not done, or if intended, rarely is productive in terms of effective decisions or specific results; in the end much interdisciplinary work ends with a disciplinary product. Using dynamic as the "dynamic process" concept presented above, table 3 shows a way of relating it to disciplinarity, in terms of the malaria problem.

Table 2

	Tools				
	A	B	C	D	E
Level of analysis	Paper and pencil	Calculators	Microcomputers	Minicomputers	Mainframe computers
1. Descriptive tables	*		*		
2. Synthesized tables		*			
3. Descriptive maps	*				
4. Superimposed maps	*		*	*	
5. Synthesized mapping		*	*	*	
6. Simple statistical analysis		*	*		
7. Multivariate analysis			*	*	
8. Exploratory data analysis			*	*	
9. Information theory classification			*	*	
10. Probability distribution analysis			*	*	
11. Fuzzy-set theory[1]				*	*
12. Mathematical modelling			*	*	*

[1]Fuzzy-set theory is one of several current mathematically defined approaches to the processing of vague and uncertain information which does not lend itself to classical probabilistic treatment.

Table 3:

	Nature of effort	
	Time-dynamic	Process-dynamic
Disciplinary	1 Malaria control	2 Malaria epidemiology
Multidisciplinary	3 Workshop stratification	4 Workshop for adaptive approach by mathematical simulation modelling

Box 1 describes the classical efforts based on the application of control measures to specific situations with rare or no interaction of disciplines, and with a relatively fixed scheme of work, that is, no attempts for prediction or adaptation to future events.

Box 2 describes the efforts towards modelling the transmission of malaria, both in general and for specific cases, acquiring by this approach a highly process-dynamic nature, but restricted, in higher or lesser degree, to one discipline, or a few disciplines intimately related. McDonald's model is more restrictive to a single discipline while the Garki model resorts to a wider number of connected disciplines (e.g., immunology and control).

Box 3 reflects the present efforts in stratification. The multidisciplinarity is imbedded in it by its own nature; although up to now probably this has not been carried out in such a way, a workshop style of production might have to be developed.

Box 4 describes the combination of boxes 2 and 3, under the additional approach of an adaptive attitude to problem-solving and decision-making. The multidisciplinarity of the stratification approach is taken one step forward from the time-dynamic approach to the process-dynamic one; or if one prefers so, we can say that the process-dynamic malaria epidemiological models are fortified by a multidisciplinary approach. The adaptive nature of box 4 is given by the following particular features: (a) a series of simulation models interfaced with laboratory and field research, that feed one to the other in progressive improvement in knowledge by identifying the main gaps that have priorities in research, (b) an incorporation in the workshops of people of all relevant fields related to the problem, particularly local decision-making and local decision-implementing personnel, and (c) specific orientation of the simulation models towards operational real-world problem-solving of the malaria situation.

6. Identification of possible research on development and evaluation of stratification methodologies

6.1 Stratification methodology

Measurements useful for stratification belong mainly to two categories: those that assess biological factors and those that assess social, economic and behavioural factors; both categories of factors are determinants of the malaria situation and of what can be done about it.

A "stratification methodology" includes all the individual methods applied to an area or a population to divide it into strata, i.e. the variables selected, the sampling and measurement methods used to assess them, the levels selected as diagnostic, the combination and weighing of different variables.

To be really useful, stratification should be flexible to the extent justified by the rate of change of the relevant variables: some of them can vary relatively fast, e.g. the response of malaria parasites to drugs or the geographic distribution of the human population.

The scale of stratification will be a balance between what might be technically justified and what is operationally practical.

A broad definition of research is applicable here to research on stratification methodologies, including all activities aiming at the development or evaluation of stratification methodologies, as long as an objective method of evaluation is agreed upon in advance. This could include the introduction of a stratification methodology in a control programme, on a trial basis, and its evaluation: such trials would tend to be larger than and rather different from field research projects in the strict sense, but they are likely to be more meaningful with respect to the final purpose of stratification (better control).

6.2 The evaluation of current stratification methodologies

In deciding whether or not research in this particular area is desirable and possible, and in trying to design a relevant research project, the following questions have to be addressed:

(1) What are the available and clearly defined stratification methodologies which require research?

(2) To what whole would the stratification methodology be applied?

(3) Would there be a comparison, and if so, what would be compared? A control programme before and after the introduction of stratification, or different programmes (or parts of programmes) with and without stratification or with different stratification methodologies?

(4) What would be criteria of evaluation? The process, cost and direct output of the stratification exercise (including, for example, the *a priori* evaluation of the resulting control plan)? Or, much more ambitious and more difficult, the cost, efficiency and effectiveness of subsequent control activities.

6.3 The development of new general stratification methodologies

Many relevant experiences are deposited in publications, unpublished reports or human memories. It may be worthwhile to retrieve those experiences and to try to translate them into explicit, relatively general and transferable stratification methodologies. Evaluation would be either *a priori* (e.g. by a panel of experts on malaria and its control), or along the lines suggested above (see paragraph 6.2 above), or as learning material (see paragraph 6.7 below).

6.4 Development and evaluation of a stratification methodology as part of a particular malaria control planning exercise, without collection of new field data

One would start without an explicit stratification methodology from a particular current malaria situation. The design of an investigation would have to address the following questions:

(1) What are the steps and responsibilities for arriving at the formulation of one or more stratification methodologies eligible for evaluation? The application and evaluation of some modern managerial techniques may be relevant here.

(2), (3) and (4) as above in 6.2.

6.5 Development and evaluation of a stratification methodology as part of a particular malaria control planning exercise with collection of new field data

This is similar to paragraph 6.4, except that the identification of crucially missing field observations, their actual collection and their utilization are added to the steps and responsibilities for arriving at the formulation of one or more stratification methodologies. Otherwise, the questions to be addressed in designing an investigation are the same as under paragraph 6.4.

6.6 Evaluation of individual assessment methods potentially useful for stratification

6.6.1 General considerations

Given that certain variables have been accepted as relevant for stratification, there is room for research on their assessment in the field, aiming at getting information that is adequate in quality and quantity at a minimum cost; adequacy would be evaluated in terms of allowing meaningful stratification and/or in terms of comparison with an accepted standard method of assessment; in addition to measurement methods as such, the research may be concerned with sampling schemes and with the kinds of personnel responsible for assessment. (A related possible area for research is concerned with data processing, see paragraph 6.8).

Methods potentially eligible for this kind of research are many and varied, considering the number and variety of variables that may be relevant for the diagnosis and stratification of a malaria situation. Relevant variables may belong to such widely different categories as the physical environment, the biological factors of host, vector and parasite, and social, economic and behavioural factors. Relevant methods may belong to such widely different categories as questionnaires, biological laboratory methods, and remote sensing. The next section (6.6.2) considers only a very limited and biased set of examples.

6.6.2 Some examples

Considering the importance of drug-response of *P. falciparum* in relation to stratification, the first three examples are concerned with its assessment.

(1) Evaluation of simplified *in vivo* tests, e.g. using only three or even two measurements of parasite density; the following evaluation methods could be used, possibly combined: evaluation of usable information actually lost when using only two or three data points from 28 or 7 days tests; evaluation of a simplified test, introduced as such in a programme, in terms of feasibility, information obtained and cost (see also (3)).

(2) Evaluation of simplified *in vitro* tests, e.g. using fewer, or even only one, concentration per drug tested; here also two kinds of evaluation methods, analogous to those outlined under (1), could be used.

(3) Evaluation of the response to treatment, within the regular activities of the health services, as a first line assessment of the drug response; the method to be evaluated could include both the clinical response of all "cases" and the collection and examination of a blood film in a sample; with respect to the latter, a cost/effectiveness comparison could be made between different kinds of sample: "clinically typical cases" (to be defined), or apparent clinical drug failures, or a systematic sample.

The four next examples are concerned with the use of serology for stratification:

(4) Evaluation of serological surveys at first admission in a sample of schools, as a tool for mapping intensity of transmission.

(5) Evaluation of pooled sera as a screening device in case detection.

(6) Evaluation of antibody titres as an index of the intensity of transmission.

(7) Evaluation of antisporozoite antibodies as an index of the intensity of transmission.

The next two examples are concerned with mortality and morbidity:

(8) Comparison of death registration in the population, mortality of in-patients, and questionnaires on mortality, as alternative indicators of mortality from all causes and from malaria.

(9) Evaluation of the clinical diagnosis of malaria as an indicator of malaria morbidity, through objective evaluation (to be defined - it is not the same as a positive blood film) of a sample of the diagnoses.

The last example is concerned with remote sensing:

(10) Given that strata have been tentatively defined in environmental terms, evaluation of available outputs of remote sensing as a tool for mapping the strata.

6.7 Development and evaluation of teaching/learning aids and methodologies concerned with stratification

Some of the materials that could be considered:

(1) A course outline, including slides and exercises (individual or collective).

(2) A self-teaching programmed instruction manual.

(3) A stratification game simulating, through a group discussion, the interaction of responsibilities and disciplines involved in stratification.

(4) Interactive computer simulations relating the cost of information, the cost of control, alternative decisions about stratification, and effectiveness of the programme.

Evaluation of the materials could be considered in terms of knowledge gained in a given time period, as assessed by pre- and post-tests, and in terms of subsequent performance in a real life stratification exercise.

6.8 Development and evaluation of data processing methodologies sensu lato concerned with stratification

There may be room for research concerned with economic and effective collection, recording and processing of data relevant for stratification; effective display of the outcomes of stratification, and methodologies for producing and updating such displays rapidly and economically.

Some of the methodologies developed by medical geographers may be relevant here, such as computer mapping, including the identification of clustering, significant deviations and associations.

Agenda

1. The conceptualization of stratification and its practical implications.

2. Definition of objectives of stratification and elaboration of approaches.

3. Techniques, measurement methods and criteria of stratification.

4. The resource requirements for and feasibility of carrying out stratification.

5. Differentiation of malaria control measures for delineated strata (practical application).

6. Methods of expressing and documenting stratification for dissemination of information and for training.

7. Practical considerations of malariological stratification as an integral component of stratification for the control of locally endemic diseases within the primary health care strategy.

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LIST OF WORKING PAPERS

Number	Title	Author
1.	Draft Agenda	
2.	List of Working Papers	
3.	List of Participants	
4.	The concept of stratification of territories and its practical implications	Dr V.S. Orlov et al.
5.	Operational stratification of malarious areas	Dr V.S. Orlov et al.
6.	Basic stratification of malarious areas	Dr V.S. Orlov et al.
7.	Practical approaches to the delineation of malarious areas in tropical Africa	Prof. M. Wéry
8.	Quantification and epidemiological diversity of malaria mortality in Africa - practical experience	Dr P. Carnevale Dr J. Vaugelade
9.	Epidemiological diversity and selection of measure for malaria control within the strategy of primary health care - an illustration of some experience in China	Dr C. Yang
10.	Integrated vector control and selection of measures suitable for specific epidemiological conditions	Dr R. Fontaine
11.	Approaches to malaria stratification in relation to the rational use of anti-malaria drugs	Dr A.V. Kondrashin
12.	Identification of possible research on development and evaluation of stratification methodologies	Dr L. Molineaux
13.	Stratification of malaria situations in tropical Africa for the development of malaria control through primary health care	Dr R.L. Kouznetsov Dr L. Molineaux Dr P.F. Beales

SCHEME OF OPERATIONAL STRATIFICATION (India)

INFORMATION PROGRAMME SUPPORT (District or zone level) — SELECTION OF PROGRAMME OBJECTIVES (Country/State/Province level)

CRITERIA	STAGE I. COLLECTION OF INFORMATION	STAGE II. PROCESSING THE DATA	STAGE III. GROUPING OF DATA	STAGE IV. ANALYSIS OF DATA	STAGE V. STRATIFICATION OF AREAS
I. MALARIOLOGICAL SITUATION BEFORE IMPLEMENTING CONTROL AND ERADICATION MEASURES (INITIAL ENDEMICITY LEVEL).	1. Results of malariometric surveys (or information on the ecology of the vector and parasite as well on social factors relevant to the spread of malaria). 2. Distribution and species of vectors	Table I. Results of malariometric surveys. Series of maps by factors which determine malaria malaria distribution. Map. Distribution areas of malaria vectors in the district	Map Ia. Initial malaria endemicity level. Map Ib. Degree of malariogenic potential.		1. Selection of priority areas. Map 7 + Map 8 ⟶ Map 7.8
II. THE SITUATION AT THE TIME OF THE GREATEST EPIDEMIOLOGICAL IMPROVEMENT.	3. Data on the quantity of blood slides collected and examined and positive slides by parasite species: for blocks that have been transferred into the consolidation phase (A); for blocks that remain in the attack phase (B)	Table 2. API in blocks at the time of transfer into consolidation phase. Table 3. API and AFI in blocks which always remained in the attack phase.	Map 2. Duration of improvement period. Map 3. Mean API/AFI for the 4-year period after reaching the lowest level.	AT THE CENTRAL LEVEL THE GROUPED DATA (MAPS 1-10) ARE GENERALIZED FOR THE WHOLE COUNTRY (Maps 7 through 10 for the entire country are drawn)	2. Making of malaria prognosis in priority areas. 2.1. Prognosis in the absence of measures Map 5a + Map 7.8 ⟶ Map 7.8.5a 2.2. Prognosis in the presence of measures. Map 2 + Map 3 + Map 7.8 ⟶ Map 7.8, 2.3.
III. THE MEASURES AND THE VOLUME AND DURATION OF WORK REQUIRED, TO OBTAIN AN EPIDEMIOLOGICAL IMPROVEMENT.	4. Data on insecticidal spraying over the whole period of reduction malaria prevalence/incidence. 5. Data on the use of antimalaria drugs for the same period.	Table 4. Total number of spraying rounds for the whole period of reduction of malaria prevalence/incidence. Table 5. Consumption of antimalaria drugs per capita for the whole period of reduction of malaria prevalence/incidence.	Map 4. Set and volume of measures required to obtain an epidemiological improvement.		3. Elaborating measures for the attainment of a maximum effect. Map 4 + Map 7.8 ⟶ Map 7.8.4
IV. THE PERIOD OF MALARIA RESURGENCE	6. AFI, AVI during the peak incidence year. 7. AFI, AVI during the peak incidence year minus 3 years.	Table 6. The rate of malaria resurgence.	Map 5a. The rate of P. falciparum resurgence. Map 5b. The rate of P. vivax resurgence.		4. Calculation of the present-day cost of measures that resulted in a maximum effect in the past.
V. THE PRESENT SITUATION	8.1. Monthly P. falciparum incidence for the last 5 years.	Table 7a. Monthly distribution of P. falciparum incidence. Graph 1a. Pattern of monthly distribution of P. falciparum incidence, mortality, malignant malaria cases and transmission period.			AS A RESULT, A MEDIUM-TERM PLAN OF MALARIA CONTROL MEASURES FOR THE WHOLE COUNTRY IS WORKED OUT, WITH REFERENCE TO GENERAL AND CONCRETE OBJECTIVES FOR EACH AREA TYPE.
	8.2. Monthly P. vivax incidence for the last 5 years.	Table 7b. Monthly distribution of P. vivax incidence. Graph 1b. Pattern of monthly distribution of P. vivax incidence and transmission season.			
	9. API for the last year 10. AFI for the last year.	Table 8. API & AFI for the last year.	Map 6. API for the last year		
	11. Data on number of malignant malaria cases and lethality for the whole observation period.	Table 9. Number of malignant falciparum malaria cases and deaths due to malaria for the whole observation period.	Map 7 P. falciparum malaria.		
	12. Data on existence of drug-resistance P. falciparum populations.	Table 10. P. falciparum drug-resistant.	Map 8. Drug resistance P. falciparum malaria.		
	13. Data on existence of insecticide-resistance vector populations for the last 3 years.	Table 11. Resistance of Anopheles to insecticides (data for the last 3 years).	Map 9. Distribution of malaria vectors and their resistance to insecticides.		
	14. Data on spraying and the use of antimalaria drugs for the last 5 years.	Table 12. The affect of measures on the incidence level.	Map 10a. Effect of measures on P. Falciparum incidence level. Map 10b. Effect of measures on P. vivax incidence level.		

AFI - Annual P. falciparum incidence; AVI - Annual P. vivax incidence; API - Annual parasite incidence

THE USE OF ANTIMALARIAL DRUGS IN DIFFERENT TYPES OF AREAS IN SOUTH-EAST ASIA (1985)

Treatment	Type of Area							
	1		2			3	4	5
	A	B	A	B	C			
Presumptive by ACD PCD DDC FTD	600 mg chloroquine	600 mg chloroquine	600 mg chloroquine	600 mg amodiaquine		As in 1	As in 1 and 2	1000 mg sulfadoxine/pyri-methamine + 45 mg primaquine 600 mg amodiaquine or chloroquine
Radical	1200 - 1500 mg chloroquine + 75 mg primaquine (5 days)	1500 mg chloroquine + 30 mg primaquine (once x 8 weeks)	1500 mg chloroquine + 45 mg primaquine	1000-1500 mg sulfadoxine /pyrimethamine + 45 mg primaquine or 1500 mg sulfalene/pyrimethamine + 45 mg primaquine		As in 1	As in 1 and 2	1500 mg chloroquine + 75 mg primaquine (five days) or sulfadoxine/pyrimethamine or sulfalene/pyrimethamine + 45 mg primaquine
Suppressive	-	-	-	-	-	-	-	300 mg amodiaquine once a week
Mass Drug Administration	600 mg chloroquine + 45 mg primaquine	600 mg chloroquine	600 mg amodiaquine + 45 mg primaquine					600 mg chloroquine + 45 mg primaquine

Type of area

1 = Area with overwhelming prevalence of P. vivax malaria:

A = Local population is free of G-6-PD deficiency
B = Local population is affected by different levels of G-6-PD deficiency

2 = Area with overwhelming prevalence of P. falciparum malaria:

A = P. falciparum sensitive to antimalarials
B = P. falciparum resistant at RI and RII levels
C = P. falciparum resistant at RIII level

3 = Area with a prevalence of P. malariae malaria

4 = Area with a more or less equal distribution of different malaria species

5 = Area with a large migrant population

ACD = Active case detection

PCD = Passive case detection

DDC = Drug distribution centres

FTD = Fever treatment depots

USE OF VARIOUS MALARIA CONTROL MEASURES IN DIFFERENT STRATA IN TROPICAL AFRICA

Strata	Antiparasite measures			Vector control measures														
				Reduction of man-mosquito contact					Spraying with insecticides		Control of mosquito breeding							
	Treatment of suspected or confirmed malaria cases	Chemoprophylaxis	Mass drug administration	Screening of suitable houses	Use of bednets	Use of repellents	Site selection of villages and communities	Deviation of vectors to animals	Indoor spraying	Outdoor spraying	Larviciding	Peri-domestic sanitation	Filling of small ponds & ditches	Drainage	Improvement of irrigation system	Shoreline transformation	Environmental manipulation in relation to irrigation system[6]	Other environmental manipulations[7]
1. Rural areas with stable perennial transmission.	+	+[1]	-	+	+	+	-	-	-	-	-	+	+	-	-	-	-	-
2. Rural areas with stable seasonal transmission.	+	+[1]	-	+	+	+	-	+	-	-	-	+	+	-	+	-	-	+
3. Rural areas with unstable transmission and possibility of recurrent epidemics, including oases.	+	+[1]	+[3]	+	+	+	-	+	+[3]	+[3]	+	+	+	+[8]	+	-	+[8]	+[8]
4. Rural areas at high altitude with unstable transmission and possibility of recurrent epidemics.	+	+[1]	+[3]	+	+	+	+[4]	+	+[3]	+[3]	-	+	+	+[8]	+[8]	-	+[8]	+[5]
5. Populations, nomadic pastoralists moving from strata to strata	+	+[1,2]	+[3]	-	+	+	+	+[5]	-	-	-	+	-	-	-	-	-	-
6. Modern irrigation schemes.	+	+[1]	+[3]	+	+	+	+	+	+[3]	+[3]	+	+	+	+	+	-	+	+[8]
7. Temporary development projects associated with aggregations of labour.	+	+[1]	+[3]	-	+	+	+	-	+[3]	+[3]	+[3]	+	+	+[8]	-	-	-	+[8]
8. Urban and suburban areas.	+	+[1]	-	+	+	+	+[4]	-	+[3]	+[3]	+	+	+	+	-	+	-	+[5]
9. Non-immune visitors or temporary residents in endemic areas.	+	+	-	+	+	+	+[5]	-	+[3]	-	-	+	-	-	-	-	-	-

1 = only for pregnant women
2 = for groups moving from strata 3 and 4 to strata 1 and 2
3 = in case of epidemic or epidemic threat
4 = for new settlements
5 = for camping
6 = water level fluctuations, intermittent irrigation, sluicing and flushing
7 = salinity regulation, vegetation clearance, reforestation or deforestation
8 = when applicable

THE USE OF ANTIMALARIAL DRUGS IN AREAS OF TROPICAL AFRICA WITH OR WITHOUT *P. FALCIPARUM* DRUG RESISTANCE

Treatment groups	Level of clinical competence	Areas where *P. falciparum* continues to be sensitive to chloroquine I	Areas where *P. falciparum* has a low grade and/or a low frequency of resistance to chloroquine II	Areas where *P. falciparum* has a high level and/or high frequency of resistance to chloroquine III	Areas where in addition to high resistance of *P. falciparum* to chloroquine the parasites are also resistant to sulfonomide/pyrimethamine combinations IV
A: Treatment of					
1.1 Mild and moderate malaria infections.	Primary health care level.	Chloroquine orally (25 mg base/kg) over 3 days.	Chloroquine orally (25 mg base/kg) over 3 days.	Amodiaquine (25 mg base/kg) over 3 days.	Amodiaquine (25 mg base/kg) over 3 days.
1.2 Mild and moderate malaria infections not responding to initial treatment.	Referral level		Amodiaquine orally (25 mg/kg) over 3 days or for non-immune subjects sulfadoxine or sulfalene (1500 mg) and pyrimethamine (75 mg).	Sulfadoxine or sulfalene (1500 mg) and pyrimethamine (75 mg).	Mefloquine (750 mg) or quinine 1800 mg for 7 days and tetracycline (5 mg/kg) 4 times a day for 7 days.
1.3 Severe malaria cases.	Referral level 1.3.1 Where facilities for intravenous are available.	Quinine 20 mg salt (loading dose) in 10 ml/kg isotonic saline or 5% dextrose i.v. infusion over 4 hours, then 10 mg salt/kg over 2 to 4 hours, 8-hourly until patient can swallow tablets, to complete 7 days treatment, or, chloroquine 5 mg base/kg in 10 ml/kg isotonic saline or 5% dextrose i.v. infusion over 4 hours then 5 mg base/kg over 2 to 4 hours, 12-hourly to total dose 25 mg base/ kg.	As in I A, 1.3.1 but only with quinine, as soon as patient can swallow tablets, a single dose of sulfadoxine or sulfalene (1500 mg) and pyrimethamine (75 mg).	As in II A, 1.3.1.	As in II A, 1.3.1 but only with quinine, as soon as patient can swallow tablets, a single dose of mefloquine (750 mg) or quinine 1800 mg a day until day 7 in conjunction with tetracycline (5 mg/kg) 4 times a day for 7 days.
	1.3.2 Where facilities for intravenous infusion are not available.	Quinine 10 mg salt i.m. 8-hourly until the patient can swallow tablets to complete 7 days treatment, or, chloroquine 5 mg base/kg i.m. 12-hourly to a total dose 25 mg base/kg, or as divided doses 2.5 mg base/kg, followed with another dose 2.5 mg base/kg then same dose may be repeated every 11 hours to a total dose 25 mg base/kg.	As in I A, 1.3.2 but only with quinine, as soon as patient can swallow tablets, a single dose of sulfadoxine or sulfalene (1500 mg) and pyrimethamine (75 mg).	As in II A, 1.3.2.	As in II A, 1.3.2 but only with quinine, as soon as patient can swallow tablets as above.
B: Chemoprophylaxis (once a week).		Chloroquine 5 mg base/mg.	Amodiaquine 5 mg base/kg.	As in II B. for special groups and conditions see text 4.3.	Not proposed, since no effective and safe drugs are at present recommended. For protection of special groups see text 4.4.
C: Mass drug administration[1] (periodicity depending on epidemiological conditions).		Chloroquine 10 mg base/kg and primaquine 30 - 45 mg.	Chloroquine or amodiaquine 10 mg base/kg and primaquine 30-45 mg.	Amodiaquine or chloroquine 10 mg base/kg and primaquine 30 - 45 mg.	Not proposed, since no effective and safe drug or combination of drugs are at present recommended.

[1] It is assumed that this will only occur in combination with effective antivector measures and the period of mass drug administration is limited to a very short period required to control an epidemic.

INTEGRATED VECTOR CONTROL AND SELECTION OF MEASURES SUITABLE FOR SPECIFIC EPIDEMIOLOGICAL MEASURES

Introduction

Integrated vector control (IVC) is the utilization of all appropriate technology to bring about an effective degree of vector control, for the suppression of diseases, and requires as a basis, sound ecological understanding, considering the environment as well as public health. Implied is a careful orchestration of individual methods to achieve the required goal. While implying that multiple measures of vector control are needed, IVC should not exclude the intentional application of a single measure where knowledge of naturally occuring biotic and abiotic population controls and vector habits indicate that the single applied measure alone may suffice. Stratification of a malaria problem may aid integrated vector control, by accurately classifying a set of local background conditions, facilitating preparation for action and selection of the correct mixture of measures.

IVC encompasses six essential characteristics:

(1) A sound ecological understanding of the target vectors.

(2) A quantititive analysis of the costs and benefits of a programme in terms of its impact on man and his environment.

(3) Implementation of source reduction programmes wherever possible.

(4) Development and implementation of a supplemental programme involving an integration of complementary control measures.

(5) Development of a monitoring system that will detect changes in the effects of the mosquito control programme.

(6) A constant update of the control programme to meet changes in the ecologies of the target mosquitos.

Ecological background control measures and surveillance require some further elaboration.

1. Ecological background

For any given vector species or strain it can be assumed that a set of natural biotic and abiotic factors and genetic variability influence its distribution, abundance and response to control measures. However, our current knowledge of these natural controls for any mosquito species is limited. Our ability to accurately describe the true niche of a given species and the catastrophic or density-dependent factors which reduce populations will enable us to further limit the extent and refine the methodology of control measures. The understanding will improve with time and research. Meanwhile, our attempts to control vector abundance and man-biting behaviour will continue to be partially integrated, partially selective, and somewhat of an overkill.

An analogy with integrated pest management for agriculture may help our understanding of the relationship of eco-epidemiological stratification of malaria to IVC. Agricultural pests reach abundance within homogeneous strata. These consist of uniform resources designed by man for man, the crop. Thus, agriculturalists study pest ecology and design control within these preformed strata. The resource supporting the population of a single strain of mosquito vector (even man-made problems) is rarely distributed uniformly in time or space. So in one sense the topographical and cultural diversity of any area presents a confusion which might be better understood after stratification. If successes of integrated pest management can be partically attributed to the simplicity of the resource, then stratification will certainly aid integrated vector control.

2. Control measures

Vector control programmes are now confronted with numerous physical, chemical, biological, and genetic control measures. Available measures are similarly compiled in technical manuals and these in turn are revised periodically. While there is no great need to further understand control measures over and above an increased understanding of the eco-epidemiological situation where they are applied, the use of multiple measures will bring up questions of sequencing, timing, and interaction. While the sequence of source reduction followed by complementary methods, may not be appropriate in all settings, it does imply that these two classes of measures be considered carefully when integrating them. They should often be applied in order rather than by blanket coverage and their interaction with simultaneously applied or existent natural controls must be considered.

3. Surveillance

With malaria control, the goal of integrated vector control - an incidence threshold, acceptable to the community - should serve as the ultimate standard for surveillance operations, but not as the immediate indicator for antivector measures. Factors, which accurately forecast the risk of transmission should therefore be chosen for monitoring. Anopheline density, longevity, man-biting habit and length of the sporogonic cycle can all influence malaria transmission alone or in combination. Density surveillance is simplest and in many but not all situations may be most appropriate. Additionally, density monitoring is the unavoidable first step to monitoring either longevity or man-biting habit. Where longevity or man-biting habit do vary sufficiently under natural conditions, particularly for species whose density tends toward stability, the monitoring of all three factors should be considered. Often interventions are intentionally designed to alter longevity or man-biting rates, thereby requiring some sort of periodic assessment of these variables. Where ambient temperatures characteristically reach a lower extreme, *Plasmodium* development in the vector, ambient temperature monitoring would certainly aid an integrated vector control programme. The setting of these thresholds followed by surveillance allows concentration of control efforts in time and place, and an immediate evaluation of the measures implemented.

The diversity of control measures used will also prescribe certain supplemental surveillance measures. Larval control must be complemented by surveillance of larval habitats and threshold levels of tolerance conceived to be associated with production of critical levels of adult anophelines. When pesticides are used, periodic reassessment of susceptibility should also be incorporated into the surveillance programme. More sophisticated control measures will require additional secondary monitoring. While a large variety of secondary monitoring systems may have to be considered, the numbers in a practical control programme must be limited to those which are truly essential.

In conclusion, surveillance for integrated control takes several forms with several purposes. The methods used will naturally vary in accordance with the eco-epidemiological situation. Understanding the vector ecology and disease ecology will naturally assist in choosing among various surveillance measures. The selection of the type of surveillance measure as well as their geographic distribution and density may similarly be modified by a preliminary and ongoing stratification of the problem.

Current integrated vector system for malaria control

Accounts of integrated vector systems for malaria control are very sparse, particularly in comparison to the frequency of reviews or presentations of the principles of integrated vector control. Several are in small, relatively homogeneous areas obviating the need for a major eco-epidemiological stratification. Presumably, many malaria control programmes currently have IVC underway which for various reasons remain incomplete or incompletely documented.

References

Alekseyeva, Z.M., Medico-geographical evaluation of the malariogenic potential in the USSR's territory. Thesis of a Candidate of Geographical Science, 1982 (in Russian)

Atlas of Tanganyika, Survey and Mapping Division, Dar es-Salaam, 1956.

Bakradze, T.L. Osobennasti epidemiologü malarü y processe ee likvidustsü y grazinskoy SSR. [Characteristics of epidemiology of malaria during its eradication in the Georgean SSR], Virsaladze, Tbilisi, 1974, 205 pp (in Russian)

Beklemishov, V.N. [The influence of migration on malaria during the great patriotic eras and the necessary control measures.], Medical parasitology and parasitic diseases, 15 (3): 3-24, 1947 (in Russian)

Bustamente, F.M. Distribuicao geografica e periodicidade estacional da malaria no Brasil e sua relacao com os fatores climatices. Situacao atual do probleme, 18th International Congress of Geography, Rio de Janeiro, 8-19 August 1956

Celli, A., Malaria, Longman Green, London, 1900, 275 pp

EURO. Receptivity to malaria and other parasitic diseases. Report on a WHO Working Group, Izmir, 11-15 September 1978, EURO Reports and Studies no.15, WHO Regional Office for Europe, Copenhagen, 1979.

Gabaldon, A., Malaria incidence in the West Indies and South America. In: Malariology, Boyd, M.F., ed. (1949), 2 vols., Philadelphia & London, Vol. 1, 764-787

Gill, C.A., The Seasonal periodicity of malaria and the mechanism of the epidemic wave, Churchill, London, 1938.

Karunaratne, W.A., The influence of malaria control vital statistics in Ceylon, Journal of hygiene and tropical medicine, 68: 79-85, 1959

Klug, A.S., [Typing of malaria foci in Bushkiria,] In: Proceedings of Bushkirskiy Inst. EMS, Issue 1, 160-164, 1941, (in Russian).

Lysenko, A.Y., Nemirovskaya, A.I., Malarykov, E.S., Ivanova, L.V., [Experience in Tadzikistan malaria foci typing, 1958,] In: Proceedings on malaria and helminthiases, Stalinabad, Vol. 1, 5 - 12, 1956, (in Russian)

Lysenko, A.Y., [Investigations on epidemiology of malaria in North Vietnam. IV. Division of North Vietnam into malaria zones.] Medical parasitology and parasitic diseases, 34: 189-194, 1965, (in Russian).

Lysenko, A.Y. & Semashko, I.N. [Geography of malaria,] In: Lebedev, A.W. ed. "Medical Geography", Academy of Services, USSR, Moscow, 1968 (in Russian)

McDonald, G. The epidemiology and control of malaria, Oxford University Press, London, 1957, 201 pp.

Singh, J., Malaria and its control in India. Journal of the Royal Sanitary Institute, 72: 515-625 (1952).

Slipitsina, N.K. Transmission season and the zones of malaria in the Soviet Union. In: Problems of medical parasitology and prevention of infectious diseases, Moscow, 258-257, 1964 (in Russian)

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