MANUAL ON PERSONAL AND COMMUNITY PROTECTION AGAINST MALARIA IN DEVELOPMENT AREAS AND NEW SETTLEMENTS

prepared by the

WHO Division of Malaria and Other Parasitic Diseases

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# Preface

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PREFACE

The first draft of this manual was prepared in 1969 by the late Dr E. J. Pampana (former Director of the WHO Division of Malaria Eradication) and represents one of the last contributions of this eminent malariologist to WHO antimalaria programmes. It was the time when a revised global strategy of malaria eradication was under way and when new developments in the science and application of malariology were being reported – a matter which necessitated a delay in printing the original manuscript with a view to up-dating it to conform with these new developments.

In its revised format, as a manual on personal and community protection against malaria in development areas and new settlements, it is mainly intended for health and economic planners in developing countries having a malaria problem. The malaria specialist can find in it also recommended approaches to deal with the malaria problem in such development areas or new settlements. It is hoped that this manual will prove a valuable guide in the protection against a disease long known to be a major deterrent to socioeconomic development, and will thus serve governments, United Nations agencies, bilateral agencies, big firms, corporations, or private enterprises, assisting or engaged in such developmental activities, particularly in the developing countries, where malaria still exerts its toll on human life, causing much sickness and misery.

It is realized that groups of workers assembled at construction sites are particularly liable to epidemics caused by various micro-organisms on account of the non-uniform immunological status of the workers and their families. These people will previously have been exposed to different infections circulating in the locality where they came from, and some may even harbour disease agents. In addition, parasitic diseases such as schistosomiasis and filariasis may spread in these artificial agglomerations, particularly in projects where artificial water impoundments are under construction. The reader will find some reference to these possibilities in the manual, which otherwise deals exclusively with malaria.
1. INTRODUCTION

In many developing countries today, new types of population movements are occurring apart from the traditional nomadic or seminomadic movements or those of seasonal pastoral or agricultural pendular migrations (transhumance). The new migratory movements we are concerned with here have certain objectives: either to seek paid employment or to settle down in recently opened up or reclaimed land.

The first category of migratory movement is generally towards planned construction projects needed for the development of the country, including dams and lakes for hydroelectric power, irrigation, and water management purposes, irrigation canal networks, roads, and railways. These development projects require a large labour force, a small proportion of which can be recruited within the project area but the great majority must be brought into the locality from different parts of the country, and even from other countries, for rather lengthy periods extending over many months or even years.

The second category consists of migrations towards areas which have recently become promising for newcomers, perhaps because they have been made healthier than they were by malaria control or eradication activities, or because they have been opened up to immigration, thanks to the construction of roads or irrigation networks or the clearing of jungle, possibly promoted through the assistance offered by the government or other agencies to the new settlers.

In both these types of migratory movement, the initiative comes from the individual himself, from his family, or the community. In the first category, however, it is usual for thousands of people to aggregate independently in the project area. As soon as they arrive at the project, they are organized into a hierarchical community under a chief who usually attends first to the organization of the housing or camps for the labour force and the provision of medical care and sanitation needed for all project personnel, including the labourers and their families. Such sanitary and health protection measures are considered essential, not only from a humanitarian point of view, but also to serve the main interests of the project. This manual is intended mainly for planners, constructors, and project managers to explain why development projects, by changing the ecological features of the area, often increase health hazards, particularly with regard to malaria. In tropical and subtropical countries where malaria transmission occurs, malaria usually heads the list of hazards. It is a common experience that in the appropriate season a malaria epidemic often occurs only a couple of months after the arrival of the immigrants, claiming many lives and causing so much sickness as to disrupt the timetable of operations and jeopardize the success of the whole project. It is essential, therefore, that the capital investment for the project should include funds for safeguarding the health of the community in the project area, particularly against malaria.

The second category of migratory movements for settlement, particularly when not planned, would expose the immigrants to similar health hazards but unfortunately these immigrants are not incorporated into an organized hierarchical community and have no leader or contractor interested in their work output or health. Further, the area where they intend to settle often has no adequate health service, either for preventive or for curative medicine, and may even be beyond the reach of the national administrative organizations. Ways of offering such immigrants at least some protection against malaria, which if left rampant would cause havoc and destroy the immigrants' hopes of settling in the new land, are also explored in this manual.
2. THE PHENOMENON OF IMMIGRATION INTO DEVELOPMENT PROJECTS OR INTO NEW SETTLEMENTS, AND ITS EPIDEMIOLOGICAL IMPLICATIONS

It is well known that movements of population in malarious areas have their adverse effects, reflected by a rising malaria transmission level and a consequent increase in the incidence of infection. Such movements, when not compulsory, are made voluntarily with the intention of improving living conditions, either through paid employment or settlement in new lands to exploit the natural resources. These movements resemble the classical migrations of earlier times when better pastures or seasonal cultivation were the objectives of the periodical movements of nomadic or seminomadic groups.

The migrants who are the object of this manual (henceforth referred to as "immigrants"), whether they proceed to work in a development project or to settle in new lands, differ from nomads and seminomads in the following ways:

(a) their migrations are not periodical and pendular since they may stay in the same locality for months or even for a lifetime;

(b) nomads and seminomads join compact interrelated groups coming from a particular area and moving together. The immigrants dealt with in this manual are rather assorted and unrelated groups of people, often coming from different localities and usually accompanied by their wives and children;

(c) during their migrations, nomads or seminomads continue to live in close touch within their group, while immigrants often live in contact with other immigrants from different localities as well as with the local population of what we shall refer to as the "project area" or the "aggregation area";1

(d) nomads and seminomads generally roam with their tents while project immigrants are often accommodated in labour camps and immigrants to new settlements have to live, for some time at least, in improvised shelters;

(e) nomads and seminomads usually move with their cattle and other domestic animals, while the immigrants in most cases arrive at their place of work without livestock.

All these features of the immigrants' life have a bearing on malaria epidemiology. First, owing to the fact that the immigrants come from different areas, some may be, or have been, infected with malaria parasites and are thus more or less immune; however, their babies and young children as well as the immigrants arriving from non-malarious areas will have no immunity to malaria. The former, should they settle in an area where malaria transmission occurs, will increase the number of sources of infection in the locality while the non-immune immigrants will offer the malaria parasites a good chance to produce great numbers of gametocytes and consequently such people become important sources of infection for the local malaria vectors. Secondly, immigrants, at least for some time after their arrival, are likely to spend the night in improvised shelters and thus are greatly exposed to the bites of vectors. Thirdly, the construction works and the establishment of new settlements involve excavations of soil and the formation of new surface water collections such as borrow-pits, ditches, and pools, not to mention the lakes resulting from the construction of dams or swamps resulting from the interruption of the natural land drainage by embankments built to carry roads, railways, etc. The aggregation area will thus progressively offer increased breeding sites for the vectors—permanent sites, such as those cited, or potential sites in dried-out areas that fill when the rains come.

Fourthly, immigrants arriving without cattle may be the cause of increased man-biting by anophelines, so that a species that was formerly a weak vector becomes a more important one.

1 In this manual "aggregation area" refers to the area where the staff and labourers work and have their living quarters, while "project area" refers to the aggregation area and the surrounding villages within a 3-km radius.
Fifthly, for the sake of completeness, it should be added that the strains of malaria parasite harboured by the immigrants may differ immunologically from those infecting the local population and there may be an absence of cross-immunity.

All these factors can raise the maliariogenic potential of the area. In tropical climates and with efficient vector species, but also with weaker vectors, the interplay between these factors gives rise to severe malaria epidemics and a very high endemicity is established in an area which may previously have had only a low or moderate endemicity. In India, tropical aggregations of labour and the accompanying malaria epidemics have in the course of time transformed many areas which had been slightly maliarious into highly endemic ones. Events of this nature were described as early as 60 years ago by Christophers & Bentley (1908) who referred to them as "tropical aggregations of labour". The tragic picture of the latter was vividly described by Bentley (1911) in the following way.

"In the east, the coolie labourers . . . are drawn almost entirely from the poorest and most ignorant classes of the population; they are often brought long distances and set down in a country where the climate, and even the food obtainable, differs greatly from that to which they are accustomed. If housed at all, they are generally crowded into temporary huts, but frequently they are left to find what shelter they can. Often they have no one to look after them when sick and no means of obtaining food when they are unable to work. Their work is arduous and their pay is small; and it is no uncommon thing to find them attempting to exist upon a miserably insufficient diet. Camped, as they usually are, upon the site of their work, their surroundings are almost always highly insanitary and, if much earth-work is going on, the numerous pools of water speedily become the breeding places of countless swarms of mosquitoes. In these circumstances it is not surprising that coolie labourers should be decimated by epidemics. But whatever happens to the coolies, the work has still to go forward, so that, as long as it is in progress, there is continued immigration of new labourers to fill the gaps caused in the labour force by sickness, desertion and death. This continual immigration is a further source of mischief, for the constant introduction of gangs of susceptible newcomers into camps which already are hotbeds of disease increases the trouble, just as the addition of fuel to a glowing fire increases the blaze."

The geographical location of a project area has a great bearing on the maliariogenic potential caused by aggregate labour. In maliarious areas of the temperate zones such aggregations cause less danger than those in tropical or subtropical ones. In the former, malaria is only seasonal and during most of the year cannot be transmitted. Moreover, Plasmodium falciparum is generally absent, and even when introduced it tends to disappear spontaneously. It may be mentioned also that most of the countries in temperate zones have already eradicated malaria.

In tropical zones in Africa, it is known that malaria epidemics do not occur among the population in holoendemic areas and consequently, if the immigrants also come from a holoendemic area, the two groups are likely to be highly immune to new infections causing overt attacks among the adult population, although babies and young children and non-immune expatriates will succumb to the disease.

On the other hand, many mountainous tropical countries in Africa have experienced great failures in settling inhabitants from the densely populated plateau areas (above an altitude of 2000 m), where no malaria transmission exists, in the extensive, sparsely populated - though very fertile - low-lying valleys situated in the holoendemic malaria belt because shortly after their arrival these non-immune immigrants are decimated by malaria epidemics and those who survive run away.

In territories other than those in tropical Africa where holoendemic malaria is rare, labour aggregations represent a much more serious problem as malaria epidemics affect both the stable population and the immigrants.
It is essential that an assessment of the malaria hazard that could be precipitated by labour aggregations should be made prior to the arrival of the immigrants. If malaria transmission is not possible in the area on account of the absence of suitable vectors, there will of course be no danger; similarly, there will be no danger if the local population has no malaria and the immigrants come from areas that are also free from malaria. If the immigrants are free from malaria while there is a source of infection for the local population, a large influx of non-immune immigrants and an increase in density of the vector population could give rise to intense transmission. If the stable population, in spite of the presence of vectors, has no malaria (anophelism without malaria) while a certain proportion of the immigrants are infected, transmission may increase and give rise to an epidemic outbreak; such events are well known in "war malaria". Techniques available at present for quantifying this hazard are still unsatisfactory. An estimation of the local reproduction rate (MacDonald, 1957) cannot give us much information because among the various factors the anopheline density in relation to man, referred to in the formula as "m", and the proportion of anophelines with sporozoites in the salivary glands which are actually infective, referred to as "b", are likely to increase as immigration continues. Moreover, the aggregation will be composed of immunes and non-immunes and their numbers will be unknown, so that we cannot guess how many sources of infection will arrive in the area. Likewise, the determination of vectorial capacity based on studies of local vectors - apart from its recognized limitations - cannot tell us what will happen when the aggregation is taking place.

Moreover, attempts to determine the various levels of malarial potential have not yet attained a general consensus, and as this manual is intended to offer some general guidance on protection against malaria, a practical way of discriminating between areas where the receptivity is low, medium, or high, has to be recommended. A convenient system has been developed by Indian malarologists to indicate the degree of danger for non-immune troops when they go to a malarious area - a phenomenon compared to that of aggregations of labour forces in a development project or a new settlement in malarious areas. It is based on the local spleen rate (among the 2-9 years age group), provided this rate is known for the area before any control or eradication activities take place.

If the spleen rate is nil, the danger is also nil. If the spleen rate is 1-10% the danger is low, if it is 11-30% the danger is high, and if it is above 30% the danger is extreme (India, Armed Forces Medical Services, 1953). The use of spleen rates, although it has lost much ground since the 1940s, particularly after the excellent results obtained in extensive insecticidal residual spraying campaigns when it was replaced by parasite prevalence or incidence has also been found to have serious drawbacks in developing countries where such campaigns have not been carried out or are limited in extent, even if the method was once extensively and successfully employed. The spleen rate is still a valuable and very convenient epidemiological method which does not require laboratory services, can be obtained anywhere in a short time, and gives a rather stable index that does not change much during the course of the year. As most development or settlement projects are taking place in malarious developing countries, the Indian system - as an arbitrary tool - for assessing the malaria danger in project areas has been adopted here. The "high danger zone" will be the area where the population before malaria control or eradication had a spleen rate of between 11% and 30% while the "extreme danger zone" will be the area with a spleen rate of above 30%. For areas referred to above as "low danger zones" having a spleen rate below 10%, we prefer to retain the term "hypo-endemic zones".

3. VARIETIES AND CLASSIFICATION OF THE PHENOMENON

It has already been mentioned that the most important difference between the two types of immigration is that immigrants looking for employment in a development project will soon be established in an organized community comprising the whole labour force while this will not happen to immigrants looking for a new place to settle in.
From the standpoint of the measures to be applied in order to protect the immigrants against malaria (or any other disease) the first group is pyramidaly structured and at the top is the executor of the project - whether a small contractor or the executive manager of a large corporation - who is responsible for the health of the immigrants. In the pre-planning stage, the health authority can start discussing health measures for the future project with the executor. Similarly, during the planning stage, the health authority will be able to insert in the proposed health plan of the project its own scheme of measures to be applied, and will also deal with the same project executor in all health matters during the development phase. As every development project must have a plan of operations, the enterprise can therefore be described as a planned one. This allows the health authority of the country to study the area chosen before work begins and to propose, if technically indicated, some modification of the site originally envisaged for the labour camps and draft a plan of health (including an antimalaria programme) for inclusion together with the required budgetary provisions in the total plan of the project. The plan may also contain clauses that make it obligatory for the executor to be responsible for the execution of the health plan according to the instructions outlined in the section covering health protection (p. 32); in case of non-compliance, the other party could apply sanctions just as it would if the target dates of the contract were not met.

For immigrants moving to a new settlement area who have no organizational structure, even after they have commenced settling in the area, there is no chief or leader with whom the health authorities can negotiate a health protection plan. Moreover, most of these “loose” immigrations into new settlement areas are unplanned and involve individuals and their families wishing to move forwards to a “new frontier” - an expression that has been adopted in some countries of eastern Asia. In a few instances the government may have planned for such settlements, including housing schemes and the provision of medical care and sanitation, but as the new settlements represent a new frontier arrangements prepared in advance seldom all function satisfactorily. It may be stated that in no planned settlement of this type can be found the full coverage of health and social needs that certain major development projects have for their people living in the aggregation area.

It must also be realized that the various antimalaria measures to be recommended for either of the main immigrant groups will also vary according to the type of antimalaria programme in the country as a whole. If a country-wide malaria eradication programme is operating the eradication measures must cover also the aggregation area to attain complete interruption of transmission. If there is no malaria eradication programme but only a control programme, the antimalaria measures will aim at significantly reducing the malaria prevalence rate to the same target level as that attained in the other areas of the country where control is applied. If no organization for malaria control exists in rural areas, this should be introduced into all development projects and perhaps in some of the planned new settlements; in the unplanned settlements attempts to prevent deaths from malaria and reduce morbidity associated with it will perhaps be the only realistic goal.

4. PLANNED DEVELOPMENT PROJECTS

4.1 Examples of planned development projects

Such projects, mostly occurring in rural areas of developing countries, are gradually increasing in number all over the world as a result of national aspirations and efforts made to hasten development, and through the promotion of such activities by means of bilateral or international assistance.

In this manual, a development project is considered as any public works project that is not maintenance work, i.e., routine and repairs, but which needs hundreds or thousands of

1 Such types of settlement should not be confused with the planned settlement (or resettlement) of people evacuated from areas to be flooded by major impoundment schemes such as the Aswan High Dam in Egypt. This type of settlement is an organized one and included in the overall development scheme to ensure the provision of all housing, health, education, and other social amenities.
labourers recruited from different parts of the country, or even from abroad, who gather in the locality of the project and/or in neighbouring villages. As has been said before, the range of sizes of such projects is quite large—from the forest clearing project that may require a few hundred woodcutters to multipurpose development projects with thousands of labourers and employees, constituting almost a state within a state, such as the Tennessee Valley Programme, the Kariba Dam, the Aswan High Dam, the Mekong River Project, the Trans-Gabonais Railways, and the Onchocerciasis Control Programme in the Volta River Basin area. Irrespective of size, if such a project is in a tropical malarious zone all the consequences of "tropical aggregation of labour" will follow unless a plan for an antimalaria programme has been stipulated in the development scheme and all requirements for its implementation have been ensured.

It might be assumed that after the many lessons of past history public leaders realize that in such labour aggregations the whole development scheme will suffer unless the protection of health is well planned and efficiently carried out. Men will be stricken by malaria, and some will die; many will leave the project as soon as their fever subsides and newcomers will follow them. In severe outbreaks the work cannot continue at a normal rhythm and the whole scheme may finally be abandoned. Some classical examples may be quoted here.

The construction of the Panama canal is an example that should not be forgotten. In 8 years, the French project suffered 50 000 deaths from malaria and yellow fever, and the work could not continue. In May 1904, the United States Government took over but the health situation did not improve until the Surgeon-General of the United States Army succeeded in entrusting the responsibility of sanitary work to General Gorgas. In 1906, yellow fever claimed its last victim in Panama; that year malaria among the canal workers still caused a yearly hospital admission rate of 821 per 1000; 7 years later in 1913 the rate of hospital admissions had dropped to 76 per 1000. Russell (1955) stated that "had the same death rate prevailed for the Americans as for the French, there would have been 71 000 more deaths among the American employees than actually occurred from 1904-14." During the whole period of construction of the canal, the prevention of disease, which allowed the huge project to be successfully completed, cost only 1.7% of the total cost. Russell (op. cit.), quoting Gorgas, stated "that this small percentage devoted to health probably saved the U.S. a total of $80 million." Needless to say, Gorgas' classical antimalarial work was carried out before modern antimalarial drugs and insecticides had been discovered. "According to Gorgas the control work consisted, in order of importance, of drainage, brush and grass cutting, oiling, use of soluble larvicide, prophylactic quinine, screening and the killing of adult mosquitoes in the quarters of labourers" (Russell, op. cit.).

Another gigantic development project of the pre-eradication era was that of the Tennessee Valley, which should be regarded as a model for all large multipurpose development projects in malarious areas. The 1933 Tennessee Valley plan called for the construction of a series of great multipurpose dams to form a chain of lakes from the river mouth to the headwaters of the tributary rivers. The primary purposes of the scheme were to provide a navigable channel for river transportation, to control devastating flood waters, and to produce low-cost hydroelectric power. The region was highly malarious; in 1934, a blood survey along 75 miles of the river showed an average malaria infection rate of 35% (in certain areas, it reached a maximum of 78%) and it was known by previous experience that impoundments made on other rivers had resulted in malaria epidemics transmitted by the same vector, Anopheles quadrinaculatus, that was present in the Tennessee Valley. Antimalaria work consisted chiefly of sanitary engineering measures and was so successful that not only were the huge forces of the tremendous scheme protected but malaria was greatly reduced in many areas (Tennessee Valley Authority, 1947). Since 1948, i.e., 6 years before the resolution for malaria eradication was adopted by the fourteenth Pan American Sanitary Conference, not a single indigenous case of malaria has been found by careful and continuing surveillance in the areas affected by this project.
Other examples from India demonstrate the many instances of malaria epidemics arising from tropical aggregations of labour. "One among the many examples of the pre-DDT era, but as recent as 1942, where antimalaria cover was not provided, was the large railway construction project at Rangahapur, near Manipur Road (Assam) which started in April 1942. Only six weeks later, 90% of the labourers became ineffective through malaria and the project had to be closed down" (Afridi, 1962). Already in 1917, however, Clemenha (1917) had given numerous examples of malaria epidemics following the construction of railways and put forward the proposal that "as soon as the Railway Board have decided to construct any portion of the line ..., information shall be given to the local Government concerned who will arrange to convene a committee" consisting of various responsible officials and among them, the Malaria Research Officer of the Province.

Another example is the Sarda canal construction project (1920-29) from which much can be learned. This project was located in the Indian terai where the conditions existing were such that epidemic malaria was certain to occur among the labour aggregations during the autumn. Such an epidemic did occur before antimalaria measures were started, and the work had to be closed down because 96 men out of every 100 imported went down with fever at one time or another and the constructors refused to carry on with the work until the working conditions were ameliorated by the control of malaria.

It is surprising to read how, some 40 years ago, able malariologists in India succeeded in controlling malaria under those circumstances in spite of the continuous turnover of the labour force (Senior White, 1928), but their awareness was the result of many sad experiences.

4.2 Delegation of authority to the executor of the project, coordination with national health authorities, and examples of antimalaria programmes in major projects

In planning a major development project in a malarious region, particularly in the tropical and subtropical belts, a section dealing with health protection, including the important topic of malaria prevention among the workers and their families in the project area, should be included in the plan of operations for the project. In major projects with thousands of employees and labourers, protection should also cover the populations of villages situated in the work area or within a radius of 3 km. In minor projects (e.g., forest clearing, minor road or canal construction work, etc.), protection can be limited to the employees and labourers with their families, and the corresponding tasks should be detailed in the contract.

The responsibility for fulfilling the health clauses in the plan of operations or, more simply, the contract should rest, particularly in developing countries, with the project manager representing the executor of the project whether it is a large company or an international agency such as FAO or a small project executed by a contractor. Financial provisions for the health work should have been specified and included within the budgetary provisions for the whole project. This applies equally to projects undertaken by governments through assistance from private firms, bilateral agencies, or multilateral agencies such as the United Nations Development Programme (UNDP) (see Annex 3). Should the executor of the project be a government or an international agency, the latter may allocate all or parts of the work to contractors; in that case it may be convenient to delegate to them also, in their special areas of activity, the application of health protection measures.

The technical supervision of all health protection activities, though possibly executed by different organizations, should always rest with the national health authority. In the case of developed countries, the government could carry out the programme through its own organizations, and the responsibility for applying adequate health protection measures should then rest with the national health authority and, as regards malaria, with the national malaria eradication service or malaria control organization, if either exists. In certain instances, local councils have to be involved in the planning and execution of the health measures.
Usually, the work of a major development project is carried out through contractors and subcontractors selected on the basis of submitted tenders. It is very important that when the executor calls for tenders, the requirements concerning the health protection should be clearly specified as an obligation on the contractor or the subcontractor. Companies submitting tenders must also be instructed about what they are expected to do in the fields of health and sanitation. This instruction to tenderers is often disregarded. One example of this neglect occurred in a major project in Laos; an epidemic of malaria broke out, and 2 labourers out of a total of 1132 died of the disease and 6 foreign engineers had to be flown back to their country of origin for treatment for pernicious forms of malaria. The programme was so disrupted by the epidemic that the contractor applied for a year's extension of the contract (involving an additional cost of US $720 000). In this project, malaria was not even mentioned in the instructions given to the tenderers; labour camps were not put under surveillance, and neither residual spraying nor drug prophylaxis was prescribed.

Although this manual is mainly concerned with malaria protection, it should not be forgotten that the immigrant labour in tropical countries is exposed to a number of other serious health problems including dysentery, pneumonia, schistosomiasis, leishmaniasis, trypanosomiasis, and onchocerciasis. Thus, if a major project is in an area that is not effectively looked after by a government health unit ensuring basic health services, however simple, and if the government is unable to establish such a unit in time, it is highly desirable that the contracting firm should establish a health service and this item should, of course, be specified in the health section of the plan of operations. Some beds should be available in the health unit, and if a hospital is not being built in the area there should be facilities for taking patients who need hospital care to the nearest hospital. The unit should also ensure basic sanitation, including a safe water supply, the sanitary disposal of excreta and refuse, and assist in solving the problem of housing. The technical supervision of these basic health services, temporarily operated by the project, should remain with the government and efforts be made to coordinate these activities with national health activities in the rest of the country with a view to ensuring the continuation of such services once the project is completed. The same should be done in the fields of agriculture, social and economic development, education, etc. The project colony may in fact become a state within the state and it should not be cut off from its administrative framework.

In minor projects with a labour force of a few hundred, there should be at least a small health unit operated by one or more polyvalent medical auxiliaries able to give elementary medical care, some advice on sanitation and, as regards malaria, treat fever cases, take blood specimens when instructed, and follow the instructions of the national malaria eradication service or malaria control organization.

The Volta River Project in West Africa exemplifies many of the points raised above. The Volta is some 1600 km in length. In the early 1950s, the United Kingdom and the Gold Coast Governments appointed a Preparatory Commission to make a detailed feasibility study for damming the lower Volta. The cooperation of the late Dean Topping and Professor George MacDonald was enlisted to prepare the chapter on health in the report of the Commission. Their recommendations constitute a blueprint of how to set about providing health protection in a major engineering project in a tropical region and cover not only malaria but also all major health risks (Preparatory Commission for the Volta River Project, 1956). The project envisaged, however, proved to be too expensive and in 1957 the Gold Coast (now Ghana) entrusted the work to an engineering firm which introduced certain modifications in the engineering scheme and made its financing possible. To give some idea of the scope of the project, the plans provided for the building of a 640-m long rock-filled dam at Akosombo and the construction of an aluminium shelter on the new harbour of Tema. The man-made lake resulting from the dam necessitated the resettlement of 50 000 people in other areas. The dam was to be built by another contracted firm (which had 2800 labourers at a time), but the Ghana Government retained the services of certain supervisors and consulting engineers of the former firm and, through a Government contract, this consultant staff was authorized to establish sanitary rules and regulations for all persons employed. The main antimalaria measures comprised twice-yearly DDT house-spraying, larval control - though not widespread - and a drug suppression programme
for expatriates. New houses were provided for the labour forces. Outpatient clinics and a hospital (operated by the Government) were established. Through these health protection measures, the general level of health of both Africans and expatriates on the project remained good (Hughes, 1963).

Another example is the Kariba Hydroelectric Project (Webster, 1960) located in an area of Zambia with a sparse indigenous population having a spleen rate of 80% and a parasite rate of over 30%. *A. gambiæ* was present in high density and the danger of an epidemic following the arrival of immigrants was obvious. The Kariba Project Board started by appointing a medical officer and a malaria control officer. Before the arrival of large numbers of immigrants, antilarval oiling operations were carried out in rock pools and selected breeding places. This selective oiling operation was later largely discontinued on the basis of results of catching stations. After September 1955, house-spraying on a total coverage basis was carried out three times a year using a 10% gamma-HCH water dispersible powder formulation. New dwellings were sprayed before being occupied. Constant watch was kept for the occurrence of any new living compounds and improvised dwellings that could not be sprayed were destroyed. Elaborate houses were also sprayed but with an HCH emulsion. Drug prophylaxis was free and compulsory for all workers (pyrimethamine, 25 mg weekly) and provision for the recommended supply of drugs was written into the contract documents. Furthermore, all the windows of houses in the township for non-immune expatriates were screened. Hospital services provided by the Board had to be paid by the employers. This measure was found useful according to Webster (1960) because it induced the contractors to take an interest in keeping their employees fit and out of hospital by the implementation of the health protection measures stipulated in the contracts. Results were so good that not once in the progress of the scheme was work held up, or even threatened with delay, by preventable diseases, and malaria played an insignificant part in causing disability and death among the workers and their families. Nevertheless, as Europeans were less disciplined in protecting themselves, malaria was present among them in a higher proportion and caused the deaths of two persons who had neglected to take prophylactic drugs, but for the first two years not a single case of malaria was found among the European wives and children.

The success in providing protection from malaria in the two major development projects briefly summarized above is emphasized by the many examples of projects where, in the absence of protection, most of the labourers fell ill with malaria, many died, and the project failed. This is exemplified by a land development project planned in Kedah, West Malaysia, in which health protection was neglected. The first stage of the programme consisted of clearing jungle. The contractor employed his own labour force and the work started in January 1964. In March, malaria cases suddenly became quite numerous and the morbidity and mortality rates were fairly high; in 2 years there were 120 deaths in a labour force of 4000. Replacements had to be recruited from other states and the contractor, unable to meet the targets assigned, had to pay heavy fines and eventually the contract was given to a larger firm. The latter also lost about US $400,000 and went bankrupt. Only in October 1967 was action taken against malaria, and one spraying cycle was carried out in conjunction with the distribution of some antimalarial tablets. No other antimalarial action was taken. About 500 settlers, for whose benefit the jungle had been cleared, eventually arrived in January 1968. In spite of the antimalarial work, the local dispensary reported 186 cases of malaria during the period June-August and 4 deaths occurred. All these deaths and the great number of malaria cases, not to mention the financial losses, could have been prevented if the housing compounds had been sprayed in time and some additional antimalarial measures had been taken.

In many tropical countries at the present time there are major development projects receiving considerable international assistance (see Annex 3 for procedures for obtaining WHO collaboration in development projects financed by UNDP). Even in such projects, certain setbacks have been recorded on account of inadequate planning of the health protection measures. An example is the Lower Mekong River project, which is the largest project ever assisted by UNDP and which will benefit the four riparian countries of the Lower Mekong — namely, Cambodia, Laos, Thailand, and Viet-Nam. The project is supported by 26 contributing countries, loans from United States agencies, and by the contributions of the four riparian countries themselves. It is conducted by the Lower Mekong Basin (LMB) Committee, which has its own secretariat, and
the Economic Commission for Africa and the Far East (ECAFE) has a special Committee for
Coordination of Investigations of the Lower Mekong Basin. This latter Committee submitted
in November 1965 a proposal "that a WHO team should investigate the health implications of
this development programme". The LMB Committee agreed and a team composed of a public health
adviser and a sanitary engineer conducted a study during January/October 1967. In 1968 the
LMB Committee accepted their recommendations which were to be included in the 10-year develop-
ment plan. As a malaria outbreak was raging among the labour force in one of the dams already
under construction in Laos, the Nam Ngum Dam, WHO assisted in organizing in 1969 a technical
meeting for the malariologists of the four riparian countries (WHO Regional Office for the
Western Pacific, 1969). For the purposes of this manual, it is pertinent to note that although
most of the impoundment reservoirs foreseen by the plan are in malarious areas (1) the tenders
handed to the construction firms did not mention that such a malaria problem would face the
staff and labourers, (2) the measures to be taken by the contractors in order to protect the
labour force and to minimize future malaria risks due to the engineering works and the
impoundment were also not mentioned, and (3) no consideration was given to general health
planning in the resettlement of the families displaced from the areas to be flooded in the
six construction projects or fishermen along the shores of the reservoirs. Since then, with
assistance from UNDP and WHO, great improvements in health planning and protection against
malaria have been introduced in the overall planning and implementation of this major scheme.

Another example of a United Nations-assisted project is the Aswan High Dam in Egypt.
This exemplifies a situation where a construction project is planned for a non-malarious area
but where a future malaria hazard is feared as a result of ecological changes in the environ-
ment. The construction of this dam in 1969 resulted in the creation of an extensive lake
(Lake Nasser) stretching for 500 km south of the dam, 150 km of it being in Sudan. The average
width of the lake is 16 km. The creation of this lake and the ecological changes brought
about by such an extensive expanse of surface water have introduced a major malaria hazard—
namely, a greater opportunity for A. gambiæ (species B) to advance from northern Sudan into
Egypt. Remembering the previous experience when this vicious malaria vector invaded Egypt
in 1940 and the consequent raging malaria epidemic in a non-immune population (130 000 deaths
in 2 years) were directly attributed to malaria: Soper, 1970) caused economic havoc, the
Regional Planning Development Project sponsored by FAO, together with WHO and UNDP, helped to
carry out the necessary surveys and studies and draw up an agreement between the Governments
of Egypt and Sudan to monitor the northern limit of A. gambiæ in Sudan and apply antimalaria
measures (mostly larvicidal) with a view to maintaining an A. gambiæ-free zone stretching
for 150 km south of the southernmost border of the lake in Sudan. Since 1970, joint inspection
teams from both countries have been assessing annually the progress of work related to larvi-
ciding, house-spraying with DDT, disinsection of boats, trains, and cars arriving at Wadi Halfa
town, and radical treatment of any imported malaria cases detected in villages situated between
Aswan in Egypt and Wadi Fatma in Sudan.

4.3 Measures to be taken

4.3.1 General considerations

4.3.1.1 Notification of the project to the relevant health authorities

At the earliest stage of a major development project, the Ministry of Health should be
involved in the planning in order that the health hazards of such a project can be properly
assessed. For this reason, projects are preceded by feasibility studies by a team of experts
which should include an experienced public health adviser who could be assisted by specialists
in different health fields, such as malariologists, sanitary engineers, and entomologists.
At any rate, when the plan of operations is being drafted the plan for health protection,
particularly the part dealing with protection against malaria, should constitute a special
chapter in the overall project plan.
In minor projects, of which the central government may be unaware, it is imperative in tropical and subtropical regions that the local authorities should arrange to be informed at an early stage and that they notify as soon as possible the existence of such projects to the national health authority. Even a minor project like the cutting of forest will need an official permit and this should not be issued before the health authority has expressed its opinion.\(^1\) When a project is in a malarious region, the choice of a site for the labour aggregation by the malaria epidemiologist may in itself be sufficient to avoid most of the danger. Needless to say, the notification that is usually sent to the national health service giving details about the objectives, site, and number of immigrants involved in the project should immediately be transmitted to the national malaria eradication service or the malaria control organization, should either exist in the country.

4.3.1.2 Coordination

In the planning of development projects as well as new settlements there should be coordination between the executing department or company and the health service or, for malaria, malaria service, if there is one. For internationally assisted or executed major development projects covering a group of countries, this coordination could be effected through WHO. Such coordination has to be initiated from the onset and it is unfortunate that national public works departments and engineering companies are often rather unwilling to obtain health clearance for projects. They probably would do so when the projects are chiefly concerned with water management, since they are aware of the risk of diseases such as malaria and schistosomiasis connected with the work, but not when the projects involve road and railway construction or forest cutting. One also wonders whether in major projects financially assisted by UNDP the technical advice offered by WHO is always followed. In this connexion, it is worthwhile mentioning that in May 1967, UNDP representatives participated in a meeting with WHO Regional Directors. At the meeting it was stressed that there is a need for the education of government planning bodies on the importance of health activities in development programmes.

4.3.1.3 Health education

Elementary health education of immigrants and the stable population is necessary, with particular reference to protection against malaria. It is true that immigrants in a project will be obliged to follow the health instructions given by their hierarchical superiors, but they should know why some regulations have been issued; for example, instructions not to spend the night out of doors, to take the weekly suppressive antimalarial drug, or to report to the dispensary if they have fever. Labourers could be assembled on pay-days, at meetings called by the project manager, or during festivities or other social occasions and appropriately instructed. Modern audiovisual methods should be employed whenever possible. It is essential that this health education should be a continuous activity involving all the staff of the project and assessments should be made occasionally to ensure that it has permeated to all members of the community at all levels.

4.3.1.4 Development projects offer better chances of success of antimalaria programmes

The control of malaria or even the complete interruption of transmission in a tropical aggregation of labour in a development project, which may last for years, fortunately have better chances of success than they do in new settlements or the country as a whole. It is the relationship between the population of the aggregation area with the executor of the project - largely an employer/employee relationship - that engenders communal solidarity and promotes discipline in carrying out instructions related to health protection on the part of employees, labourers, and their families. Under these conditions, we may expect that at least three major requirements of the antimalaria programme will attain a very high coverage - namely, health education, case detection and drug administration, and residual spraying of houses.

\(^1\) Unfortunately, minor projects are often not notified. It has been reported, for instance, that in some forested hilly regions of India, forestry departments make contracts to cut wood and make charcoal; labour then moves into the area. The national malaria eradication service may know about it only after an epidemic malaria outbreak has started among the workers.
As regards case detection, reporting of fever cases should be made compulsory and penalties might be applied for non-compliance; active case detection should be very easy in labour camps and the grouped housing of project staff. This is one reason why it is possible in such development projects to suggest house visiting every other day and why, even when there is no malaria eradication programme and therefore no proper surveillance, a daily search for fever cases can be made, at least in the labourers' quarters. Drug administration for treatment and, if necessary, for prophylaxis could also be made compulsory by the project authority with penalties applied for non-compliance. In camps it is easy to locate all employees and labourers but in settled rural communities the majority of people are generally scattered in the fields or in distant farm huts when drug distribution visits are made to their houses. Residual spraying of employees' houses and labour compounds can also attain 100% coverage because there will be no refusals or closed houses.

4.3.1.5 Site selection

The importance of this antimalaria measure has been stressed by Russell (1952) who stated "sometimes only a few miles will make all the difference between the need for constant malaria control and for none at all or only a little".

Before a development project or settlement is planned definitively the planners should obtain expert opinion from a malarialogist on the suitability of the area proposed for the aggregation of immigrants. The site of construction work for the project is determined in some cases by technical requirements such as the precise location of a dam or a bridge, and can hardly be changed. What matters most for malaria protection is the choice of the site where the immigrants' quarters will be built and where people will spend the night. In the Kariba project, the labourers' and employees' quarters were located at a distance from the work front and transportation was provided.

In this manual the word "site" without further qualifications refers to the area of the living quarters of the immigrants. The selection of the site should be based on the following conditions.

(1) The maintenance of appropriate distances from:

(a) the nearest breeding places of the vectors; and

(b) the nearest village or even isolated dwelling of local inhabitants.

Criterion (la) would lose its importance if the site has itself some vector breeding places but it assumes some importance when the site has been cleared, levelled, drained, and, if necessary, filled so that no breeding place can again form during the rains. This land preparation of the immigration area should be carried out before the immigrants arrive.

Criterion (1b) would lose part of its importance if some of the immigrants were already infected but, here again, its importance is obvious when efforts are made to screen immigrants on their arrival and treat those infected.

The recommended distance between the site and the two danger points should be based on a knowledge of the effective flight range of the local vector or vectors. The maintenance of malaria transmission in a community is conditioned by the critical density for every species required to maintain such transmission, as well as by the life span and man-biting habits of the local vector or vectors (MacDonald, 1957). Thus, if 50 {A. gambiae} females arrive in a Nigerian community, the chances are that some will already have sporozoites in their salivary glands and will start to spread infections. On the other hand, if 1000 {A. pharoensis} females invade an Egyptian community, the chances of finding an infected mosquito among them would be much lower.

1 The effective flight range is preferred to the maximum flight range since the latter represents a record obtained from a few individual mosquitoes of a vector population.
very small. Furthermore, the non-infected and young *A. gambiae* females in the first example would perhaps be enough to start malaria transmission among both semi-immune and non-immune populations in the aggregation area, while most if not all the *A. pharoensis* mosquitos, even if newly infected from malarious immigrants, would not reach the infective stage since the infectivity rate for this mosquito is quite low.

The appropriate distance to be maintained between the site and the two danger points should be based on entomological findings and should certainly not be less than the "half-mile" (0.8 km) standard which was adopted when malaria control was mostly based on antilarval measures, and which is still acceptable in the tropics. It must be realized, however, that this distance can be flown by many tropical vector species - certainly by *A. gambiae* and *A. funestus* - but the danger is mitigated by the fact that dispersal in all directions will reduce the number of vectors reaching the project area, particularly as the distance between the point of origin and the site increases. At the same time, the life span of the female mosquito will be shortened on account of its exposure to greater natural hazards through its repetitive movements between the project site for feeding and the breeding place for oviposition.

(2) The altitude of the site may be a deterrent to vectors. It may be difficult to state whether vectors do not fly to the top of a hill because of its height or simply because of its distance from the breeding place in the plains below. It may also depend on the species of vector. In many areas, with *A. maculipennis* as the main vector, people can escape infection by spending the summer nights in the hills. Even in Africa, at the periphery of the *A. gambiae* and *A. funestus* distribution area (Ethiopia, Transvaal) "it is possible, by seeking the high grounds well away from the valleys, to find sites in which anopheline infestation is a small fraction of that to be found in sites close to water" (Boyd, 1949). In the Kariba project, the township for the non-immune expatriates, Camp Hill area, was at a height of 548-640 m on the top of a hill which "would catch the breeze and shun the 'fly' and mosquito menace" (Webster, 1960). The household helpers did not spend the night on Camp Hill but down in their own villages, which necessitated the provision of transport but obviated the danger of having sources of infection in the midst of a non-immune group.

(3) Another condition acting on the influx of vectors from the two danger points into the site is the absence or presence of obstacles to flight. A village between the important breeding ground and the site will absorb a large proportion of the vectors which will stop to feed in the village and not require to go further in search of a blood meal. This will favour the site, provided the village is not too close. A forest can act as an obstacle to the flight of the vectors, but not when the vector is a forest mosquito such as members of the subgenus *Kerteszia*, as in Latin America, or *A. balabacensis*, as in some countries in eastern Asia. On the contrary, it would be advantageous in such cases to clear the forest for about a kilometre around the site.

(4) The orientation of the site in relation to the prevailing wind is perhaps important but it would be difficult to choose between the windward and leeward positions for the site. It is often said that anophelines fly on light breezes, though less readily than culicines; consequently it should be safer to locate the immigrants on the windward side but certain observers have noted that, in certain situations, the attractants emanating from man's presence are carried downwind by the breeze and consequently the mosquitos have to fly against the wind to reach their feeding place. It seems certain, however, that a wind-swept area would be unfavourable to anophelines. In India, non-immune troops are instructed to select their camping grounds at least 0.8 km away from any village or habitation, on higher levels, and not to leeward of prevailing winds coming from villages or the breeding places (India, Armed Forces Medical Services, 1953).

Once the site is chosen, the area assigned to the construction of houses or huts should be cleared, drained, and levelled for a radius of at least 100 m to exclude the possibility of any surface water collecting. If this is impossible, larviciding will be necessary.
4.3.1.6 Water management and man-made lakes

Many major development projects consist of building a dam behind which a new lake will be formed. These man-made lakes may be dangerous in relation to malaria but it is possible to plan and maintain them in such a way that the breeding of anophelines can largely be prevented. The engineers of the Tennessee Valley Authority pioneered the application of such preventive measures and, according to them, the mosquito problem was eliminated by deepening and filling or by diking and dewatering. This project has already been mentioned in section 4.1. It may be useful to summarize here the methods followed for preventing the breeding of anophelines in such major schemes (Tennessee Valley Authority, 1947).

(1) Pre-impoundment works

(a) Preparation of reservoir basins. As the water surface of the man-made lakes must be clear of vegetation and floating matter, the reservoir basins had to be cleared of trees and bushes prior to impoundment and drainage ditches dug along the margins of the future lake to avoid the formation of pools when the water level drops.

(b) Deepening and filling was carried out by removing earth from one-half of the marginal area subjected to fluctuating water levels, and depositing it on the other half to create a new shoreline with a marginal depth of 0.6 m or more above the level of the lake.

(c) Diking and dewatering. Levees and dikes were constructed to control floods along the sides of the reservoir. An internal drainage system was constructed in the area catching the flood to bring the water to a single point where it could be pumped into the reservoir.

(2) Post-impoundment measures

(a) The most important post-impoundment measure for the control of A. quadrimaculatus in TVA reservoirs was water level management. In addition to manipulating the reservoir water levels to serve the primary purposes of navigation, flood control, and power, TVA also regulated reservoir inflows and discharges in the best way for controlling mosquitoes. Water level management for malaria control included an early spring surcharge to strand drifting and floating matter, a constant level phase at full pool level to inhibit the growth of marginal vegetation; weekly intermittent fluctuations to strand or expose mosquito eggs and larvae and the micro-organisms upon which the larvae feed; and a gradual remittent type of fluctuation to provide a clean shoreline during the latter part of the season. Since 1953 water level management alone has provided satisfactory mosquito control on most of the TVA reservoirs.

(b) Supplementary control measures were needed in only a few (7-10) reservoirs and comprised maintenance of drainage, control of plant growth by herbicides, and larviciding operations with ground dispensing equipment and later from helicopters (utilizing 30% DDT oil concentrate applied at a rate of 0.1-0.3 kg of DDT (technical) per hectare). These larviciding operations were conducted during the period May to September.

4.3.2 Planned development projects in countries having a malaria eradication programme

4.3.2.1 The objectives to be attained and the need for additional measures

The objective of the protection measures for the population around development projects in a country having a malaria eradication programme cannot be other than the interruption of malaria transmission and the maintenance of this interruption permanently in unison with the rest of the country. However, on account of the high malariogenic potential of the project areas, the usual malaria eradication programme techniques would probably be unable to achieve such an objective. A combination of weapons must therefore be used to reinforce this attack.
If malaria eradication is part of the health plan, which should itself be a part of the socioeconomic plan of the country's development, it is possible that some development projects appear already in the plan of operations for malaria eradication. If so, it would be easy to start protection before the influx of immigrants. In most cases, mostly because of a lack of communication or cooperation, the national malaria eradication service only finds out about these projects when they have already been in operation for some time. It would be very unrealistic to expect that, if the project area is situated in the delimited malarious area and therefore part of the "programme zone" it will be adequately covered by the routine attack operations. The usual malaria eradication programme operations, however, are not sufficiently effective against the higher malarigenic potential caused by the aggregation of immigrants, and the resources provided in the plan of eradication operations are invariably insufficient for any additional measures that would be required to meet the situation created by the development project and not contemplated in the original malaria eradication programme plan. This has been shown many times, particularly in India, a country which had special experience of the terrible results of malaria in tropical aggregations of labour in the pre-DDT era. In spite of such experience, even during the implementation of malaria eradication programmes epidemics of malaria have occurred in development projects and necessitated additional measures to deal with the situation. Summaries of two examples from India are given below.

(1) In Gujarat State, in the Surat National Malaria Eradication Programme Unit, a development project for the Ukai Dam had its labour colonies located near the local population. The area was hyperendemic in 1953 before the eradication programme began, but in 1958 the dispensary malaria cases amounted to 1-4 per 1000 of patients suffering from all causes. The area was under HCH spraying (0.2 g/m²) and active case detection (ACD) from the end of 1960. The first positive case was found in December 1961 in Bavli village and during the following month a woodcutter's camp was found where a mass blood examination detected 10 positives. Strong measures were adopted: daily active case detection, mass blood surveys, screening of all newcomers to whom a dose of 600 mg of 4-aminoquinoline antimalarial was given and, if positive, a 5-day treatment of primaquine. Focal spraying was carried out but new cases still occurred. The labourers were encamped on cleared ground near water sources under leaf-roofed shelters without walls. They slept in a loin-cloth with no other cover. From January to June 1962, there were 271 positives (179 indigenous) out of 12 387 blood films examined. In the second semester of 1962, however, out of 10 289 blood films only 46 were positive. One A. fluviatilis mosquito caught feeding outdoors had oocysts. According to the authors, the outdoor sleeping habits permitted a high level of malaria transmission to take place in spite of antimosquito measures and daily surveillance. They also noted that daily surveillance, with a view to meeting newly arrived immigrants and detecting fever cases among the local population and immigrants on the first day, was successful in preventing an outbreak among the labour colonies of the Ukai project, which were situated perilously near the active focus.

(2) Another dam, the Khodier Dam, was constructed in Saurashtra. The work commenced in 1959. The site was about 5 km away from the nearest village, where malaria transmission was quite active in 1959 before the national malaria eradication programme began. Labourers came from various parts of Gujarat and other states and by December 1960 there were 1900. Their quarters were sprayed in June and September 1960 and in February 1961. On 14 April 1961 the first case of malaria was found by ACD. The outbreak started with 774 fever cases of which 135 were positive for malaria. Out of 8 A. culicifacies mosquitoes dissected, one showed salivary gland infection. It was found that many newly built structures had not yet been sprayed and that people were sleeping in the open air during the hot season. A mass blood survey with mass treatment of the labour force was carried out in May (600 mg of chloroquine plus 25 mg pyrimethamine for adults) and positives received another dose of chloroquine and 5 daily doses of primaquine. The results of succeeding mass blood surveys showed that no extension of the outbreak to the neighbouring 14 villages had occurred (Bhatt et al., 1962).

For these two examples it is clear that ordinary malaria eradication operations planned on a country-wide basis are not sufficient to interrupt or prevent re-establishment of transmission in aggregations of workers at development projects.
4.3.2.2 Sharing of responsibilities

The first question that arises is whether the eradication operations in the project area should be carried out by the malaria eradication service or by the executor represented by the project manager. It has been found that when time-limited eradication programmes are being conducted, the government health service (malaria eradication programme) is the best agency to undertake the work with the cooperation of the project personnel. One point must be stressed, however; the funding of the activities should be a charge on the project, considering the financial possibilities of major development schemes. The director of the operation could be seconded by the malaria eradication service and his salary paid by the project. As a project staff member administratively but under the technical direction of the malaria eradication service, he can then organize the work on a sound technical basis.

In minor development projects where the number of labourers does not exceed a few hundred, the project area would not justify being made into a special new sector and the national malaria eradication service can support the operations financially although the project should still provide funds to pay personnel engaged in spraying, active case detection, and larviciding. Unless there is a dispensary within a short walking distance, it is necessary to construct one on the project site to provide treatment for the patients; the weekly drug distribution could be made on pay-days by a malaria eradication service inspector stationed at the project, at least during the transmission season. Blood slides of fever cases should be sent to the next sector office or zone headquarters for examination and the results should be sent to the project inspector who will direct the operations required in the project area.

4.3.2.3 Measures to be applied before the arrival of immigrants in the project area

Starting protection measures before the arrival of immigrants presupposes that, once the national malaria eradication service has been informed about the start of a project, the service has taken steps to select the site of the labour camps and employee's quarters and has carried out a reconnaissance survey of the area to form an opinion on the intensity of malaria transmission in the project area. Should the intensity be very high, the eradication service should carry out the following antimalaria measures before the arrival of immigrants.

1. Residual spraying of all houses and huts prepared for or available to the immigrants. An appropriate insecticide (as used by the eradication service in neighbouring areas) should be employed.

2. If immigrants have to spend some weeks or months in improvised shelters that are difficult to spray, larval control measures in a radius determined by entomological survey must be applied at least until all immigrants are housed in premises that can be effectively sprayed. This larval control operation must be mentioned in the section of the overall plan of the project dealing with health protection. Larval control is likely to be facilitated by thorough clearing of vegetation in the same radius. However, clearing is not always a useful measure against certain vectors that prefer to breed in water fully exposed to sunlight, e.g., A. gambiae, A. minimus, A. flavirostris, and A. maculatus. In such cases, clearing is indicated only if efficient source reduction operations (i.e., drainage and filling of all actual and potential breeding places) or larviciding is carried out systematically.

3. Geographical reconnaissance of the project area is required and suitable itineraries covering immigrant camps and neighbouring villages must be prepared for the malaria personnel; checkpoints must be established where the immigrants can be met on arrival, screened, and properly briefed.

4. Stores for equipment, insecticides, and drugs will be made ready in the project area and all material will be procured (presumably from the national malaria eradication service). If the general health service has no health unit or dispensary in the project area, this is the time for the project to establish one and to appoint a polyvalent auxiliary health worker (a medical assistant, for example) to take charge of it, unless a physician can
be recruited. In a major project, a small laboratory with at least one microscopist should also be established. It would be convenient to select and train the personnel needed for all operations of the attack phase, including surveillance, so that as soon as the project work starts, all the antimalaria operations can be set in motion. It is very important for these operations to be performed under strict supervision to ensure total coverage of both spraying and surveillance. For this reason, the project area must be made a "special sector" of malaria eradication operations.

4.3.2.4 Measures adopted after the arrival of immigrants

If the spleen rate of the local population in the immigration areas (whether in a temperate, tropical, or subtropical climate) does not exceed 10%, the normal attack measures should be supplemented with the following:

1. watching for, and screening, all newcomers;
2. passive detection and compulsory reporting of cases of fever.

The screening of newcomers involves setting up checkpoints on the road or landing place(s) in order to make contact with all immigrants and their families on arrival. Their place of origin and their travel routes can then be recorded, blood specimens taken, and presumptive treatment administered, particularly during the transmission season. At the same time, the newcomers can be briefed on malaria and the protective measures to be taken. If an immigrant's blood film is positive, he should report to the dispensary (or health unit) of the project for radical treatment and his blood should be examined monthly as a routine follow-up in the surveillance mechanism (Pampanga, 1969). If microscopic examination of the blood cannot be carried out or if the results will not be available for a week, each immigrant should receive, instead of presumptive treatment, a 3-day course of treatment with chloroquine plus one dose of pyrimethamine (adult dose, 50 mg) on the first day (see Annex 2).

If the immigration area is in a tropical or subtropical climate and the spleen rate of the local population before any control measure is applied ranges from 11% to 30% ("high danger zone", see p. 7), the normal attack measures should be carried out with a maximum of efficiency and supervision, and the following operations must be included:

1. Watching for, and screening, all newcomers.
2. Full surveillance should be instituted from the arrival of the first batch of immigrants; this will include domiciliary active case detection organized on a weekly basis, in addition to passive case detection. All the other components of surveillance will be carried out except for epidemiological investigation of the cases, which will be optional, during the first year of the attack phase.
3. Geographical reconnaissance should be kept up-to-date and every new house or shelter sprayed immediately or, if it cannot be sprayed, destroyed. This "mop-up" spraying is regarded as being of paramount importance.
4. As long as immigrants continue to arrive, and as long as malaria has not been eradicated from the rest of the country, attack measures must be maintained. If the immigration area is in a tropical or subtropical climate and the spleen rate of the local population, prior to any control measures, was above 30% ("extreme danger zone", see p. 7), all the additional measures required for high danger zones should be applied plus the following measures:
5. Active case detection should be carried out every other day, one day in the labourers' quarters, the alternate day in houses. It is believed that alternate day ACD is not very difficult in a project area because of the relative compactness of the area and the

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1. Provided the local strains of malaria parasite are not resistant to pyrimethamine, otherwise a daily dose of 15 mg of primaquine (adult dose) can be given during the 3-day course of chloroquine and on the fourth and fifth days also.
discipline and close relationships in the project. Families of expatriates and probably non-immune persons may be exempted from the " tertian" visits, provided the head of the family notifies any case of fever in his house to the special sector office of the malaria eradication service on the day it occurs so that presumptive treatment can be given to make any gametocytes in the blood non-infective for mosquitos.

(6) One additional spraying cycle must be carried out in addition to those recommended, and the timing of these cycles should be indicated by the malaria technical officer.

(7) In each spraying cycle, mass treatment including every individual will be carried out with chloroquine and pyrimethamine, or chloroquine and primaquine if there is resistance to pyrimethamine in the local strains of vector.

If, in spite of the application of measures 1-7, indigenous cases of malaria still occur, additional measures are called for.

(8) Mass drug prophylaxis, preferably with pyrimethamine unless there is pyrimethamine resistance in the local strains of vector, should be provided for all the population of the project area every week, and continued until the end of the transmission season or the end of the peak period of transmission (see Annex 2). Drug prophylaxis is particularly recommended for non-immune persons. Unfortunately, expatriates, who are likely to be non-immune, often object to regular drug taking. In that case, they should be made aware of the risk they take. House-screening is always to be recommended for non-immune persons, but that does not eliminate the need for drug prophylaxis when there is intensive malaria transmission.

(9) Larval control has been recommended for the period before immigrants arrive and it should be continued until all houses are protected (by residual spraying). It could be resumed as an alternative to mass drug prophylaxis but it should not be forgotten that for some vectors the critical density for starting malaria transmission is extremely low and it will probably be more difficult to conduct effective larval control than to obtain a satisfactory coverage with drug prophylaxis.

The additional measures described in this section may be redundant in some cases but inadequate in others. They may be redundant if the malaria season of the immigration area is very short or when the preparatory work has been so thorough that breeding places of vectors are far enough away from the area to cause no problem. The national malaria eradication service epidemiologist should decide which measures can be omitted.

The additional measures may be inadequate when the vector avoids sprayed houses, has become resistant to the insecticide, or its critical density for initiating malaria transmission is so low that the daily mortality caused by the insecticide is not high enough to prevent an outbreak occurring. These are probably the main reasons for the continued appearance of indigenous cases in spite of measures 1-7 and the reason for suggesting measures 8 and 9. If transmission still persists it would appear that until the population is definitely stabilized and immigrants cease to arrive, interruption of malaria transmission cannot be achieved. The epidemiologist may then wish to renounce the aim of time-limited eradication in the project area and be content with comprehensive malaria control until the time comes when eradication is feasible.

4.3.3 Measures to be taken in countries with a malaria control programme

In this case, the goal to be attained is less ambitious than that discussed in section 4.3.2 because it is not necessary to interrupt transmission but only reduce it in order to minimize malaria morbidity and mortality.

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1 House-screening is recommended in the better types of house for expatriates who could use electric fans or air-conditioning to improve ventilation impaired by screening. In labourers' camps, screening is of little use because the maintenance of screens is not easy.
4.3.3.1 The objective

As a national malaria eradication programme covers the whole malarious area of the country, it is bound to become aware of, even if not informed beforehand, all important development projects. Malaria control, on the other hand, is seldom nation-wide, does not cover all the malarious areas, and it is therefore quite possible that a development project may start in an area not covered by malaria control operations. In this case, an epidemic outbreak may not be recognized until long after it has begun.

Malaria control generally covers some selected areas that are either most severely affected by the disease or have actual or potential socioeconomic importance. Consequently, in such countries there are two special points that must be emphasized:

(1) The government of a malarious country should issue instructions to the relevant departments that the national health authorities represented by the Ministry of Health and its malaria control organization should be notified as soon as possible about any recruitment or migration of labour for development projects organized either by these departments or by private enterprise so that comments may be made. Local authorities, police forces, etc., should be instructed to look for, and report to the Ministry of Health through appropriate channels, the existence of any projects involving the movement of population towards malarious areas.

(2) The project area (i.e., the area where the immigrants are going to stay and neighbouring villages within a 3-km radius) will be included in the country's malaria control programme and should receive high priority because of its high malarious potential and socioeconomic importance.

4.3.3.2 Sharing of responsibilities

A country carrying out malaria control in selected urban and rural areas must have a malaria control organization or a malaria section within the Ministry of Health staffed with some specialized personnel, including a malarialogist, probably an entomologist, and a sanitary engineer or a malaria superintendent, and they should be assisted by a number of trained auxiliary personnel. Such an organization, with the cooperation of the project staff, can be made responsible for the planning and implementation of malaria control in the project area provided the project includes in its overall plan budgetary provisions to cover the cost of operations recommended by the malarialogist.

4.3.3.3 Measures to be applied before the arrival of immigrants

When the project has been notified in advance to the malaria control organization, the latter could be expected to cooperate with the project staff in selecting the aggregation site. The control organization should make a pre-operational survey of the project area, outline the programme of operations, and indicate the number of malaria workers needed as well as the quantities of insecticides, equipment, and drugs required. At the same time, the control organization should start the spraying of all buildings erected to accommodate staff and labourers so that when the immigrants arrive they will be able to sleep in sprayed premises.

In major projects it is to be hoped that the equivalent of a health unit will be established. In minor projects the health unit may be staffed by only one person, such as a polyvalent auxiliary trained in malaria, who is assigned to the project area to take charge of the dispensary. From the budgetary standpoint, difficulties are bound to arise because the principle of charging health expenses to the project may not be familiar to the executor. For this reason, appropriate legislation may be required to cover this general point. Some countries have already adopted legislation to compel projects to budget for the health protection of the labour force, including the establishment of a dispensary and a malaria control programme covering the labour camps, and neighbouring villages situated within a zone of radius 2-5 km from the aggregation area.
4.3.3.4 Measures to be adopted after the arrival of immigrants

The antimalaria measures to be applied should be the same as those applied in other malarious areas under control; in practice, house-spraying should be carried out once or twice a year and antimalaria drugs for preventive or curative treatment should be made available. However, the results may not be very satisfactory when the bulk of immigrants begins to arrive; consequently additional measures should then be applied.

If the project area is in a hypoendemic area with a spleen rate of less than 10% in the stable population, normal control measures, as applied in malarious areas of higher endemicity, should be instituted. Although in a malaria control scheme there is usually no provision for surveillance, in a project it would be quite easy to train a person to visit the quarters of the labourers every day to identify anyone away from work, take his temperature, and give him a single-dose treatment. Should fever return, the 3-day treatment should be given (see Annex 2). If the project is large, there should be a laboratory for microscopical blood examinations and, in this case, the domiciliary health worker should also take a blood specimen and administer presumptive treatment. If the results of the blood examination are positive, he should administer radical treatment. Compulsory reporting of fever to the dispensary should be enforced. In addition, the domiciliary health worker should watch for, and screen, newcomers. If the project is in the high danger zone (with a spleen rate in the stable population of between 11% and 30%), the following additional activities are suggested:

(1) all new structures should be sprayed immediately and a "mop-up" team called to the area whenever indicated;

(2) in every spraying cycle, each person should be given a single dose of chloroquine and pyrimethamine (see Annex 2);

(3) on every pay-day, the labourers should be briefed to report cases of fever immediately to the dispensary and should be instructed, through health education, about malaria protection measures;

If the project is in the extreme danger zone (with a spleen rate above 30%), in addition to the measures described in the two preceding paragraphs, the following should be added:

(4) one additional spraying should be carried out over and above those recommended;

(5) weekly drug prophylaxis for non-immune persons should be given (see Annex 2);

(6) if, in spite of all additional measures, numerous cases still occur, weekly drug prophylaxis should be made compulsory for all immigrants all through the malaria transmission season or until the end of the transmission peak. An alternative to massive drug prophylaxis is larval control if the epidemiologist concludes that this is preferable.

4.3.4 Planned development projects in countries without a malaria control programme

Some developing countries have so few resources that they cannot afford even a minimal malaria control organization programme, although malaria may cause more sickness than any other disease. Perhaps minor antimalaria work is carried out in the capital and some other towns in the form of some house-spraying and larval control, but even the provision of antimalarial drugs for the prophylaxis of large groups of the population may be beyond the government's economic possibilities.

It is a common experience that in countries where there is no malaria control organization, the malaria control programme of a major development project is a good beginning for establishing a national organization. It would be also easy for the assisting agency to transform the malaria control scheme gradually into a multipurpose health programme and to train a number of medical and health auxiliaries who could shoulder the responsibility for health promotion and
protection among the settlers who move to the project area upon completion of the project. In this way, the project can contribute to the development of the country's health service.

4.3.4.1 Action to be taken in major projects

In spite of the absence of a malaria control organization and the poor resources of the country, a major development project will be greatly interested in controlling malaria and could provide the necessary funds and facilities. Consequently, the project should recruit its own specialized personnel to organize the work and train antimalaria workers.

Technical assistance from abroad may be necessary in major projects assisted by bilateral or international agencies. The executing agency could ask WHO to assign the relevant professional personnel (see Annex 3 on procedures for requesting UNDP assistance) and the project would include in its overall plan, the financial provisions for health protection, including the antimalaria programme. A few examples of how some major projects carried out effective malaria control in countries where no control organization existed at the time have already been given.

If no assistance is received from abroad, the project manager, in agreement with the national health authority, should recruit the professional staff necessary for planning and implementing the malaria control programme. They may be available in the country or may have to be recruited from abroad.

The professional personnel to be assigned to a major project should consist at least of a malarialogist, who may be assisted for some months by an entomologist and a sanitary engineer. The malarialogist should be assigned to the project for its entire duration. It is also desirable for the work to be assessed annually by an expert malarialogist recruited as a short-term consultant.

The tasks of the professional personnel will be as follows.

(1) To make a pre-operational survey of the project area. If the malarialogist has been appointed before the plan of the development project is finalized, he will still have the possibility of commenting on the site envisaged and can perhaps suggest a better one. Here, the entomologist's help will be required.

(2) To draft a malaria control programme, including the budgetary provisions required, for the whole project area. If the project involves the construction of a dam, the sanitary engineer's collaboration will be invaluable. He can review the engineering plan and advise on any modification that could contribute to source reduction of mosquitoes, and suggest a water management scheme in the lake or irrigation network that could lessen the malaria hazard.

(3) To advise the project's administration on the offices and houses to be built for the staff, and the equipment, supplies, and transport to be obtained.

(4) To select and train staff to be employed in the antimalaria programme; they should include a senior technical officer (e.g., a public health inspector trained in malaria) who can be seconded by the national health services and who could be made responsible for the work during the absence of a health professional. This officer should probably be a government employee so that when the project is completed his experience will not be lost but be an asset to the national health services.

(5) To establish a health unit, unless there is already one in the vicinity, where patients would obtain treatment.

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1 A malarialogist is defined as a medical officer with post-graduate training in tropical health and who has experience in practical malariology.
To establish a small laboratory capable of carrying out parasitological examinations of blood samples; this could be entrusted to a laboratory technician trained in malaria microscopy, who could be seconded by the national health services or recruited from abroad.

After the arrival of the immigrants, the antimalaria methodology outlined in section 4.3.3.4 should be followed. It should be realized, however, that in a country that has a malaria control organization there is already an established antimalaria methodology that could also be applied in the project area. In the present case, the methodology to be applied has to be initiated and the malarialogist could benefit from the experience gained in controlling malaria in epidemiologically similar areas in neighbouring countries.

4.3.4.2 Action to be taken in minor projects

In minor projects employing a few hundred immigrants that are generally not assisted by bilateral or international agencies and whose budget is insufficient to develop even a small antimalaria service within the project area, the least that should be done is to make attempts to prevent deaths and to minimize the clinical effects of the disease. The contractor should be compelled by law to announce the future project to the national health authority or its provincial office, if any, and to obtain a stock of antimalarial drugs sufficient for the treatment and weekly mass prophylaxis of all employees, labourers, and their families. He should be instructed by a physician from the national health service on dosages for clinical treatment and weekly prophylaxis for different age groups, as well as on minor larval control activities to be carried out by his men, particularly as regards source reduction. He should particularly set up a centre where one of his employees, in addition to carrying out his normal duties, would distribute 3-day chloroquine treatment to every fever case and each week on pay-days administer weekly doses of chloroquine or pyrimethamine (see Annex 2). The contractor himself, in the interests of a successful outcome of the work, should adequately brief all employees and labourers about the malaria danger and the need to take the drugs supplied to them. Non-immune expatriates employed by the project might publicly take the weekly dose to serve as a good example to other employees - after all, they will have more need of the drug than the labourers, who probably have some degree of immunity.

5. UNPLANNED NEW SETTLEMENTS

5.1 General considerations

In many developing countries, there is always a migratory movement of a sizeable proportion of the rural population to settle in newly opened lands or urban centres. In Africa, the annual growth rate of urban centres is estimated at 10% (WHO Regional Office for Africa, 1973) - a phenomenon that explains the mushrooming of shanty towns or "bidonvilles" around urban centres. Settlement in newly opened lands is motivated by the lack of land in established rural communities to support an increasing population. Some governments resort to forced settlement or transmigration from densely populated areas to other areas that are rich in natural resources but lack manpower. The construction of roads, an irrigation network, security posts, and other social amenities, including facilities for land ownership and financial loans, may have been planned or started to attract the new settlers. Certain types of transient settlement occur in many tropical countries where a 7-year cultivation cycle (shifting cultivation) is practised in forested lands. In the Sudan, large groups of people - numbered in tens of thousands - coming from West and Central Africa, cross the borders annually to earn their living as farm helpers until they can afford to continue their journey to Mecca for the pilgrimage. The same transient settlement is noted when drought and famine hit certain parts of a country, compelling large masses of people to migrate and settle temporarily in other areas. A rush of population to certain areas for private mining (gold or precious stones) or into the forest to cultivate illicit plants can also be considered as examples of this type of transient settlement.
Planned settlements, such as the resettlement of Nubians displaced from their villages by the Aswan High Dam project or the settlement of people in the Pontine marshes in Italy through the "Bonifica Integrale", or settlements sponsored by governments as part of an "accelerated agricultural scheme", as in Malaysia and Thailand, benefit, as part of a major socioeconomic scheme, from organized malaria control operations. Such schemes are rather rare and most new settlements are unplanned.

The settlement areas, once advance notice has been given to the health authorities (and through them to the national malaria eradication service or malaria control organization), should be given priority in antimalaria activities. Here again, unless budgetary provisions have been made in anticipation of such settlements, the antimalaria activities prescribed for these areas will be greatly handicapped. In some countries, the provincial or rural councils or, in the case of urban centres, the municipal councils, may be quite willing to finance such activities. For this reason, the necessary approaches should be made to draw the attention of these councils to the malaria hazard involved in the settlement movements which would disrupt their current antimalaria programme or possibly their overall health protection activities, and convince them of the cost-benefit effectiveness of an adequate investment in the malaria field. A malaria service which ignores its function in monitoring areas of new settlements or which neglects its coordinating and promotional role in protection against malaria, will soon experience serious setbacks in its current programme. Setbacks of this kind have occurred in many developing countries that were attempting time-limited eradication programmes. The extensive epidemic of malaria in Karachi town in 1967, the explosive malaria epidemic in Sri Lanka in 1969, and the "new frontiers" malaria outbreaks that became a regular feature of the Philippines and Thailand eradication programmes all caused the disruption of eradication efforts.

Since most of the population movements for settlement are unplanned and a serious malaria hazard is involved in such activities, it is imperative that health authorities (and through them the national malaria eradication service or malaria control organization) should strive to find ways and means to obtain advance information or detect such settlements in time. It cannot be expected that new settlers will announce their arrival in the area, particularly if settlement there is illegal or done for illegal purposes. On the other hand, most immigrants approach a government official to obtain permits for forest clearance, timberlogging, house construction, or the rights to rent or own land, etc., and it is the duty of the official to notify his department, which should immediately transmit the information to the health authorities whenever a sizeable settlement activity is anticipated or in progress. The police service can also make a valuable contribution by notifying the health authorities.

5.2 Measures to be applied and difficulties encountered

The antimalaria measures prescribed for unplanned settlements are similar to those outlined for planned development projects (see section 4.3), though they are carried out with much greater difficulty because the new settlers usually have no disciplined organization or a responsible chief. For this reason, antimalaria measures have to be carried out through government offices or by government services. Often, the settlers find themselves situated in an administrative vacuum with no health services or schools and perhaps not even a police post, at least during the first months or years after their arrival. As already mentioned, these unplanned settlements, even in countries with a time-limited malaria eradication programme, prove very difficult to tackle and frequently produce "problem areas" of persisting malaria transmission. The situation will be less hazardous if the settlers build their houses far apart near their land. If the families are separated from one another in this way, the chances of transmission from one family to another will be very small.

5.2.1 In countries with a malaria eradication programme

It has to be realized that unplanned new settlements in countries with time-limited eradication programmes occur frequently, particularly as the eradication programme constitutes one of the main arms of the national socioeconomic development effort, opening up new lands for
cultivation and attracting immigrants from overpopulated areas. The new lands may not even have come under the attack phase of eradication and immigrants may arrive from zones where transmission is quite low or has been interrupted for several years. The presence of immigrants in such new lands may be dangerous unless they all go into sprayed houses, a very remote possibility in unplanned new settlements. As mentioned previously, past experience of attempts at time-limited eradication programmes in many developing countries has shown that unplanned settlement occurring in areas with a high maliogenic potential under the consolidation or maintenance phase of eradication has resulted in malaria outbreaks and serious setbacks in the eradication effort.

When considering the measures to be applied in new settlements, it has to be realized that there is a great difference between the organization of antimalaria programmes in development projects and settlement areas; in the latter, most of the operations will have to be carried out by national malaria eradication service personnel. Sprayers and surveillance agents could perhaps, after some time, be recruited from among the new settlers, but all supervision, even at the lowest level (foremen), should be carried out by malaria eradication service personnel. Most measures requiring the cooperation of the immigrants will not be as successful in settlements as in development projects and hence it is important to maximize health education activities among the new settlers.

If the unplanned new settlement has been discovered by accident during the malaria eradication activities, and not because attention has been drawn to a malaria outbreak, there are two possibilities.

(1) If immigration has gone on for some months during the transmission season and a rapid visit shows that there has not been any malaria morbidity, it is probable that the aggregation is not dangerous. If this is confirmed by the fact that the spleen rate among the stable population before eradication started did not exceed 10%, the immigration area needs nothing more than the current measures applied generally in the zone to which it topographically belongs, except that both active and passive case detection must be instituted. For this reason, the malaria eradication service should assign to the area a surveillance agent who, through his daily exploratory trips, will ensure the distribution of drugs and the screening of newcomers. During these trips, he should take pains to brief all individuals and families on malaria protection. As soon as an indigenous malaria case is found among the settlers, the immigration area can no longer be considered to be harmless and will be classified as a "danger zone" (see following paragraph).

(2) Under the category "high danger zone" can be grouped new settlement areas where active transmission has occurred among the new settlers or in the indigenous population, as well as areas where the spleen rates for either group range from 11% to 30%.

For the high danger zone, as soon as it has been discovered by the malaria eradication service, irrespective of the eradication phase in the rest of the zone, the settlement area will be placed under attack measures. The usual operations of the attack phase will be carried out under strict supervision and with maximum efficiency, and the following additional measures must be taken.

(a) Immediate spraying of all houses and shelters and, at the same time, a new geographical reconnaissance should be made or the existing one up-dated.

(b) If the settlement area already contains a few hundred settlers and seems likely to receive many more, it will be considered as a new sector or subsector within the eradication organization and an office will be established within it.

(c) Screening of all newcomers must be carried out and presumptive treatment with a sporontocidal drug (see Annex 2) administered.
(d) Full surveillance should be instituted and active case detection carried out all over the new settlement at 3-day intervals (i.e., twice a week).  

(e) Residual spraying of every house is required as soon as it is built. If the shelter is unspratable, persuasion should be used to improve the construction so that effective spraying is possible because the destruction of such houses by the malaria eradication service will not be admissible as in development projects.

(f) As long as immigrants continue to arrive, and as long as malaria has not been eradicated from the rest of the country, the area will remain under attack.

(3) If the original spleen rate in the area was above 30% or if it is evident that a malaria outbreak is already raging among the new settlers, the area is considered as an "extreme danger zone" (see section 2.4), and the following instructions should be adhered to in order to intensify the measures prescribed for the high danger zone.

(a) Active case detection should be carried out every other day.

(b) One additional spraying cycle should be conducted over and above those prescribed in the zone.

(c) At each spraying cycle a mass suppressive treatment will be administered to every individual (chloroquine and pyrimethamine or chloroquine and primaquine (see Annex 2)).

If in spite of all the additional measures listed above new cases of malaria still occur, the malaria eradication service should further intensify the activities through:

(i) active case detection organized on a daily basis;

(ii) mass blood examination and radical treatment of all positives (in this case, one or more malaria microscopists would be located in the malaria sector office to accelerate examination of blood samples); or

(iii) if an accelerated mass blood examination is not feasible, weekly drug prophylaxis can be given or, alternatively, larval control applied, whichever measure appears to ensure better coverage and quicker results.

At this stage, however, the malaria eradication service should review the situation and perhaps decide not to pursue the aim of complete interruption of transmission until the population is firmly stabilized in the area but be satisfied with comprehensive malaria control. Comprehensive control may mean the prolongation of all the measures that are being applied and which, though failing to interrupt transmission, must have caused drastic reduction. These measures may appear to be quite costly but the malaria eradication service should weigh such costs and the benefits gained against any harm resulting from their suspension that may lead to the abandonment of the malaria eradication efforts or to unsuccessful settlement or agricultural development.

5.2.2 In countries with a malaria control organization

As soon as news of a major new settlement reaches the malaria control organization, the latter should send one or more staff members to reconnoitre the area, possibly make a malaria survey, and plan an antimalarial programme. If the settlement happens to be located in a malarious area, it should be included with other areas under regular control, and the existing housing structures should be sprayed immediately.

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1 Reporting of every fever case should be made compulsory if possible. Epidemiological investigation of cases and foci should be carried out from the start.

2 Experience shows that surveillance agents recruited from among the immigrants, even when the latter are pursuing illegal cultivation or practices, proved to be a commendable procedure as these settlers would trust and follow the advice of one of their own group.
The control organization may have to set up, at least in the danger areas, a health unit with a full-time polyvalent health worker trained in malaria, unless the general health services already have a health unit there. The health worker can be assigned to look after protection against malaria in the settlement area. He should be given authority to recruit, on a daily basis, one or more immigrants and train them in spraying techniques and the distribution of antimalarials. Routine spraying rounds will be carried out by the malaria control organization but spraying teams could not be stationed continuously in the vicinity of a new settlement and the "mop-up" team should therefore be composed of trained immigrants led by the antimalaria worker. The latter should also look for newcomers and screen them, up-date the geographical reconnaissance of the settlement (which is necessary also for malaria control), get to know all the families in the settlement, and contribute to health education on malaria protection. If the settlement is large, instead of a single antimalaria worker a small antimalaria team provided with transport should be set up by the malaria control organization for the new area. This will facilitate the screening of all immigrants and enable mass drug prophylaxis to be carried out whenever indicated. The antimalaria worker or the antimalaria team should be supervised by an inspector of the malaria control organization visiting the settlement at least once a month.

In considering the measures to be applied after the arrival of the new settlers, the following points must be considered.

(1) If the aggregation area of the new settlement is not in a tropical or subtropical climate, or if the original spleen rate (before any control or in its absence) in the stable population or among the immigrants was less than 10%, and the immigration has already been going on for at least 2 months in the transmission season, the usual control routine will be sufficient for the new settlement on condition that a monthly visit is made to the immigrants by a control organization inspector. Occasionally, he should also take a random sample of blood slides to check the parasite rate among the settlers.

(2) If the spleen rate ranged from 10% to 30%, i.e., the area is in the high danger zone, the following additional control measures should be recommended.

(a) Efforts should be made to watch for the arrival of newcomers and screen them.

(b) Every new house should be sprayed soon after its completion.

(c) For non-immunes, mass drug prophylaxis should be given weekly.

(3) If the spleen rate was above 30% the area is in the extreme danger zone and the following measures should be taken in addition to those described above.

(a) One more spraying cycle should be carried out.

(b) During each spraying round, a mass drug suppressive treatment should be given to every person.

(c) Mass drug prophylaxis is indicated if a high malaria prevalence rate still exists; alternatively, larval control may be applied, whichever proves more feasible, economical, and produces results more quickly.

5.2.3 In countries without any malaria service

If the country has no antimalaria organization or only limited control confined to urban centres, its resources are meagre, and there are very few, if any, trained personnel, it would be unthinkable to demand a proper malaria survey in a settlement aggregation area. Under these circumstances, efforts should be made to give every malaria patient appropriate and timely treatment to save his life and provide clinical relief. For this purpose, the area should be visited by a physician from the national health service, possibly accompanied by a government
official or an agriculturist, to give advice on the location of dwellings and inform the settlers about the malaria danger, the site of the nearest health centre, and, if no centre exists, recommend the establishment of a health post for treating the patients should the situation warrant it. If the area is remote and there are only a few hundred settlers, a responsible person can be selected from among the immigrants, such as a shopkeeper, a religious leader, or a midwife, who would agree to be trained to distribute correct dosages of anti-malaria drugs to patients in the different age groups.

As the main protection against malaria will be antimalaria drugs, these should either be distributed free or, where possible, sold at a low fixed price, certainly not higher than the gross cost price. We believe that it should be a government's responsibility to produce or formulate the antimalarias for this purpose. At least one drug - chloroquine - should be prepared as "government antimalaria tablets". The tablets should bear a government trademark so that they can easily be identified and their sale or resale should be forbidden. The tablets should be grooved for easy division into 2 or 4 parts. It is also suggested that the tablets should contain 200 mg or 100 mg of the base or active ingredient, or possibly tablets of both strengths could be prepared. Easily comprehensible leaflets or pictorial charts should reach all settlers and nearby stable populations explaining the single-dose treatment of chloroquine to the various age groups. Single-dose treatment is the one to be recommended under such conditions since it can be assumed that the settlers have some degree of malaria immunity.

Obviously, in the circumstances described, antimalarias should be given chiefly for treatment but, if some kind of agricultural cooperative structure exists, it may be entrusted to administer drug prophylaxis, particularly to pregnant mothers and the younger age groups, on the suggestion of the visiting physician. No country, however poorly developed it may be or how meagre its resources, should neglect to provide this minimum protection for new settlers.

5.2.3.1 Malaria scouting and treatment

In order to make treatment more accessible to malaria patients, an alternative arrangement is suggested which represents a step above the minimum described above. It requires, firstly, that among the immigrants there should be some persons who are able to read and write, and, secondly, that the government can devote a little more money to the protection of the immigrants. It consists in setting up a system of what might be called "malaria scouts", chosen from among those immigrants who are willing to undertake house-visiting mainly to distribute drugs to fever cases. The scouts should also brief the head of the family on individual protection against malaria (use of mosquito nets or pyrethrum joss sticks) and on the use of the antimalarias. They will keep a record of the names of patients, their ages, and the number of tablets given to each patient, in this case three daily doses. The training of the malaria scouts should take place in the area and be provided by the visiting physician or a senior malaria inspector of the national health service. The malaria scouts could be supervised every 3-4 months by the same inspector who would interview a random sample of families and discuss his findings with the scouts. The malaria scouts should preferably be volunteers, comparable with the "secouristes volontaires" in some West African countries. Should it be necessary to pay them, the monthly salary should not exceed the equivalent of about 5 days' salary of a public works labourer since their work will be part-time.

5.2.3.2 Use of medicated salt

Wherever this method is feasible, it can eliminate one of the difficulties experienced in dealing with new settlers - namely, their elusiveness. If the immigrant area is sufficiently isolated from the rest of the country, it should be possible to restrict the salt supply and allow the sale or free distribution of medicated (chloroquinized) salt only. The visiting

1 Clearly, if a government considers producing its own tablets, it would not do it solely to help new settlements since these tablets would constitute the main antimalaria weapon for the whole country.
physician or malaria inspector can advise the settlers about the precautions to be taken in the storage, distribution, and consumption of this medicated salt. The use of chloroquinized salt has given very encouraging results among some nomadic populations in Iran (Mofidi, 1966). In some isolated communities in Tanzania, Clyde (1966) was able to reduce the parasite rate among the 6-10 year age group from 71.7% to 2.7% and in the age group above 16 years from 27.7% to 1.2% using 0.3% chloroquinized salt over a period of 3 years.

5.2.3.3 Mobile health teams

In some West African countries that have no special malaria service, mobile health teams exist and consist of medical professionals and auxiliaries travelling around the country with the main purpose of screening people in the various localities for some endemic diseases, making the necessary laboratory and X-ray examinations, and prescribing or giving any necessary treatment. Malaria is one of the diseases tackled by these teams. If the immigrants’ aggregation areas were periodically visited by a team - not only to screen for malaria but also other infections - the aggregation would benefit greatly. A visit by such a team every 4 months could measure spleen and parasite rates whenever indicated, carry out mass blood examinations in epidemics, give technical advice on antimalaria measures that might be applicable under the local conditions, and train volunteers to administer correct doses of chloroquine to persons in the various age groups suffering from fever. Apart from distributing drugs to patients during their visit, the team could leave a stock of chloroquine tablets with the trained volunteer.

5.2.3.4 Collaboration with the army

A country may have no malaria service or mobile health teams but is likely to have an army. If the malaria scouts, instead of being recruited from among immigrants, are selected from army personnel, they could carry out their malaria scouting as a military duty. The army malaria scouts could be trained more easily, possibly in a polyvalent health capacity, and would have better drug storage and travelling facilities. Supervision would also be easier. It is known that in some countries the army has given a great amount of assistance to the rural populations by providing teachers and there seems no reason why it could not provide this special type of health worker or malaria scout.

From the organizational standpoint, should the army take the responsibility for malaria scouting, nuclei of scouts could probably be set up in strategically situated localities from which the scouts could visit the various aggregations by bicycle, horseback, canoe, or even motorized vehicle. The technical responsibility of an army malaria scouting service should rest with an army medical officer who should visit the aggregation areas periodically for the same purposes as the civilian medical officer of the central health service.

5.2.3.5 Measures after the establishment of settlers

If the establishment of the settlers has been proceeding for a few years, agriculture will have developed, villages will be growing, and some sort of rural hierarchy will have been set up. The latter will be able to convey the health needs of the community to the government. The area may also have become of some importance because of the size of the population and its productivity, and the government is likely to step in - also for fiscal reasons - to establish administrative offices, schools, and, it is hoped, a health unit in the area. It is then desirable that the health unit should take up the antimalaria work.

Distribution of antimalaria drugs will continue and they will now be on sale in certain government offices or private drug stores and will be distributed free by the health unit. Mass drug prophylaxis on a weekly or fortnightly basis for certain vulnerable groups of the population, particularly expectant mothers and pre-school children, could now be introduced. With regard to the pre-school children, the health unit should make efforts to explain to mothers and expectant mothers how dangerous malaria is for the young children and how it can be prevented in children between the ages of at least 6 months and 7 years, when a certain
degree of immunity may have developed, with appropriate weekly or fortnightly doses of a suitable drug such as pyrimethamine during the transmission season. Even schoolchildren could benefit from weekly prophylaxis but they could only be given the drug during scholastic terms and might become infected again when they return to their homes during vacations; it is also difficult to ensure that the teachers give the drugs to the children regularly. Experience has shown, however, that drug administration for schoolchildren will greatly reduce absenteeism caused by malaria (WHO Interregional Conference on Malaria Control in Countries Where Time-Limited Eradication is Impracticable at Present, 1974) and thus contribute to the educational programme.

6. PERSONAL PROTECTION AGAINST MALARIA

In this manual the importance of preparing the immigration area before the arrival of the immigrants has been stressed repeatedly. Some people will have to go into the area to make the preparations or for other purposes such as to conduct a feasibility study or a malaria or health survey. If the area is malarious, these people must protect themselves during their stay. Furthermore, in any development project (or new settlement) there are bound to be persons who have to spend some nights outside the protected area for various reasons, and it will be necessary for them to take some protective measures against malaria. Therefore, all health education activities must include personal protection against this disease.

Personal protection against malaria is based on three main activities:

(1) prevention of mosquito bites;
(2) destruction of the vectors in the immediate area;
(3) drug prophylaxis.

6.1 Prevention of mosquito bites

6.1.1 Site location

This measure has already been discussed (see section 4.3.1.5) and is very important when an individual or a group has to spend one or more nights in the open. A tent should be erected or a temporary shelter improvised.

6.1.2 Mechanical defence

This can be obtained through house-screening (applying wire or plastic net screens to windows, doors, and other openings leading to the outside) provided that all the inhabitants are indoors during the hours of the vector's feeding activity. Screening of houses is welcomed where there is sufficient natural or artificial ventilation in the screened house to make it comfortable (the opening of doors and windows, even for a short time, to allow ventilation will transform the screened house into a mosquito trap). Needless to say, screens have to be fixed carefully on all openings and regular inspections must be made to see whether screens require repair or replacement. Tents, huts, improvised shelters, and poorly constructed houses cannot be effectively screened.

6.1.3 Bed-nets

Nets have the advantage that they can be set up in a few minutes over any bed, or even a mat placed on the floor or a hammock, and they can be an effective protective device for travellers and even immigrants (particularly young children). To be effective it is necessary that mosquito nets should:
be made of a thread of adequate thickness (30/5 thread or 40/60 thread) and the
netting should have a mesh of 23-26 holes per in² (11-12 holes per cm²).

not be conical but pyramidal with a rectangular base. The edges should be capable
of being tucked under the mattress or mat. Large beds or mats are preferable to small
ones since the body is then some distance away from the net and mosquitoes are unable to
bite through the holes. If bed-nets are used by persons sleeping out of doors, their
impregnation with an insecticide or insect repellent will increase the protective value.

Persons sleeping under a mosquito net should remain there for at least most of the hours of
the vector's biting activity.

6.1.4 Preventive clothing

After dusk, in the tropics, shorts and short-sleeved shirts should be replaced by long
trousers and long sleeves. At one time the wearing of "mosquito boots" was advised. Today,
women can wear long trousers and both men and women should wear socks impregnated with a
repellent. A repellent should be smeared on the ankles if socks are not worn, as well as
on the wrists, face, and neck.

6.1.5 Repellents

Repellents are products, natural or synthetic, that can be applied to the skin, clothing,
bed-nets, etc., to ward off insects, particularly mosquitoes. Their effect persists for
several hours. Since the 1930s, the classical antimosquito repellent of the tropics, oil of
citronella, has progressively been replaced by synthetic repellents such as Rutgers-612,
Indalone, dimethylphthalate (DMP) and "6.2.2", which is a proprietary mixture of the three
named repellents in the proportions indicated in the name. This mixture affords a 4-hour
period of protection against anophelines - more than any of the three components separately;
the most active of the three, DMP, gives a protection for about 3 hours. This substance was
widely used during the Second World War. All Indian Army personnel in a malarious area were
given a 4-oz (113 g) supply of DMP. It is a clear, odourless, non-greasy, inflammable
material. Repeated applications on a chafed or sunburnt skin, however, are likely to produce
irritation.

All these repellents have now largely been replaced by deet (chemically, N,N-diethyl-m-
toluamide). Like DMP, this is a contact repellent and not a volatile repellent like oil of
citronella. The meta-isomer is more effective than the ortho- and para-isomers, and should
constitute at least 70% of the technical product (WHO Expert Committee on Insecticide
Resistance and Vector Control, 1963). Deet is less oily than the other usual repellents;
it can be applied to the skin in concentrated form but is so active that it can also be used
diluted, in alcohol, for example, and is usually available as a 50% alcohol solution. It
can also be used as a lotion and as a spray. It is said to resist rubbing, perspiration, and
water. This is the outstanding repellent for mosquitoes and is 4-8 times more effective than
DMP. Against A. gambiae (Clyde & Kingazi, 1957) it remained active for 18-20 hours, which
means that an application before dusk would be sufficient for the whole night. One must be
careful, however, not to touch any mucous membrane (eyes, mouth, nasal orifices) with the
smeared repellent. Like other repellents including DMP, deet affects some synthetic plastic
materials (watch-glasses, fountain pens, etc.), paints, varnishes, and some synthetic fibres
but not nylon. Like DMP it can be used for impregnating clothing and bed-nets.

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To determine the mesh of the netting; first draw an inch (or centimetre) square on a
piece of thick paper, then lay the netting on the square so that the bottom row of holes of
the netting lies along a line of warp (the threads of the warp are more regularly arranged in
the material than those of the woof, owing to the fact that the warp is formed by threads
stretched lengthwise in the loom, while the woof threads are shuttled cross-wise). Once the
netting has been placed in position, count the holes of the bottom edge of the netting in the
square from right to left and add to these the number of holes along a woof diagonal starting
from the lowest left hole, which is thus counted twice, until the line intersects with the
upper edge of the square (Russell et al., 1963).
If deet or DMP are not available, oil of citronella may still be easily found in the tropics. It can certainly be used but it should be applied to the skin every 20 minutes or so.

In the United States of America, the standard clothing repellent, M.1960, consists of benzyl benzoate 30%, n-butyl acetonilide 30%, and 2-butyl-2-ethyl-3-propanediol 30%, to which is added 10% of Tween-80 (a dispersing agent) (Russell et al., 1963).

6.2 Destruction of the vectors on the spot

Any residual insecticide can be used; for individual protection, however, pyrethrum space-spraying is very convenient and can be applied quickly. Pyrethrum is invaluable for knocking down and killing mosquitoes in a closed environment; for that reason, it is generally used as the main active component of commercial aerosols. Commercial low-pressure spraying cans produce sufficient aerosol in 4.5 seconds to treat 28 m².

Although commercial aerosol sprays are more expensive, they are certainly handier than a kerosene solution of pyrethrum flowers or extract. However, if economy is essential, 0.5 kg of crushed pyrethrum flowers can be soaked in 4.5 litres of good quality, nearly odourless kerosene and allowed to stand for 72 hours. Solutions are obtained more quickly by diluting commercial standardized concentrated pyrethrum extracts (25% pyrethrum concentrate) with kerosene to obtain a 0.25% solution.

6.3 Drug prophylaxis (Annex 2, Table 1)¹

Personal drug prophylaxis has saved thousands of lives and should never be neglected when a person is in malarious localities without any effective protection against mosquito bites. It should be noted that pregnancy is not a contra-indication to the use of antimalarial drugs. Strictly, malaria drug prophylaxis can only be achieved with drugs that have a causal prophylaxis action, i.e., against the sporozoites or the pre-erythrocytic forms. Thus if pyrimethamine or proguanil is used, the term "prophylaxis" will be correct, but not if chloroquine is chosen. In practice, however, what is meant by drug prophylaxis is more often clinical prophylaxis, which is achieved by drugs like chloroquine that kill the erythrocytic forms only and bring about suppression of the overt attacks of malaria.

For personal prophylaxis, if the local P. falciparum strains are not resistant to pyrimethamine or proguanil, one of these two drugs would be preferable. They would act surely as suppressants but in some cases also as causal prophylactics, i.e., they will prevent the infection altogether. Both products kill the pre-erythrocytic forms of some strains of P. falciparum. As regards the other species, pyrimethamine has also some action on the pre-erythrocytic schizonts of P. vivax, P. ovale, and P. malariae. These drugs may suppress the primary signs of infection caused by these parasites and delay the overt primary attack for perhaps a few months after the drug prophylaxis has been stopped. Both drugs still have a suppressive action on strains in which they have no manifest action on the pre-erythrocytic forms. Should the local P. falciparum strain be resistant to either of the drugs (proguanil or pyrimethamine) then a 4-aminquinolene compound (chloroquine or amodiaquine) should be used for suppression. A weekly dose of 300 mg of one such drug in areas with low transmission, or 600 mg where transmission is intense, would act as a suppressive cure.

In areas where it has been confirmed that local strains of P. falciparum are highly resistant to 4-aminquinolines, as in parts of South-East Asia, South America, and Central America, the weekly administration of sulfadoxine or sulfalene with pyrimethamine is recommended for non-immunes for a rather limited time (WHO Scientific Group on Chemotherapy of Malaria and Resistance to Antimalariais, 1973). The adult weekly doses of such combinations are 50 mg of pyrimethamine with 1 g of sulfadoxine or 2 g of sulfalene. An association of the standard daily proguanil regimen with the addition of daily dapsone (25 mg) during the

¹ See also Wkly epidem. Rec. (1973).
peak transmission of malaria has been successful in groups of non-immunes in parts of Viet-Nam, where chloroquine resistant strains of *P. falciparum* are very frequent.

7. EXPENDITURE ON ANTIMALARIA PROGRAMMES

As repeatedly mentioned in this manual, the planning of an effective, and at the same time economic, antimalaria programme requires the services of an experienced malarialogist. His knowledge of the local epidemiological and socioeconomic features of the project area and his assessment of the strength of the national health services and the malaria service, as well as the intensity of the malaria hazard that could be engendered by the project, will enable him to recommend the appropriate antimalaria measures that will meet the requirements within the budget available for the work.

In most eradication programmes in developing countries based on residual spraying with DDT and surveillance, the average annual *per capita* cost (during an 8-year period covering the preparatory, attack, and consolidation phases) is about US $0.35 (World Health Organization, 1972). In well-organized malaria control programmes (based on residual spraying, some larviciding, and drug administration), the average cost *per capita* per annum may reach US $0.20. Such average costing *per capita* per annum in rather extensive programmes, running for a good number of years and involving the protection of more than a million people, seems unsuitable for costing antimalaria programmes in project areas involving the protection of not more than a few thousand people over a much shorter period, depending on the time-schedule of the construction phase of the project. In that case, the *per capita* cost *per annum* of an antimalaria programme in the project area would obviously be higher than the rates quoted above on account of the emphasis on the quality of work performance and the high initial cost of equipment and transport needed during the life of the project, which is comparatively short in most cases.

It is not possible to give estimates for expenditure on antimalaria operations in various ecological situations because much depends on the local rates for salaries and wages, which constitute 30-80% of the total expenditure. The cost of imported equipment, transport, and insecticides and drugs has lately increased by almost 30% or even more, and further increases in the price of these commodities may be expected. In addition, higher freight rates are now charged by shipping companies. The cost also depends on a considerable extent on the type of insecticide or larvicide to be applied and the method of applying the latter - with ground equipment (conventional or ultra-low-volume dispensers) or by aerial spraying. In residual spraying programmes, the substitution of malathion for DDT, when the vectors become resistant to the latter, would double the cost. These facts present a challenge to the malarialogist, who has to select the appropriate antimalaria measures to be applied on the basis of their epidemiological effectiveness as well as on economical considerations based on the project budget and the resources available for health protection. Examples given in this manual show that larviciding operations are seldom recommended in areas where mosquito breeding places are extensive, unless they are confined to a few drains or swamps. The cost of the larvicide for simple oiling for example (diesel oil No. 2 to which is added a spreading agent 0.5% Triton X.100) is about US $3.7 per hectare (World Health Organization, 1973). If the area to be treated is extensive, mass drug administration will therefore be the method of choice, either to supplement residual house-spraying in development projects or as the main method of control in unplanned settlement projects. If mass drug administration is the main antimalaria measure, the annual *per capita* cost for malaria protection will be much higher than that incurred when antimosquito measures, particularly residual house-spraying, are applied. The cost of antimalaria drugs alone (based on an adult dose of 600 mg of chloroquine - 50 mg of pyrimethamine) in mass drug administration campaigns covering 100 000 population is about US $2500 or 2.5 cents *per capita* for one administration. If this is repeated fortnightly during a 6-month transmission period the cost of drugs alone *per capita* per annum will be US $0.30. The total cost of such mass drug administration, including the operational costs, would certainly increase this rate to more than US $1 *per capita* per annum.
In considering expenditure on malaria protection, the cost of antimalaria engineering methods, covering the expenditure on drainage, filling, and water management, should be included whenever feasible or indicated. The budgetary allocations for such permanent antimalaria measures have to be charged to the overall engineering budget or to the antimalaria component of the project budget, but should not be included in the calculation of the per capita annual costing of the repetitive measures.

Needless to say, no organized antimalaria programme can achieve the desired results, even if the most elaborate equipment and the most effective insecticides are available, unless a competent antimalaria structure or organization exists that can ensure effective supervision and periodical assessment of progress. Therefore, the supression of some positions for key supervisory personnel for reasons of economy will be a false economy. The malarialogist should keep a record of the annual financial expenditures on the antimalaria programme and his annual report on the progress of the work should include a section showing the savings in man-days for labourers and staff, as well as on the saving in demand for curative medicine resulting from the antimalaria measures. In this way, he can draw attention to the value of the investment in antimalaria work, and convince the project authorities about the need for it.
SUMMARY OF ANTIMALARIA MEASURES FOR IMMIGRATION AREAS

The following table summarizes the various measures that are suggested in this manual for the protection of immigrants after their arrival in a project or settlement area. The measures suggested for countries with a malaria eradication programme do not differ much from those suggested for countries with only a simple malaria control programme; in fact, the only difference is the great importance given to surveillance in the former countries.

It is realized that the list of measures to be effected is perhaps too demanding. It is also recognized that the sharp distinction between "high danger" and "extreme danger" zones on the basis of the spleen rate only is too artificial. For example, an area with a spleen rate of 25% where the local vector is A. gambiae would probably be more dangerous than another area with a spleen rate of 35% but having A. culicifacies as the main vector; this is also true because house-spraying in the latter species would produce much better results and the same would also apply a fortiori to larval control. However, the scheme of antimalaria measures presented in this manual for application in various malarious situations envisages a higher degree of malaria transmission than would normally be expected. It is preferable, therefore, to leave it to the discretion of the responsible epidemiologist to decide whether under the local circumstances a less aggressive approach can be made without risk.
### TABLE 1. SUMMARY OF MEASURES ADVISED FOR IMMIGRATION AREAS

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<tr>
<td>F. New settlements</td>
<td></td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>yes</td>
<td>S</td>
</tr>
</tbody>
</table>

- a - obligatory; (+) - optional; a', a'' - alternatives.
- b - PS - full surveillance (during first year of attack; however, epidemiological investigation of cases or foci is dropped).
- c - PCD - passive case detection; S - search for fever cases in labourers' quarters. Figures in parentheses indicate intervals (days) between house-visiting in active case detection.
- d - Provided screening of newcomers is maintained as long as immigration continues.
- e - Measure for non-immunes only.
DRUG TREATMENT AND PROPHYLAXIS

(see Table 2 for regimens and dosages in various age groups)

A. 1-day and 3-day courses of treatment

Where the microscopical examination of blood from most or all fever cases is impracticable, as in new unplanned settlements and other aggregations in areas without a malaria service, it would be safer to treat every fever case as if it were a malaria case. This will be simple if the greatest proportion of the malaria infections, if not all, are \textit{P. falciparum} infections. In countries where this is likely, a single dose of 600 mg of chloroquine for adults is sufficient to eliminate the fever of mild attacks in semi-immunes. In order to make the gametocytes of \textit{P. falciparum} non-infective for local vectors, even if a blood examination is impracticable, the patient should receive a 1-day treatment with a single dose of 600 mg of chloroquine plus 50 mg of pyrimethamine (adult dose). If fever persists, the 3-day course should be instituted. A 3-day treatment consists of giving 900 mg of chloroquine (adult dose) on the first day in divided doses (starting with 600 mg and giving 300 mg 6 hours later) and 300 mg on the second and third days. This treatment, except in cases where there is some resistance to the 4-aminquinolines, should succeed in terminating the fever in any malaria attack and will produce a radical cure in \textit{P. falciparum} infections, at least in the majority of semi-immunes. With this treatment, \textit{P. vivax}, \textit{P. malariae}, and \textit{P. ovale} infections will still produce relapses in a high proportion of cases, and each relapse should be treated in the same way.

B. Radical treatment

Where blood from all fever cases can be microscopically examined (as in eradication programmes) the full radical treatment of infections should be carried out as soon as positive cases are notified. If the results of the examination cannot be obtained for more than 7 days, the subject should be given a presumptive treatment every week (adult dose: 600 mg of chloroquine plus 50 mg of pyrimethamine) until radical treatment is instituted. This presumptive treatment will prevent the subject, should he have gametocytes in his blood, from infecting mosquitoes.

Radical treatment will vary according to the plasmodial species. For \textit{P. falciparum} infections among non-immunes and in high transmission areas, the 3-day chloroquine course is prolonged by giving a 300 mg dose of chloroquine on the fourth and fifth days and, in addition, a daily dose of primaquine on each of the 5 days.

If the infective agent is \textit{P. vivax}, \textit{P. malariae}, or \textit{P. ovale}, the 3-day chloroquine treatment should be associated with, or followed by, a daily single dose of 15 mg of primaquine (adult dose) for 14 days. In areas where G6PD deficiency is widespread and there are records of toxic effects arising from primaquine administration, or whenever the multi-relapsing \textit{P. vivax} (Chesson’s strain) exists, it is preferable to base the radical cure course on a weekly administration of chloroquine (300 mg adult dose) and primaquine (45 mg adult dose) for 8 successive weeks since this regimen is less liable to cause demonstrable toxic effects and is effective against Chesson’s strain of \textit{P. vivax}. If the 14-day primaquine administration proves too difficult to supervise (making sure that the patient swallows the prescribed drugs daily), administration of this drug can be limited to 7 days or 5 days, as is the practice in some countries in East Asia, provided the surveillance mechanism is very efficient. If the local strains of \textit{P. falciparum} are highly resistant to chloroquine, a radical cure can be obtained through a single dose of a combination of pyrimethamine and a long-acting sulfonamide (see Table 2).
Annex 2

C. Dosages for different age groups

The WHO Expert Committee on Malaria (1961), realizing the great variations in dosages and the difficulties in selecting the appropriate ones, particularly in mass campaigns, endorsed in its Eighth Report a recommendation from the Regional Office for Africa (WHO Regional Office for Africa, 1959) that antimalarials used in large programmes be formulated in tablets such that 1 tablet would be appropriate for the age group 3 months to 3 years; 2 tablets for the age group 4-9 years; and 3 tablets for all those of 10 years and above. This system, which is known as the "1, 2, 3 tablet posology system" has certain disadvantages. For example, to give a child of 4 years the same dose as that given to one of 9 years, and similarly to give a baby of 3 months the same dose as a child of 3-1/2 years is most undesirable. For this reason, it should be possible to recommend different dosages for the 0-11 months, 1-4 years, 5-9 years, 10-13 years, and 14 years and above age groups. To facilitate this, all antimalarial drug tablets should be grooved for division into four sections to allow the distributor to give the appropriate dosage to each age group. In Table 2 is shown the dosages of antimalarials recommended for the various age groups under different treatment regimens. The dosages are meant for mass or routine distribution but they may not be as accurate as those that a clinician would approve for individual treatments, based on the weight of the patient and general health criteria, etc. In mass drug distribution using a single dose administered by unqualified auxiliaries, the main objective is to ensure a therapeutic or suppressive effect of the drugs and avoid dangerous overdosage. Some minor secondary effects may occur in a few subjects following the recommended treatment, but these are negligible from the public health standpoint.

Chloroquine tablets are very bitter and children may object to taking them unless they are coated; if coated tablets are not available, chloroquine or amodiaquine syrup and elixirs are on the market. A Nivaquine syrup contains, for instance, 5 mg of chloroquine base per ml^3. Both pyrithazine and long-acting sulfonamides are practically tasteless.

D. Mass drug administration

There are indications (MacDonald et al., 1967) that even in areas where residual spraying at a rate of three cycles of DDT per year does not succeed in interrupting transmission; three mass drug administrations, given concurrently with the spraying rounds and covering at least 80% of the population, would succeed. That is why, when the situation is particularly difficult in immigration areas, three cycles of insecticidal spraying plus mass drug administration in each spraying cycle is strongly recommended. Such mass suppressive treatments generally consist of chloroquine with either pyrithazine or primaquine. For adults, the dose should be 600 mg of chloroquine plus either 50 mg of pyrithazine or 45 mg of primaquine (for the dosages for the various age groups, see Table 2). Primaquine has the advantage over pyrithazine that it does not provoke resistance. Even pyrithazine, however, if given always together with a strong dose of a 4-aminoquinoline should very rarely, if ever, produce resistance. However, primaquine is eliminated more quickly than pyrithazine and this is a disadvantage in mass treatments.

Even this bivalent attack, however, is not always sufficient. Periodical mass drug prophylaxis can then be used. Mass drug prophylaxis aims at keeping the population continuously free from parasites; to this end, mass drug administration is repeated periodically at weekly or fortnightly intervals. It is well known that total coverage of the rural population by mass drug prophylaxis is far from being achieved. However, it could be achieved within the disciplined population of a project area and should certainly be chosen in preference to larval control when either is required to supplement residual spraying of houses. However, the very high coverage that can be expected from either mass drug prophylaxis or larval control in a project area under tropical conditions has little chance of being attained in new settlements.

When mass drug administration is required on a fortnightly basis in a population of immigrants it is preferable to administer chloroquine and pyrithazine together.
Since 15% of the deaths of children in holoendemic areas and at least 5% of those in hyperendemic areas (Charmot, 1969) are due directly to malaria, mass drug prophylaxis is particularly necessary up to the age of 7-8 years unless transmission is being strongly reduced by house-spraying. The other vulnerable group that would greatly benefit from such mass drug prophylaxis is expectant mothers.

Mass drug prophylaxis is sometimes based on chloroquine and primaquine but, as mentioned before, the use of primaquine should be monitored for any toxic manifestations occurring as a result of G6PD deficiency.

If the local strains of P. falciparum are highly resistant to chloroquine, and wherever this species of parasite is the prevailing one (as in most tropical regions), the mass administration of a combination of pyrimethamine and one of the long-acting sulfonamides can be used, particularly for the non-immune population in areas of intense malaria transmission, as well as for semi-immunes in urban centres known to have little transmission. Such a drug combination cannot be guaranteed to be safe for prolonged administration, even though there may be no doubt about its efficiency (WHO Scientific Group on Chemotherapy and Resistance to Antimalarials, 1973).

E. Additional information for guidance of the malarialogist or technical officer

E.1 Approximate proportion of population in various age groups to total population

Under conditions such as those existing in tropical Africa, the usual proportions in a stable population are as follows:

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1 year</td>
<td>4%</td>
</tr>
<tr>
<td>1-4 years</td>
<td>15%</td>
</tr>
<tr>
<td>5-9 years</td>
<td>15%</td>
</tr>
<tr>
<td>10-14 years</td>
<td>14%</td>
</tr>
<tr>
<td>15 years and over</td>
<td>52%</td>
</tr>
</tbody>
</table>

If mass drug administration is indicated, the malarialogist should obtain by means of a rapid census of the population in the project area the age composition of the various age groups to help in estimating the quantities of antimalarial drugs required.

E.2 Proprietary names and prices of antimalarial drugs

Many proprietary antimalarial drugs are available on the market and the chemical names of some common preparations together with indicative wholesale prices for 1974 are given in Table 3.

E.3 Optimum daily dosages

As the average weight of individuals in each of the stated age groups differs greatly in relation to the various ethnic groups, it may be of help to the clinician when prescribing a daily dose of an antimalarial drug to base it on the weight of the individual or, in mass drug administration, on the average weight in each age group. The optimum oral daily dosages of various drugs per kilogram of body weight are given in the following tabulation.
<table>
<thead>
<tr>
<th>Drug</th>
<th>Optimum daily oral dosage (mg/kg of body weight)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-aminoquinolines</td>
<td>15</td>
</tr>
<tr>
<td>pyrimethamine</td>
<td>0.5-1</td>
</tr>
<tr>
<td>8-aminoquinolines</td>
<td>0.5-1</td>
</tr>
<tr>
<td>proguanil</td>
<td>2-3</td>
</tr>
<tr>
<td>sulfones</td>
<td>0.5</td>
</tr>
<tr>
<td>sulfalene</td>
<td>25</td>
</tr>
<tr>
<td>sulfadoxine</td>
<td>15</td>
</tr>
<tr>
<td>sulfadimethoxine</td>
<td>20</td>
</tr>
<tr>
<td>Regimen and objectives</td>
<td>Periodicity</td>
</tr>
<tr>
<td>------------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>Single-day course (individual treatment)</td>
<td>Once when suspected</td>
</tr>
<tr>
<td>As clinical cure for semi-immunes when no microscopic examination has been made</td>
<td>Once (to new immigrants)</td>
</tr>
<tr>
<td>As presumptive, before microscopic confirmation</td>
<td>Once or once weekly until radical cure is instituted</td>
</tr>
<tr>
<td>3-day course (individual treatment)</td>
<td>First day: start with</td>
</tr>
<tr>
<td>As clinical cure for all malaria infections (and radical for P. falciparum) for both semi-immunes - when not responding to single-day course - and also non-immunes</td>
<td>6 hours later</td>
</tr>
<tr>
<td>Second day</td>
<td>chloroquine</td>
</tr>
<tr>
<td>Third day</td>
<td>chloroquine</td>
</tr>
<tr>
<td>As above but with a sporontocidal effect for administration to new immigrants upon arrival to project area, particularly when no microscopic examination has been made</td>
<td>As above but add on first day</td>
</tr>
<tr>
<td>Radical cure courses (individual treatment)</td>
<td>Daily for 14 days</td>
</tr>
<tr>
<td>Radical treatment of P. vivax, P. malariae, and P. ovale infections</td>
<td>Weekly for 8 successive weeks</td>
</tr>
<tr>
<td>As above wherever indicated for practicability and wherever P. vivax strains produce many relapses (Chezson's strain)</td>
<td>Daily for 5 days</td>
</tr>
<tr>
<td>In P. falciparum infections among non-immunes in highly malarious areas</td>
<td>Once in single dose</td>
</tr>
<tr>
<td>In chloroquine-resistant strains of P. falciparum in non-immunes or semi-immunes in less malarious urban centres</td>
<td>Once in single dose</td>
</tr>
</tbody>
</table>

* The dosages in this column are adjusted for 6-12-month-old infants; infants below 6 months in semi-immune populations would have some immune protection antibodies transferred from their mothers.
## Table 2. Antimalarial Drug Regimens and Doses in Various Age Groups (continued)

<table>
<thead>
<tr>
<th>Regimens and objectives</th>
<th>Periodicity</th>
<th>Drugs used</th>
<th>13 years and over group (adults)</th>
<th>9-12 years group</th>
<th>5-8 years group</th>
<th>1-4 years group</th>
<th>less than 1 year group (doses for 7-12 months)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>15 14 13</td>
<td>12 11 10 9</td>
<td>8 7 6 5</td>
<td>4 3 2 1</td>
<td></td>
</tr>
<tr>
<td><strong>Weekly prophylaxis</strong></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Mass administration among semi-immunes</td>
<td>Once weekly</td>
<td>chloroquine</td>
<td>300 mg</td>
<td>300 mg</td>
<td>150 mg</td>
<td>75 mg</td>
<td>37.5 mg</td>
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<tr>
<td>Selective administration to vulnerable groups in semi-immune population</td>
<td>Once weekly</td>
<td>chloroquine or pyrimethamine</td>
<td>300 mg</td>
<td>300 mg</td>
<td>150 mg</td>
<td>75 mg</td>
<td>37.5 mg</td>
</tr>
<tr>
<td>In non-immune population or individuals in highly malarious areas (tourists, expatriates, etc.)</td>
<td>Once daily</td>
<td>chloroquine or proguanil</td>
<td>600 mg</td>
<td>300 mg</td>
<td>200 mg</td>
<td>100 mg</td>
<td>50 mg</td>
</tr>
<tr>
<td></td>
<td></td>
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<tr>
<td>In P. falciparum infections among non-immunes when highly chloroquine-resistant strains exist (prophylaxis given only for a few months)</td>
<td>(a) Once weekly</td>
<td>pyrimethamine + sulfadoxine</td>
<td>50 mg (+)</td>
<td>37.5 mg (+)</td>
<td>25 mg (+)</td>
<td>12.5 mg (+)</td>
<td>6.25 mg (+)</td>
</tr>
<tr>
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<td></td>
</tr>
<tr>
<td><strong>Fortnightly prophylaxis</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In mass administration where fortnightly distribution is easier, and where local strains of P. falciparum are susceptible to chloroquine and pyrimethamine</td>
<td>Once every 2 weeks</td>
<td>chloroquine + pyrimethamine</td>
<td>300 mg (+)</td>
<td>300 mg (+)</td>
<td>150 mg (+)</td>
<td>75 mg (+)</td>
<td>37.5 mg (+) (6.25 mg)</td>
</tr>
<tr>
<td>Mass administration where P. falciparum strains are resistant to pyrimethamine, and where G6PD deficiency is not highly prevalent</td>
<td>Once every 2 weeks</td>
<td>chloroquine + proguanil</td>
<td>300 mg (+)</td>
<td>300 mg (+)</td>
<td>150 mg (+)</td>
<td>75 mg (+)</td>
<td>37.5 mg (+) (2.5 mg)</td>
</tr>
<tr>
<td>In mass administration where local strains of P. falciparum are highly resistant to chloroquine (prophylaxis here to continue for few months)</td>
<td>Once every 2 weeks</td>
<td>Pyrimethamine + sulfadoxine or sulfadoxine</td>
<td>50 mg (+)</td>
<td>37.5 mg (+)</td>
<td>25 mg (+)</td>
<td>12.5 mg (+)</td>
<td>6.25 mg (+)</td>
</tr>
<tr>
<td>Monthly suppressive (or periodical)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In monthly mass administration among semi-immunes as main method of control</td>
<td>Once monthly during transmission season</td>
<td>chloroquine + pyrimethamine</td>
<td>600 mg (+)</td>
<td>400 mg (+)</td>
<td>200 mg (+)</td>
<td>100 mg (+)</td>
<td>50 mg (+)</td>
</tr>
<tr>
<td>In periodical mass administration to semi-immunes at each cycle of residual spraying as a supplementary measure to the latter</td>
<td>Once at every cycle of residual spraying</td>
<td>As above</td>
<td>As above</td>
<td>As above</td>
<td>As above</td>
<td>As above</td>
<td>As above</td>
</tr>
</tbody>
</table>

A The dosages in this column are adjusted for 6-12-month-old infants: infants below 6 months in semi-immune populations would have some immune protection antibodies transferred from their mothers.

b This dosage has been tried with success among military personnel in areas with highly chloroquine-resistant strains of *P. falciparum* (see section 6.3).
<table>
<thead>
<tr>
<th>Name</th>
<th>Weight of active ingredient (or base) in each tablet</th>
<th>Indicative price (1974)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-Aminoquinolines: chloroquine, Camoquin, Araalen, Nivaquine, Flavoquine, Resochin</td>
<td>100 or 150 mg</td>
<td>1000 tablets of 100 mg base, US $5.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1000 tablets of 150 mg base, US $7.00</td>
</tr>
<tr>
<td>Syrups of 4-aminoquinolines: Nivaquine syrup</td>
<td>5 mg in each 1 ml³</td>
<td>One bottle of 125 ml³, US $1.00</td>
</tr>
<tr>
<td>Pyrimethamine: Daraprim</td>
<td>25 mg</td>
<td>1000 tablets of 25 mg, US $4.50</td>
</tr>
<tr>
<td>Proguanil: Paludrime</td>
<td>100 mg</td>
<td>1000 tablets of 100 mg, US $7.00</td>
</tr>
<tr>
<td>8-Aminoquinolines: primaquine, Quinocide</td>
<td>15 mg</td>
<td>1000 tablets of 15 mg, US $7.50</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1000 tablets of 7.5 mg, US $5.00</td>
</tr>
<tr>
<td>Sulfalene (or sulfametapyrazine): Kelfazina</td>
<td>500 mg (0.5 g)</td>
<td>1000 tablets of 500 mg, US $50-60</td>
</tr>
<tr>
<td>Sulphones: dapsone</td>
<td>25 or 100 mg</td>
<td>1000 tablets of 100 mg, US $6.00</td>
</tr>
<tr>
<td>Sulfadoxine (or sulfadoxamine): Fanasil</td>
<td>500 mg</td>
<td>1000 tablets of 500 mg, US $65.00</td>
</tr>
<tr>
<td>Sulfadimethoxine: Madribon</td>
<td>500 mg</td>
<td></td>
</tr>
</tbody>
</table>
ANNEX 3

PROCEDURE ADOPTED FOR WHO CONSULTATION
IN DEVELOPMENT PROJECTS FINANCED BY UNDP

1. For a country project, a government submits a request to UNDP to finance the development project. Such requests are submitted to the Administrator of UNDP through the Resident Representative of the UNDP (RRUNDP) in the country concerned.

2. For an intercountry project, a request must be submitted in the same manner by at least three of the governments concerned.

3. The request is then placed under evaluation in UNDP. The Administrator may decide to send a consultant to assess the request on the site. At the same time,

4. UNDP makes a résumé of the government's request, a copy of which is sent to WHO inviting technical comments. In some cases, a copy of the full request accompanies the résumé. Other agencies can also be requested to make comments on relevant sectors in the project plan and to indicate any provisions that will be required for activities they deem necessary in their areas of competence.

5. Both the appropriate WHO Regional Office and the relevant technical units at WHO headquarters prepare comments which include an indication of any WHO participation that is deemed necessary. Special consideration is given to the question of whether an actual provision for WHO, as Executing Agency, is required to cover either the short- or long-term recruitment of experts or consultants, or the provision of fellowships, supplies, etc. The comments specify the precise field of activity, length of duration, timing, etc., envisaged. On the other hand, assistance may be available from local WHO staff working in the area and this can also be proposed to UNDP.

6. The consolidated comments of WHO are then transmitted to UNDP. Comments of other associated participating agencies are also sent by UNDP to the proposed executing agency.

7. Following the receipt of comments from agencies, UNDP discusses the proposal with the government (through the RRUNDP) and with the executing agency and other "associated" agencies. These discussions may lead to the mounting of a preparatory assistance mission financed by UNDP to elaborate or revise the request (UNDP may or may not participate); such missions frequently include agencies that are to be associated with the project. If necessary, the Administrator can himself send an appraisal mission without the participation of agencies.

8. After government/UNDP/agency consultation, the request, if accepted by the Administrator, is submitted to the Inter-Agency Consultative Board for scrutiny. The Administrator then makes his offer to the government. If the offer is accepted, the request is submitted (in the form of a Recommendation of the Administrator) to the Governing Council which approves the project and earmarks funds for UNDP's contribution to the project as a whole.

9. Pre-project activities involving pre-allocations (i.e., allocations available before Governing Council approval) up to US $30,000 can be approved by the Administrator to permit the project to get under way rapidly. An executing agency can, under these arrangements, recruit a project manager who will, among his first duties, draft the Plan of Operation - the basic tripartite instrument to be signed by the government, UNDP, and the executing agency.
10. Ideally, at this moment contact is established (usually on the initiative of UNDP) between the executing agency and associated agencies to give effect to agreements whereby technical assistance to the project can be provided under subcontractual arrangements by various agencies in relevant fields of activity (see para. 4). These subcontracts between the executing agency and other agencies or firms are made through simple exchange letters.

11. When the Plan of Operation is signed and the government has paid the first instalment of the local operating costs, the Administrator gives formal authorization for the executing agency to commence operations. The full allocation of funds is then made to the executing agency and the operations proceed under the authority of the executing agency.
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