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THE CONTROL OF MALARIA VECTORS IN THE CONTEXT OF THE HEALTH FOR ALL BY THE YEAR 2000 GLOBAL STRATEGY

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ABSTRACT. The changing picture of malaria worldwide needs to be viewed in the context of other developments before we can determine the directions to take to be able to provide the thrusts required in malaria vector control. As a result of population growth, increasing urbanization and continuing pressure on scarce natural resources, the epidemiology of malaria and its manifestation as a public health problem are undergoing profound modifications, indeed in several parts of the world. This picture is further complicated by the spread of resistance to pesticides in the vector and to drugs in *Plasmodium falciparum*. In the immediate future, these trends will continue. In addition, the appearance of suitable vaccines is a highly probable event to be taken into consideration.

The WHO Global Strategy of Health For All by the Year 2000 aims at the improvement of levels of health through primary health care. Among other things, this implies a greater reliance on community involvement and on intersectoral collaboration for health.

In this light, the major malaria problems in the year 2000 will be: (1) "hard core" endemic areas with inadequate infrastructure and poor socio-economic development; (2) resource development areas, in particular those under illegal or poor controlled exploitation; (3) expanding urban areas and (4) increased mobility of non-immunes, particularly if uncontrolled.

In order to cope with these problems, thrusts are required towards the development of vector control strategies, covering the following fields: (1) tools for vector control integrated in primary health care, (2) new chemicals, (3) improved and new biologicals, (4) environmental management and the adoption of health safeguards in resource development projects and (5) manpower development.

INTRODUCTION

The title of this paper implies that we look ahead and try to determine the directions that need to be followed in malaria vector control in future years. These considerations need to take the dynamics of disease transmission into account as well as the expected developments in respect of approaches to its control. Overall environmental and social trends must be viewed as setting the stage for future changes in malaria epidemiology and control issues. This approach is reflected in the layout of this paper into five, increasingly specific, parts.

GLOBAL TRENDS

By far the most influential trend at the global level is population growth. Between 1980 and 2025, the world population will almost double to a total of more than 8 billion (United Nations 1985). The greatest growth is due to take place in the less developed countries, in most of which malaria is either endemic or in some state of control, requiring continuous action. Population growth therefore is a multiplier factor for inputs needed for malaria control.

The degree of urbanization, already quite staggering in some parts of the world, is bound to increase in most continents. Latin America, already the world's most urbanized continent in 1980, will have 466 million people, or 75%, living in cities in 2000. The number of people in cities of more than 5 million inhabitants will increase even more sharply. Although this phenomenon will be most apparent in Africa, in concrete terms Latin America will have the largest portion of its population in such cities by 2000: 147.5 million, or 23.8% (United Nations 1985).

It is a well-known fact that non-renewable natural resources are already under severe stress from over-exploitation today. If current trends continue, the situation will no doubt deteriorate further, affecting the lives of more and more people. As an example, more than 11 million hectares of tropical forest is lost annually worldwide (United Nations (FAO) 1982). Arable land being brought under irrigation is bound to increase with 75 million hectares between 1985 and 2000, 15 million hectares of which will be added in India alone. The total world reserve of

[1] Presented at the 52nd annual meeting of the American Mosquito Control Association, Seattle, Washington, March 30, 1987.

potentially arable land will decrease from 24% of total land surface in 1981 to 22% in 1994.[2]

With these and other well-known examples in mind we can describe a number of global trends, which are extremely relevant for the epidemiology of malaria and for the approaches needed for vector control:

The numbers of people affected and their life expectancy will go up.

The rate of urbanization will go up as well, which means that more rural land will be turned into urban areas, more people and larger proportions of total populations will live in cities, there will be more giant cities (i.e., cities with at least 5 million inhabitants) and slum areas are bound to increase as a consequence.

People will be increasingly mobile, either for political, economic or touristic reasons. This will increase the mobility of pests, vectors and pathogens, resulting in the increased exposure of non-immunes to inoculations with vector-borne diseases.

With natural areas dwindling, we will see a world with less forest and hence fewer people living in forested areas, less non-cultivated arable land and less water per capita. The reduced availability of water will put drinking water and sanitation programs under pressure and it will force industry and agriculture into adopting production practices that consume less water.

On the bright side, with increasing levels of education we may expect improvements generally in hygiene and the adoption of more healthy life styles. Another benefit of increased literacy will no doubt be the greater availability of suitable human resources for health programs, particularly primary health care. There will indeed be an increasing need for the implementation of the Global Strategy of Health For All, through primary health care, as the only reasonable and feasible approach to the attainment of better health for populations at large. With reference to malaria control, this observation will lead us to greater emphasis on the involvement of individuals and communities towards effective self-protection, vector control and source reduction through environmental action (World Health Organization 1986).

Needless to say, the Health For All Strategy, adopted by the World Health Assembly in 1981, will need to be continuously adjusted at country level to ensure the most appropriate use of resources in a very dynamic world. After having taken a look at some very specific trends in malaria in the next section, I will try to outline what this statement may entail for the control of this disease in the section following it.

TRENDS IN MALARIA

Resistance to insecticides in the anopheline mosquitoes is already a severe problem in several areas of the world. Although there are no instances known where the vector has become resistant to all available insecticides, resistance often brings with it the need for more expensive alternative compounds and thus tends to raise the cost of vector control. Insecticide resistance is bound to spread further to more vector species, encompassing a wider range of compounds.

Without incentives to industry and research groups it is doubtful that the development of new compounds will be stepped up. At present, only a few compounds are offered to the WHO Pesticide Program (WHOPES) for testing each year and an even more precariously low number of these subsequently qualify for use against malaria vectors.

A rather similar situation seems to apply to the development of drug-resistance in the parasite (only *Plasmodium falciparum* being involved so far) and the availability of alternative drugs for prophylaxis and treatment. On the other hand, it is almost certain that by 2000 there will be operational vaccines against malaria (against sporozoite and/or merozoite antigens and/or transmission-blocking), currently being developed with assistance from the World Bank/UNDP/WHO Special Program on Research and Training in Tropical Diseases (TDR).

With the shifts in population from rural areas to the cities, urban malaria, until recently a rather insignificant phenomenon in limited areas of the world, will become more important as peri-urban areas will increasingly provide some vectors with a transitional habitat with suitable breeding places and abundant hosts. On the other hand, "jungle" malaria, with its technical and operational difficulties for control will become less and less important as areas will get deforested and people will move away. The net effects of these changes will depend on many factors and may hence be difficult to predict. It seems justified, however, to assume that in Asia east of India the overall malaria incidence may ultimately even be reduced, but in India and in Africa south of the Sahara the outlook is definitely more pessimistic.

MALARIA RISKS IN THE YEAR 2000

On the basis of the observations made in the preceding sections, we might attempt to identify

[2] Winrock International. 1985. World agriculture: Review and prospects into the 1990s; a summary. (Unpublished report). Winrock International, Morrilton, Arkansas, April 1985.

what will be the most severe malaria risk situations in the year 2000. This is in itself a risky undertaking as the future cannot be forecasted with more than approximate precision. However, some of these risk situations are presently already seen to emerge and it is not difficult to extrapolate from them what consequences they might have in the longer term. A number of these are the following:

Endemic areas with inadequate infrastructure, already existing today, will persist for a sufficiently long time to represent the "hard core" of the traditionally malarious areas where little can be done to relieve the situation. Although considerable progress is expected in the provision of diagnosis and treatment, through primary health care (World Health Organization 1986), some of these areas will persist up to the year 2000. They will be concentrated in Africa south of the Sahara, southern Asia and parts of the western Pacific.

Natural resource development areas, particularly those under uncontrolled or illegal exploitation do already present a high risk and this will be increasingly true in the future. As these areas are being opened up and as they expand, they bring people with widely different malaria exposure experiences, including parasite carriers and non-immunes together in an environment which is conducive to an increased production of vector mosquitos, often in the absence of adequate infrastructural facilities for diagnosis and treatment, let alone vector control or source reduction. A different class of resource development activity is formed by government-initiated, often large-scale, projects for irrigation, hydropower generation or other purposes. These are often being planned and carried out without health safeguards being considered. The detrimental results on malaria incidence has in some instances led to considerable delays, to increased costs and to human suffering, all of which could have been avoided by appropriate action. Unless financing agencies and governments adopt health safeguards as essential components of such projects, these will form an added malaria risk in several less developed countries in the years to come.

Expanding urban areas do already form increasingly important risk areas in several countries as the originally rural breeding habitats become surrounded by urban sprawl areas and shanty towns. Typically, when such areas become more and more densely built up the conditions favoring anopheline breeding will gradually diminish and other health risks (dengue, DHF, lymphatic filariasis, plague) may arise, while malaria may remain prevalent in the expanding urban fringe.

Mobile non-immunes, already mentioned under the subject of resource development, form a risk group particularly prone to contract the disease in an endemic environment. If travellers, whether immune or non-immune, return to their places of origin they may contribute to the spread of parasites or of unfavorable parasite genes (drug resistance).

CONSEQUENCES FOR VECTOR CONTROL

Traditionally, vector control has been the main tool for the reduction of malaria transmission in endemic areas. In the malaria eradication era, residual house spraying with insecticides was considered indispensable for achieving the low levels of transmission where surveillance through active and passive case detection could reduce the incidence of the disease further. It is obvious that this philosophy will be rather inadequate in dealing with the problems outlined above. Residual house spraying will always have a role to play in areas where this method is useful, feasible and affordable, as long as an effective and safe insecticide is available. In some areas, notably in some cities, larviciding may have to be considered instead. In yet other situations, completely new approaches may be necessary. It ought to be realized that in areas of drug-resistance, vector control may contribute to prolonging the effective life-span of alternative drugs and might be applied just for that purpose. The consequences of the trends and risks described in the preceding sections fall into five broad categories: self-protection, adulticides, larvicides, source reduction and vector manipulation.

Self-protection. At the level of the individual, chemoprophylaxis and other measures for self-protection form powerful tools in the prevention of malaria. Mass chemoprophylaxis is not considered appropriate methodology for widespread application at the community level. Indeed, the popularity of chloroquine as a household drug for prophylaxis and treatment throughout many areas in Asia and Africa has been a major factor in the selection of drug-resistant *P. falciparum*. As we may expect these considerations to remain valid for some time to come, chemoprophylaxis will mostly be recommended for selected groups at risk, e.g. migrant workers, tourists, pregnant women. Other approaches should be used in addition. The reduction of man-vector contact through clothing, screening, netting, the use of repellents and/or insecticides, either solely or in combination, is a feasible and appropriate option in many situations. Clothing, bednets and curtains impregnated with pyrethroids have demonstrated their value in various parts of the world. As was shown in the Solomon

Islands, bednets can be impregnated with permethrin at village level under the guidance of a primary health care worker and it is now one of several tools in the integrated control of malaria in that country. Similarly, headbands, wristbands and anklets impregnated with DEET could be effectively applied by tourists or migrant workers travelling in endemic countries. Mosquito coils, already quite popular in many tropical countries, could be further promoted and made available at considerably lower cost. Housing improvements that reduce access of mosquitos to the occupants, such as screening of windows and doors or the replacement of ratan and bamboo by more solid materials for walls and floors, will have a major impact on malaria transmission if rigorously promoted and carried out under trained supervision. Evidently, a number of measures for self-protection requiring a minimum level of socio-economic development and basic facilities for primary health care, cannot and will not solve the malaria problem everywhere. All that is being argued is that each measure has its proper place and that we must be imaginative and flexible to cope with an increasingly complex situation.

Adulticides. Next to the "traditional" role of adulticides as residual insecticides, such as DDT, HCH, malathion, fenitrothion and others, there will be an increasingly important place for household applications like fumigant cannisters, knock-down aerosol sprays, etc., which individuals can use at home as part of self-help or community participation programs. Again, these applications require a certain level of socio-economic development. There must also be safeguards for their judicious use, both in terms of human safety and in terms of effectiveness, which implies minimal levels of literacy and well-trained primary health care workers.

Residual insecticides will have a place in malaria control for many years to come.

Larvicides. Traditionally, larvicides have always had a role to play in malaria control wherever the use of residual adulticides was either impractical or not cost-effective. Although this is bound to remain valid in the medium-term, larvicides may be especially useful in situations where they can be part of community participation programs for integrated vector control. The overall objective being to reduce vector densities, emphasis will sometimes be on permanent environmental measures rather than larvicides, depending on the local situation.

Source reduction. As much legal and government-controlled resource development in endemic countries entails migrations of non-immunes into areas with temporary housing and the potential risk of extensive vector breeding in habitats with poor infrastructures, the incorporation of environmental measures directed at source reduction will be of crucial importance in the prevention of malaria associated with such activities. In many other situations, source reduction, as a more permanent measure with durable results, may also be the method of choice. It is a critical feature of environmental management that it is based on a clear understanding of the local ecology and the epidemiology of the disease and, as is the case with other control approaches, it must always be cost-effective in comparison with other methods.

A special case for source reduction will be presented by the vast peri-urban and urban areas where poor drainage and the proximity of breeding places to residential areas will provide the conditions necessary for the transmission of malaria in some of the cities of tomorrow. Popular support for insecticidal spraying usually being poor in urban areas, such environmental measures will depend heavily on initiatives taken by municipalities, community participation being mainly through the payment of taxes or other contributions towards financing.

Vector manipulation. This term may be used to describe measures aiming at transmission control through the vector, without necessarily controlling the vector. The use of the cytoplasmic incompatibility technique for culicine control is a proven possibility. It is equally possible to apply a similar approach to the control of malaria and other human vector-borne diseases, but the methods involved have so far proved to be too costly and too complicated logistically to be of practical use. Similarly, genetic manipulation techniques aiming at increasing the frequency of refractory genes in the wild population, though technically feasible, have never been applied at the field level. Manipulating nature in a well-defined manner apparently is still beyond human capabilities. This situation may change in future if more becomes known about the molecular basis of host-parasite relationships and their genetic determinants. An exciting possibility for interference with vectorial potency through the introduction of symbionts, or competitive parasites, still needs to be explored. Methods like these may be of extreme value in areas where other vector approaches fail for lack of infrastructure or community support. Parts of the "hard-core" problem areas, still expected to be of importance in the year 2000, could benefit most if such control measures were to become operational.

MAJOR THRUSTS REQUIRED

Having had a speculative look at future trends and vector control needs, it now remains to assess these in the light of present-day knowledge and experience to see in what areas vector control research and development should be expanded and strengthened. These areas include at least the following:

Primary Health Care involvement. Although a number of tools for vector control in Primary Health Care already exist, we generally lack know-how as to how to promote their utilization. At the general health services level, public health officers are not always aware of the merits and the cost-effectiveness ratios of many available vector control methods. At the community level, people often fail to see the relationship between vector prevalence and disease or to appreciate the potential of control and prevention for the amelioration of the quality of life. Primary Health Care workers, if they are available, often lack the understanding or the specific training required to effect the necessary changes. Major target areas for operational research and training in this field should be: (1) self-protection, (2) housing improvement and (3) environmental management/source reduction.

Development of new pesticides. As there will always be a need for appropriate pesticides, the present situation gives rise to concern. The number of alternative insecticides for malaria control is not being increased as it should, although some interesting new compounds are under trial. A major effort will be required in the following areas: (1) new generations of compounds, (2) new formulations of existing compounds and (3) household applications.

Development of new biologicals. Biological control agents for malaria vectors need to be found to complement larvivorous fish, which form the major group of such agents at the moment. Although a great many potential agents have been identified, few of these have so far been developed to the operational stage. The potential for vector manipulation, alluded to in the foregoing paragraphs, has not even been touched. It is evident that major thrusts are needed in (1) further development of existing biologicals, (2) identification of new generation biologicals and (3) vector manipulation.

Environmental management. More operational research and training in environmental management will be needed in three major areas: (1) water resource development projects (i.e. health safeguards), (2) urban vector control and (3) community participation.

Manpower development. Major efforts will be required to solve the vector control manpower problems world-wide. Not only do we face a severe shortage of trained specialists who can handle the very complex situations arising as a result of more adaptable strategies for malaria control and the spread of insecticide resistance, there is also a great need for trained technicians and, most of all, primary health care workers who can deal with vector control issues at the community level.

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