ARTICLES

THE FUTURE OF VECTOR BIOLOGY AND CONTROL IN THE WORLD HEALTH ORGANIZATION

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INTRODUCTION

The World Health Organization is a specialized agency of the United Nations with its headquarters in Geneva, Switzerland. Through its six regional offices, through its country programs and through its various research, development and health promotion programs, it attempts to help its 165 member nations obtain the highest possible level of health. Dedicated to assisting both the developed and the developing nations, perhaps its greatest challenge is to assist member countries in the effective control of communicable diseases; of these the vector-borne diseases and their control are among the foremost problems.

The Division of Vector Biology and Control of the World Health Organization, is essentially a service division. Its function is to provide support for those organizational groups who are responsible for guiding the control of the vector and rodent-borne diseases such as the Malaria Action Programme, the Parasitic Diseases Programme and the Communicable Diseases Division. Our task is to stimulate and support research on the bionomics of the vectors including vectorial capacity, distribution and pesticide susceptibility; based on this information it develops effective, appropriate and economically acceptable methods and materials for use by the member nations in their national vector control programs aimed at reducing or, where feasible, interrupting transmission of vector-borne diseases. In those areas in which they are endemic, this group of diseases remains among the most important of the communicable diseases giving rise to considerable morbidity and mortality. The most widespread of these diseases is malaria and the number of cases reported to WHO is shown in Table 1. It should be noted that these reported cases do not include the area of Africa south of the Sahara for which little accurate data are available; the total incidence of malaria for the world is estimated at some 90 million cases a year. In many rural areas of the world, every child born will be exposed to malaria and, in those geographical areas where *Plasmodium falciparum* is the most prevalent species of malaria parasite, the resulting toll in mortality may be especially heavy. As an example, it is estimated that hundreds of thousands of infants die every year from malaria in Africa south of the Sahara.

In many urban areas of South East Asia and in some in the Western Pacific, most children will be exposed to one or more of the four serotypes of dengue and may develop dengue haemorrhagic fever (DHF) and unless given proper medical care, many will die of this disease. This syndrome has also appeared in the western hemisphere in Cuba and may well spread to other countries. Table 2 shows reports of dengue and DHF which have been

Table 1. Number of malaria cases reported by WHO Regions (in thousands), 1973–82.[a]

WHO Region	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
Africa[b]	6,662	5,120	4,209	5,514	4,881	7,444	5,847	3,104[d]	2,039[d]	—
Americas	880	269	357	379	399	465	512	597	630	710
South-East Asia	2,686	4,162	6,105	7,304	5,540	4,800	3,666	3,706	3,459[d]	2,936[d]
Europe	9	7	13	41	119	93	34	38	60	66
Eastern Mediterranean	746	480	429	349	227	162	125	137	186	309
Western Pacific	201[c]	179[c]	188[c]	211[c]	4,457	3.422	2,706	3,654	3,450	2,435[d]
TOTAL (excl. Africa)	3,922[c]	5,097[c]	7,092[c]	8,284[c]	10,742	8,942	7,043	8,132	7,785	6.456[d]

[a] The information provided does not cover the total population at risk in some instances.
[b] Mainly clinically diagnosed cases.
[c] Excluding China.
[d] Provisional.

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[2] Presented as an invitational paper at the joint meeting of the American Mosquito Control Association and the New Jersey Mosquito Control Association, Atlantic City, New Jersey, March 18, 1985.

Table 2. Recorded number of cases and deaths of dengue, 1976–83.

WHO Region		1976	1977	1978	1979	1980	1981	1982
Americas	Cases	—	—	—	—	—	344,203*	50,450
	Deaths						158*	—
South-East Asia	Cases	17,267	51,966	21,479	19,585	50,615	32,974	28,621
	Deaths	671	1,311	774	450	681	501	401
Western Pacific	Cases	22,624	45,820	1,279	89,121	47,941	6,081	22,624
	Deaths	71	737	2	1,590	4	0	71
TOTAL	Cases	39,891	97,786	22,758	108,706	98,556	383,258	101,695
	Deaths	742	2,048	776	2,040	685	659	472

* Cuba.

reported up to 1982. In light of the difficulty of accurately diagnosing or confirming such diagnoses, the actual number of cases of dengue is probably a multiple of these figures. The rapid, unplanned urbanization which has occurred and is occurring in very many of the developing countries (Gratz 1973), has far exceeded the ability of most municipal services to deal with the human populations densely settled in shanty towns or tenements. The open sewage drains in these places are prolific breeders of *Culex quinquefasciatus*, an efficient vector of Bancroftian filariasis. Table 3 shows the estimated number of persons at risk to infection with filariasis and those estimated as having overt cases. Because in many of the smaller cities, towns and villages of the developing world piped water supplies to every house is a rarity, if present at all, rain water, well water or water taken from neighborhood stand-pipes must be stored for the daily needs of the household in drums and clay jars and these are prolific breeders of *Aedes aegypti* or *Ae. albopictus*. Large piles of refuse on street corners and in empty lots serve as breeding sources for synantropic flies and provide food and harborage for rodent populations; these latter are reservoirs of plague, murine typhus, leptospirosis, haemorrhagic fever with renal syndrome, salmonellosis and other diseases which cause much illness. In most of these cities and towns refuse disposal services simply cannot cope with either the solid or liquid refuse which accumulates and the few rodent control services which exist do little to reduce the dense rodent populations.

To the diseases already listed must be added a long list of other arboviruses, arenaviruses (haemorrhagic fevers) and vector-borne bacterial, protozoal and helminthic diseases whose numbers can be counted in the tens and hundreds of millions: e.g., 12 to 20 million cases of Chagas' disease in the Americas, 20 to 30 million cases of onchocerciasis in Africa, Central and South America, over 200 million cases of schistosomiasis in 74 developing countries and uncertain but substantial numbers of cases of yellow fever, the encephatitides, Rift Valley fever, haemorrhagic fever with renal syndrome, flea-borne and louse-borne typhus, scrub typhus, plague, leishmaniasis and sleeping sickness. Few tropical or semi-tropical countries are spared and few inhabitants in both rural and urban areas are not at risk to one or more of these diseases and still others found in lesser numbers.

As the developing world struggles to produce

Table 3. Lymphatic filariasis. The total number of persons at risk of infection in endemic areas and the estimated number of persons with overt filariasis.

WHO Region	Total population of endemic countries[a] (millions)	Population living in endemic areas ("at risk") (millions)	Filarial infection (Mf + ve & disease) (millions)	
			Wuchereria	*Brugia*
Africa	295	113	25.6	0
Americas	136	5	1.0	0
South-East Asia	1,032	399	46.1	4.4
Europe[b]	—	—	—	—
Eastern Mediterranean	53	21	2.2	0
Western Pacific	1,161	367	6.7	4.2
TOTAL	2,677	905	81.6	8.6

[a] Population figures have been taken from *World Health Statistics Annual*, Geneva, 1982.
[b] Cases are still being reported from Turkey, but there is no recent evidence of local transmission.

enough food to feed its rapidly expanding population many water resource development projects including dams and widespread irrigation schemes have been undertaken. Unfortunately many of these projects have also resulted in substantial increases in mosquito breeding and, subsequently, substantial increases in mosquito or snail-borne disease whose toll must be added to the cases which "naturally" occur.

VECTOR CONTROL PROGRAMS

For many of the vector-borne diseases there is, as yet, no effective chemotherapy, immunization or vaccine available; for others the use of prophylactic or therapeutic drugs is not practical or, as in the case of malaria, is complicated by the appearance and rapid spread of drug-resistant strains of *P. falciparum*. Most of the disease endemic countries must, therefore, undertake substantial vector control programs aimed at controlling insect or other arthropod vectors, rodent reservoirs or snail intermediate hosts of disease. At present, and for the foreseeable future, such control operations must, for the most part, rely on the application of pesticides and surprisingly large quantities of pesticides are being used in such vector control programs. Table 4 shows the quantities being used of six major insecticides; the actual number of different insecticides and rodenticides being used and their quantities is considerably more than this. From a survey conducted in 1982–83 (Smith and Gratz[3]) of some two dozen urban vector control services in developing countries, it can also be seen (Table 5) that the cost of such programs to these countries is very high indeed. It must also be kept in mind that these costs are being borne by among the least developed of the developing countries, countries in which the average annual per capita income is often little more than $150.

Table 4. Estimated usage in 1984 of major insecticides for national vector control programs in 103 developing countries.

Insecticide	Metric tons (a.i.)	Approximate cost US $
DDT	30,215	57,408,500
HCH	18,437	27,655,500
Malathion	7,869	15,738,000
Fenitrothion	680	3,000,000
Propoxur	70	490,000
Temephos	306	4,896,000
TOTAL	57,577	109,188,000

[3] Smith, A. and N. G. Gratz. 1984. Urban vector and rodent control services. Unpublished report. WHO/VBC/84.4.

In the past most vector control campaigns were essentially "vertical" campaigns affected through semi-independent organizations within the Ministry of Health often with the responsibility for the control of but a single disease or vector. The best known of these are certainly the malaria eradication and control programs and the *Aedes aegypti* eradication program in the Americas. When it was anticipated that success could be reasonably expected within a limited period of time and that the great cost and effort involved might lead to the eradication of a disease or a vector, such vertical campaigns were considered justifiable; however, with the increasing advent of such technical problems as vector resistance to insecticides and parasite resistance to drugs along with the economic straits in which most of the developing countries find themselves, it is, in most cases, quite impossible to contemplate the continuation of such costly vertical programs. Yet, as one has seen from the figures presented earlier, the great amount of morbidity and mortality which the vector, rodent and snail-borne diseases cause, make it imperative that some effective and affordable approach to the control of these vectors be sought and implemented. It is certain that this will be done through the development of primary health care programs and that it also must include an ever-growing degree of self-reliance at the community level.

GLOBAL STRATEGY—"HEALTH FOR ALL BY THE YEAR 2000"

In 1979 the World Health Assembly meeting in Geneva representing all of the Member States of WHO adopted a resolution endorsing a global strategy for "health for all by the year 2000"; this implies that the main social target of both governments and WHO should be the attainment by all the people of the world by the year 2000 of a level of health that will permit them to lead a socially and economically productive life. The main thrust of this strategy is

Table 5. Estimated cost of urban vector control services in developing countries, 1982–83 (US $).

Vectors	Annual expenditure including manpower, etc. (Global per capita)	Pesticides alone
Insects	638,930,000 (0.35)	103,351,000 (0.06)
Rodents	95,387,000 (0.53)	7,240,000 (0.004)

the development of health care infrastructures starting with primary health care for the delivery of countrywide programs that reach the entire population and which includes measures for disease prevention. It will necessitate formulating measures that can be undertaken by individuals and families in and around their homes, by communities and by the health services at all levels. It also involves selecting technologies that are appropriate for the countries concerned in that they are scientifically sound, adaptable to various local circumstances, acceptable to those for whom they are used and to those who use them, and maintainable with resources that the country can afford. The relevance of these objectives to vector control programs is obvious—not only for the developing world but for the developed countries as well. They imply in fact that such activities must be expanded at every level if all populations are to achieve relief from the burden of vector-borne diseases and a state of well-being free from the discomfort and nuisance of pest insect attack. Since it is simply not economically feasible to add large numbers of parallel vertical programs to achieve these ends, the challenge to vector control in the future will be how to obtain these objectives with the expectation of only minor expansions in the resources already available.

The first and most obvious step is to make better use and better management of the available resources; there are many ways of doing so; some will require additional research on how existing materials and methods can be more selectively and effectively deployed and almost all will require behavioral studies on how the community and the individual can be more effectively involved in their own protection. Providing that the community is given adequate support and guidance then it follows that the more that a community can do for itself the less there will be a demand on scarce national resources for services to do things for them for which they cannot pay.

One of the most striking examples of an ideal target for such individual and community involvement is *Aedes aegypti* in the Americas, the Pacific and South East Asia as well as most of the urban areas of Africa. Practically all of the larval habitats of this vector of urban yellow fever, dengue and dengue haemorrhagic fever in these geographical areas are man-made; a large proportion of them could be cheaply disposed of or otherwise dealt with if the community could be actively involved in doing so. While this would reduce the demand for specialized vector control personnel it implies that health promotional activities in the community must be greatly increased. In addition, governments must make long-term efforts to increase the provision of piped water supplies and thus obviate the necessity for storing water in and around houses as well as provide better solid and liquid water disposal services especially in urban areas.

Many examples could be given of where communities could be far more involved in activities for their own protection; among these are the use of the simple, cheap and highly effective traps for riverine tsetse fly control, the replastering of walls of houses to reduce Chagas' vector densities, the use of cheap water-seal latrines to reduce *Cx. quinquefasciatus* and fly breeding, the use of bednets to prevent mosquito bites, the family application of pediculicides for head louse control etc., etc. Experience in some countries has even shown that volunteer workers in rural and urban areas can carry out many pest control activities, especially when provided with at least minimal training and safe pesticides for them to apply—and the motivation to do so.

The mosquito abatement districts of the United States are, in a very real sense a manner of community involvement in vector or pest control in that for the most part they are voted into creation by the communities they serve and paid for by voluntary and affordable tax levies. While this particular type of community participation may not be appropriate for a very poor community or country, it has proven to be appropriate for most of those areas of the USA where such districts or associations exist, and are certainly most appropriate to deal with vector control operations on a scale beyond that which the individual or the community itself is able to undertake by themselves.

Whatever the approach selected it must be adapted to the bionomics of the local vectors, it must be effective to the point that it actually reduces or suppresses transmission of disease and, as has been emphasized above, it must be acceptable and affordable to the community or country. To ensure that this is implemented will require the existence of well-trained core professional groups in each of the disease endemic countries who are familiar with their local vectors, the techniques, materials and methods available for their control as well as the mores of the communities in which they will work. Unfortunately, in most of the very countries with the greatest vector-borne disease problems there is also the greatest shortage of professionally trained vector control specialists capable of undertaking the operational research and the planning, implementation and supervision of vector control activities which their countries need. It is for this reason that WHO has diverted considerable resources to the creation of in-country and regional training facilities ranging from short three-week courses for the training of middle-level personnel to M.Sc. courses for the professional training of medical entomologists. Much effort is also being put into the provision of training aids for primary health care workers and their trainers and for professional level personnel.

FUTURE ROLE OF THE WHO

The World Health Organization sees as its role the responsibility for stimulating and supporting to the extent possible research on disease vectors and their control, the training of staff to carry this out and the provision of technical support to vector control programs in member countries. The latter includes contracts with research institutes and industry in the development of pesticides, both chemical and biological as well as support for research on the development of cost effective alternatives to chemical control such as biological control agents and environmental management.

However, despite the availability of a great deal of information and a broad spectrum of materials and methods that can be used to obtain efficient control of vector populations, it is all too clear that much of this information is not reaching the individuals who need it the most, i.e., the personnel responsible for implementing actual vector control operations. Often nominally effective pesticides and efficient application equipment give disappointing results. One of the reasons for this has been touched upon earlier, that is, the lack of specially trained vector control personnel especially entomologists. The responsibility for vector control is given to medical officers with little background in vector biology and control and who have a plethora of other responsibilities, or, on the other hand, to sanitarians, health assistant or primary health care workers. These personnel may themselves have little idea of just what species must be controlled or even why, of when and how to control them, of how to carry out insecticide susceptibility tests and how to evaluate the effect of control operations and improve them when necessary. Again and again one returns to the necessity for more training; the countries where the vector-borne diseases are most serious must train more vector biology and control specialists and, moreover, must ensure that there are adequate career opportunities for them to provide much needed motivation. Such trained personnel could then judge how best to apply the wealth of knowledge already available, ensure that it is adapted to local needs and train their own communities how to apply them. The core professional groups must also carry out the field research and entomological and epidemiological evaluation that can only be done in the endemic area where the control activities are being undertaken. Finally they must help develop the will in their own countries to develop vector control programs and present their political leaders with clear guidance and options so that the correct decisions can be made.

Were unlimited funds available to the disease endemic countries, vector control operations in the future might very well look as they have in the past, i.e., a very small number of professional entomologists or other professionals, usually expatriates usually paid for by donor countries, directing the activities of large spray teams paid for by national governments and directed from a national headquarters. The resources which permitted the implementation of such semi-military types of vertical operations are quite unlikely to be available in the future nor is such a paternalistic approach desirable or acceptable to most governments and peoples. Graham (1982) has already warned of some of the dangers inherent in the intervention of well-meaning consultants in international medical entomology programs who may not be familiar with the financial and cultural constraints of the community with which they are working.

CHANGES IN VECTOR CONTROL PROGRAMS

The nature of vector control programs especially in developing tropical countries must, therefore, change in the future. The exact model which must be followed will, of necessity, vary greatly from country to country. Some countries and communities where resources are greater may choose to have their own specialists undertake the work on their behalf but the very poorest communities, and these are the majority, must themselves undertake at least part of the work. Even this need not necessarily imply that each individual or family would be involved but certainly primary health care workers who are part of each community must then be trained and motivated to do so for their own village or neighborhood, being compensated for what they do either by goods or money from the community for whom they work. China has shown that this system can be very effective.

The changes which must be brought about are certainly not easy ones nor will it be very easy to ensure that it will succeed. It is only certain that the problems grow worse from year to year while resources to deal with them do not expand. Vector control in the future must, of necessity, change and adapt itself so as to meet the needs of the community with what means the community can afford to provide. The community must also realize that it can no longer be a spectator (Mouchet[4]) but must take part either actively to the extent that it can or passively by paying for some of its own protection. Governments whether local or national must take the responsibility for training the trainers and the core professionals and allocating at least minimal resources for them to work with. Ministries of Health or health departments must improve the epidemiological guidance they give to vector control personnel, for without this there is no way of establishing priorities for where work must be done.

The developed world can contribute greatly to this task. They can carry out the specialized research to develop the materials, equipment and even methods to be used and help establish the training facilities in the disease endemic countries to train the entomologists, biologists, engineers, chemists, epidemiologists and even anthropologists and sociologists who must take up the core or central professional group in each country. Thus each of us has a role whether in carrying out the research that creates the tools, in the transfer of the information on these tools to the countries and communities that need it, in the guidance of the work itself and finally in implementing it and evaluating it in terms of its ultimate objective, i.e., to what extent have we reduced transmission of disease.

[4] Mouchet, J. 1982. Vector control at the community level. Unpublished report. WHO/VBC/82.847.

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