Control of disease vectors: a current perspective

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A brief history of the use of pesticides to control vector-borne diseases is presented. Integrated vector control is defined and some promising new approaches are described, with emphasis on environmental management and methods that lend themselves to greater community participation. The role of the community in vector control is discussed, and a brief account is given of some community-based vector control projects in Africa and South America.

The use of pesticides in public health has been mainly to control vector-borne diseases. Vectors are small animals, mostly insects, that transmit pathogens from one host to another. Insects were incriminated as vectors of human disease as early as 1878, when Manson connected mosquitoes with filariasis. Soon afterwards, Ross and others showed that mosquitoes transmitted malaria (Harrison 1978). Some of the tropical diseases that most affect human well-being are vector borne (Table 1).

Most of these diseases are associated with bloodsucking insects, and many are associated with water, because the vectors spend all or part of their life cycles in or near it. For example, culicine mosquito vectors of filariasis and Japanese encephalitis breed in water, ranging from organically polluted drains to rice fields; anopheline vectors of malaria in seepage puddles, ponds, and streams; *Cyclops*, the intermediate host in guineaworm disease, in wells and ponds; *Bulinus*, *Biomphalaria*, and *Oncomelania* snails, the intermediate hosts in schistosomiasis, in streams, low earth-dam reservoirs, and rice-irrigation systems; and *Simulium* vectors of onchocerciasis (river blindness) in fast-flowing waters including spillways of dams.

Other vector-borne diseases that have caused disastrous epidemics are typhus (*Rickettsia prowazeki*), transmitted by body lice (*Pediculus humanus*), and bubonic plague (*Yersinia pestis*), transmitted from rodents to humans by fleas (*Xenopsylla cheopis* and *Pulex irritans*). These diseases are not major problems

Table 1. Prevalence and distribution of some vector-borne diseases of humans.

Disease	Vectors or intermediate hosts	Estimated world prevalence[a]	Main areas of distribution[b]
Malaria	Mosquitoes (*Anopheles* spp.)	100×10^6/yr	Pantropical
Filariasis	Mosquitoes (*Anopheles, Culex, Aedes, Mansonia*)	90×10^6	Africa, Asia
Yellow fever	Mosquitoes (*Aedes* spp., *Haemagogus*)	—	Africa, South America
Dengue	Mosquitoes (*Aedes* spp.)	—	Pantropical
Japanese encephalitis	Mosquitoes (*Culex* spp.)	—	Asia
Onchocerciasis	Blackflies (*Simulium* spp.)	18×10^6	Africa, Central and South America
Leishmaniasis	Sandflies (*Lutzomyia, Phlebotomus*)	12×10^6	Africa, mid-East, Asia, South America
Sleeping sickness	Tsetse flies (*Glossina* spp.)	20×10^3 [c]	Africa
Chagas' disease	Triatomine bugs (*Triatoma, Panstrongylus, Rhodnius*)	16-18 $\times 10^6$	Central and South America
Schistosomiasis	Snails (*Biomphalaria, Bulinus, Oncomelania*)	200×10^6	Africa, Southeast Asia, Middle East
Guineaworm	Crustacean (*Cyclops*)	5-15 $\times 10^6$ [d]	Africa, mid-East, India, Pakistan

[a] WHO (1989a) unless otherwise stated.
[b] WHO (1989b).
[c] Number of new cases reported each year, but "...the real incidence is certainly much higher" (WHO 1989a).
[d] Hopkins (1988).

now, but they continue to threaten; typhus, especially, soon becomes epidemic in times of war, famine, and overcrowding.

Once their role was established, it was soon realized that the most effective way to control the diseases was to control their vectors. Before 1914, yellow fever in Cuba and the Panama Canal Zone was controlled by draining, destroying, oiling, covering, or burying all water containers in which *Aedes aegypti* could breed (Harrison 1978). By 1940, *Ae. aegypti* had been eradicated from Brazil by similar methods, rigorously enforced by almost militaristic campaigns (Soper et al. 1943). Malaria in Italy and other countries was controlled by draining the marshes that the *Anopheles* larvae inhabited, applying the larvicide Paris Green (copper acetoarsenite), releasing larvivorous fish (*Gambusia*), and screening windows (Harrison 1978).

The insecticide era

Although dichlorodiphenyltrichloroethane (DDT) was only discovered to kill insects in 1939, by 1944 this insecticide was being used to control typhus and malaria in Italy, and its use soon became worldwide to control pests and vectors of all kinds. For the control of malaria, houses and cattle sheds were sprayed twice a year with DDT wettable powder (WP) to kill resting *Anopheles* adults.

In 1955, following the spectacular success of this technique in Guyana, Italy, Taiwan, and other countries, the World Health Organization (WHO) inaugurated a global malaria-eradication program. By 1958, 75 countries had joined and, in 1961–1962, at the peak of the campaign, 69 500 t of pesticides, mainly DDT, were applied each year by 130 000 spraymen to 100 million dwellings occupied by 575 million people. The number of people contracting malaria fell from about 300 million/year before 1946 to about 120 million/year by the late 1960s; in a population that had doubled in size, malaria was eradicated from 10 countries.

After 1965, however, malaria made spectacular "comebacks" in many countries, especially India, Pakistan, and Sri Lanka. Between 1972 and 1976, the number of malaria cases increased 2.3 times worldwide, although the late 1970s saw some improvement as control campaigns were revived (Bull 1982). The resurgence of malaria was due to a variety of factors, including:

- Premature slowing of the eradication campaigns;
- Poor management and unsustainable approaches;
- Inadequate understanding of the habits of the mosquitoes (many spent too little time indoors to be vulnerable to the spray deposits); and
- Insect resistance.

By 1980, resistance to at least one insecticide had been reported in over 150 species of arthropods of public-health importance, including 93 species of mosquitoes (WHO 1984). This led to failure of some control programs and a switch to alternative insecticides, although "in some instances, resistance has become a convenient scapegoat for failures due to other factors" (Davidson 1989). DDT has been banned in some countries, but is still used for vector control in others. Where resistance has become a problem, DDT has been replaced by organophosphates (e.g., malathion and fenitrothion), carbamates (e.g., propoxur and bendiocarb), or synthetic pyrethroids (e.g., permethrin and deltamethrin). These insecticides are, for the most part, less persistent and much more expensive than DDT. Antimalaria campaigns continue in many countries, but the goal is no longer eradication, just control.

Other vector control campaigns have also been based mainly on insecticides. Many Caribbean and South American countries have had programs to control *Ae. aegypti* since 1960 or earlier, attacking larvae with the organophosphate temephos and perifocal spraying (for emerging adults) with another organophosphate, fenthion, supplemented during dengue epidemics by fogging or aerial spraying with malathion. Although eradication was achieved in some countries, by 1977 most campaigns in the region were "ineffectual, poorly supported and lacking adequate professional supervision and leadership" (Giglioli 1979).

Many countries in South America have promoted house-spraying with dieldrin and other residual insecticides to control triatomine bugs. Large tracts of land in west and central Africa have been cleared of tsetse flies by aerial spraying, especially with endosulfan.

The most successful campaign using insecticides in recent years was the onchocerciasis control program in West Africa, which now covers 14 000 km of rivers in 11 countries. Launched in 1974, the program has involved aerial spraying of blackfly-breeding sites with the organophosphate insecticide, temephos, now replaced in some areas by *Bacillus thuringiensis* because of resistance to temephos. Onchocerciasis control has been good in the central area, but reinvasion by blackflies in the periphery is still a problem (Remme and Zongo 1989).

An international campaign against guineaworm involved treating drinking-water sources with temephos to kill *Cyclops*, the intermediate host.

Side effects of pesticides used in public health

In spite of the millions of houses sprayed with DDT for malaria control, no accidental deaths of spraymen or householders due to DDT poisoning have been reported. However, some domestic animals were killed, especially cats, with the result that rat populations increased in some sprayed areas (Bull 1982). Bedbugs, cockroaches, and other household pests soon developed resistance to DDT, and became more abundant because the DDT had killed many of their predators. This led some householders to oppose spraying.

In the past, it was claimed that environmental contamination by DDT used in malaria control was relatively minor because it was sprayed inside houses, and the quantities were much smaller than those used in agriculture. However, washing of equipment, containers, and overalls, and the unauthorized use of DDT for other purposes (e.g., fish poisoning) spread the substance outside the houses. DDT used for malaria control accounted for an estimated 8% of global DDT contamination (Bull 1982).

Where pesticides are stockpiled for use in epidemics (e.g., dengue), environmental contamination due to leaking containers (some insecticides are highly corrosive), fire, theft, war, or natural disasters is always a danger.

Extensive studies in Africa of the effects on nontarget organisms of aerial spraying of endosulfan against tsetse flies and temephos used in rivers against blackfly larvae have revealed no permanent damage to treated ecosystems. In the case of tsetse fly control, it has been argued that any changes to the ecosystems caused by spraying are insignificant compared to the changes that will follow human settlement of tsetse-cleared land. However, there is no need for complacency in these matters, and further studies are required.

Agriculture and vector-borne diseases

The links between agricultural development and human health are poorly documented and "the health sector has up to now had minimal involvement in agricultural policies or projects" (Lipton and de Kadt 1988). However, people who clear forests for cultivation are at a high risk of infection with diseases such as malaria, leishmaniasis, African trypanosomiasis, and other diseases, because of increased exposure to the vectors. Moreover, insecticide resistance in mosquito vectors has been induced by the use of the insecticides in agriculture (Bull 1982). Selection acts upon the mosquito larvae as they develop in insecticide-contaminated waters. Particularly implicated in this context have been dieldrin, DDT, malathion, parathion, and propoxur (used mainly on rice and cotton crops). Among the affected anopheline species have been *Anopheles acconitus* (Indonesia), *A. albimanus* (Central America), *A. gambiae* s. 1 (West Africa), *A. maculipennis* (Turkey), *A. culcifacies* (India), and *A. sinensis* (China).

Irrigation presents a special problem, because many vectors live or develop in water. Some vectors develop directly in irrigated fields, others in canals, seepages, artificial lakes, or dam spillways. Increasing vector populations and more human contact with them have increased the transmission of malaria and schistosomiasis in the China, Kenya, Sri Lanka, Sudan, and other countries. Japanese encephalitis has been associated with irrigation practices in Sri Lanka and elsewhere in Asia. Poorly planned resettlements of people displaced by artificial lakes have also increased the transmission of vector-borne diseases (Service 1989).

Integrated vector control

From 1945 on, DDT, lindane, and other residual insecticides provided a single, highly effective method of vector control that eclipsed all other methods until about 1970. Since then, the development of resistance, concerns about environmental contamination and human safety, and the high cost of alternative insecticides have led to a revival of interest in other methods of vector control. Some of these methods were already known, but were neglected during the DDT era: personal protection (e.g., screens and repellents), source reduction (e.g., draining or removing artificial breeding sites), the use of fish to prey on mosquito larvae, and community-based health education. Other methods, such as genetic control, synthetic attractants, insect growth regulators, and the use of remote sensing by satellite to detect vector habitats have also been attempted experimentally and in endemic situations.

Integrated vector control has been defined as "the utilization of all appropriate technological and management techniques to bring about an effective degree of vector suppression in a cost-effective manner" (WHO 1983). It demands an adequate knowledge of the biology, ecology, and behaviour of the vector, nontarget organisms, and the human population to ensure not only effective control of the vector, but also human safety and prevention of other unacceptable side effects, including environmental damage.

Although there are many integrated approaches to vector control, only some of the more promising ones are considered here, with emphasis on those that could be used in community programs to achieve greater sustainability. (See Axtell (1972) for a comprehensive discussion of this issue.)

Pesticides

Chemicals

Although DDT and other organochlorines have been banned in many countries and replaced in others because of vector resistance or adverse effects, many other synthetic insecticides are still available. WHO (1984) listed 37 compounds in common use for the control of vectors and pests of public-health importance (for a partial list see Table 2). In some places, such as California (USA), vast amounts of insecticides are still used each year for mosquito control. DDT was replaced initially by organophosphates, such as malathion, and more recently by synthetic pyrethroids, such as permethrin, which are costly but effective at very low doses. Unfortunately, there are

Table 2. Some pesticides used in public health.

Pesticide class and name	Vectors and modes of application	Remarks
Insecticides		
Organochlorines		
DDT	*Anopheles* spp.; house spray	Banned in many countries
BHC (lindane)	*Anopheles* spp.; house spray	Banned in many countries
Endosulfan	*Glossina* spp.; aerial spray	
Organophosphates		
Malathion	*Anopheles* spp.; house spray	
	Aedes spp.; fog, aerial spray	
Fenitrothion	*Anopheles* spp.; house spray	
	Aedes spp.; fog, aerial spray	
Chlorpyrifos	*Culex quinquefasciatus* larvae	Used in polluted waters
Temephos	*Aedes aegypti* larvae, *Cyclops*	Used in drinking water
	Simulium larvae; aerial spray	Used in OCP,[a] W. Africa
Carbamates		
Bendiocarb	*Anopheles* spp.; house spray	
	Triatomines; house spray	
Propoxur	*Anopheles* spp.; house spray	
Pyrethroids		
Pyrethrum extract	Mosquitoes; coils	
Permethrin	Mosquitoes; nets, clothing, soap	
Deltamethrin	*Anopheles* spp.; house spray, nets	
Microbials		
Bacillus thuringiensis	*Aedes* spp. larvae	
israelensis	*Simulium* larvae; aerial spray	Used in OCP, W. Africa
B. sphaericus	*Culex* spp. larvae	
Molluscicides		
Niclosamide	Snail hosts of *Schistosoma*	
Endod	Snail hosts of *Schistosoma*	Extract of *Phytolacca* seeds

[a] OCP = onchocerciasis control program.

already many reports of mosquito and biting-fly resistance to pyrethroids, some of them also because of cross-resistance to DDT (Miller 1988). Reports of such proven resistance to pyrethroids have come from Israel, Saudi Arabia, Sri Lanka, Tanzania, and the USA among others.

Pathogens

Some effective microbial pesticides are now available for vector control, especially spore/crystal preparations of *B. thuringiensis* serotype H-14 var. *israelensis* (*Bti*) and *B. sphaericus*. These microbials are highly toxic and specific to the targeted larvae of mosquitoes and blackflies. However, they are relatively expensive and difficult to formulate because the toxic crystals sink and become inaccessible to most larvae, although floating, slow-release formulations of *Bti* are now available (Hudson 1985). *Bti* is widely used in the onchocerciasis control program in West Africa and, increasingly, for mosquito control in California and elsewhere. Because these microbial pesticides are virtually nontoxic to mammals, they can be applied by community volunteers.

Plant extracts

Endod, an extract of seeds of the Ethiopian plant *Phytolacca dodecandra*, and damsissa, a product of *Ambrosia maritima* in Egypt, are effective against the snail intermediate hosts of *Schistosoma*. Other local natural products could be developed for vector control. For example, fruit pods of the tree *Swartzia madagascarensis*, widely used in Africa as a fish poison, were also found to be toxic to *Anopheles* larvae and *Bulinus* snails (Minjas and Sarda 1986); Alpha T from the marigold flower (*Tagetes*) is toxic to mosquito larvae (Arnason et al. 1987).

Personal protection

Personal protection includes all measures taken at the individual or the household level to prevent biting by vectors. Anklets impregnated with repellents significantly reduced biting rates of mosquitoes on volunteers in Tanzania (Curtis et al. 1987). Washing with soap containing a repellent (diethyl toluamide, DEET) or an insecticide (permethrin) reduced mosquito biting rates in the Gambia (Lindsay and Janneh 1989). Bed netting has been used for centuries to give personal protection against biting insects (Lindsay and Gibson 1988). When impregnated with insecticides, the netting provides community protection as well; mosquitoes rest on the treated fabric and are killed. In numerous large-scale trials in various parts of the world, malaria transmission appears to have been reduced by the systematic use of nets impregnated with permethrin or deltamethrin (Rozendaal and Curtis 1989).

House improvements such as screening, insecticidal paints (Lacey et al. 1989), and filling in cracks in the walls could provide definitive measures against triatomine bugs (Schofield and White 1984).

Predators

Larvivorous fish such as *Gambusia affinis* have been used for controlling mosquito larvae for many years. Among the more promising recent developments is the use of young Chinese catfish (*Clarias fuscus*) to control *Ae. aegypti* in household water containers in China (Wu et al. 1987) and a community-based malaria-control scheme in India, which paid for itself by selling carp and prawns that were reared in the same group of ponds as the guppy fish used for controlling mosquitoes (Gupta et al. 1989).

Many other organisms have been tested for the biological control of vectors. Candidates for controlling larvae of *Ae. aegypti* and other mosquitoes that develop in small containers are dragonfly larvae in Myanmar, the copepod crustacean *Mesocyclops aspericornis* in French Polynesia (Rivière et al. 1989), and the predatory mosquito species, *Toxorhynchitis* (WHO 1988).

Trapping

Mechanical and other types of traps have been used to reduce populations of tsetse flies. Several designs have been developed, some of them incorporating chemical attractants and insecticides. In Uganda, an effective tsetse trap has been made from old tires and locally available plant materials (Okoth 1986). Light traps, installed in pig sties, have been tested for the control of *Culex tritaeniorhynchus* in Japan (Wada 1988).

Environmental management

Changing the environment to prevent vector breeding or to minimize contact between vectors and people can be an effective control mechanism (WHO 1982). Environmental management methods (Birley 1989) include:

- Environmental modification, i.e., any permanent or long-lasting change in land, water, or vegetation, such as filling, draining, or forest clearance;
- Environmental manipulation, e.g., flushing streams, changing water salinity, and removing shade plants; and
- Modifying human habitation or behaviour, e.g., locating new settlements away from vector populations, modifying house design, and changing water supply and waste disposal.

Intermittent irrigation was used to prevent the development of mosquito larvae in rice fields (Lacey and Lacey 1990) and layers of expanded polystyrene beads prevented *Culex quinquefasciatus* from laying their eggs in wet pit latrines in Tanzania (Maxwell et al. 1990). Much environmental management work can be done by community volunteers with guidance in the initial stages from vector-control specialists.

Training and education

Integrated control strategies require more people trained in vector biology. In addition to the usual sources of health education, such as schools and clinics, information can reach the public through billboards, newspapers, radio, and television. A dengue-control theme has even been incorporated into a "soap opera" in Puerto Rico (Gubler 1989).

The role of the community

Many problems and failures in vector control have been due, not only to technical difficulties, poor management, and lack of continuity, but also to the fact that not enough attention had been paid to the beliefs and attitudes of the affected communities. For example, many *Ae. aegypti* control campaigns in the past 20 years have relied too heavily on ultra-low-volume spraying, which is not always effective. The use of this method has given people a false sense of security, reinforced their belief that *Ae. aegypti* control is the government's responsibility, and taken away the pressure to get rid of larval habitats in their own backyards (Gubler 1989).

A recent WHO report (1987) explores the ways in which more responsibility for vector control can be transferred from the national to the district level and ways of getting people more involved in protecting themselves against vector-borne diseases because "community participation makes people more aware of their ill-health and general underdevelopment and of how they can overcome these problems." Vector control at the community level has to compete with more basic needs, such as food, shelter, and employment, and the need for it may not be appreciated during periods of little or no disease.

Nevertheless, examples of successful community participation in 15 countries include: setting tsetse traps; draining, filling, or clearing weeds from mosquito breeding sites; rearing larvivorous fish; source reduction of *Ae. aegypti*; and distribution of nylon filters to keep *Cyclops* out of drinking water. Vector-control campaigns should work closely with primary health-care programs to achieve greater effectiveness and sustainable results (WHO 1987).

Research on community strategies for vector control

Building research capacity, producing new knowledge, and creating linkages among researchers are perceived as essential components of development by the International Development Research Centre (IDRC). However, IDRC-supported projects must contribute to improving the welfare and standard of living, particularly of the poor and disadvantaged who are to be the ultimate beneficiaries of the research. IDRC tries to ensure that the activities it supports meet the long-term goals of development as viewed from the perspective of these beneficiaries: sustainable growth, equity, and participation.

Environmental and community control of dengue in China

This IDRC-supported project (91-0032) of China's Hainan Island Bureau of Public Health focuses on feasible and sustainable intervention at the community level to prevent the occurrence of dengue epidemics on the island. The research team will work closely with affected communities to establish long-term, integrated, preventive measures through health education aimed at controlling vector breeding in the home environment and surrounding areas.

Village volunteers will participate, through committees, in the periodic reporting of suspected dengue cases and in the active surveillance by boats in the local harbours for *Aedes* breeding sites. Larvivorous fish will also be used in drinking-water storage vats.

It is hoped that this project will not only lead to a sustainable strategy to prevent dengue epidemics, but will also pave the way for preventive health in general in the island.

Malaria-vector control

Nepal

The Nepal Malaria Eradication Organization (NMEO) is examining sustainable strategies to minimize problems due to malaria in rural communities. Under the *Environmental control of malaria* project (88-0212), NMEO is exploring environmental management methods of malaria-vector control that will be suitable under local conditions and that can be implemented with community involvement. The study will be carried out through the existing community-based political system by the rural units of the NMEO. The results will be examined closely by the national health authorities with a view to rapid establishment of a sustainable malaria-control system in the endemic areas of Nepal.

Peru

Malaria control is a major challenge in Peru, where the disease assumes serious proportions in the poorest jungle and Amazonian areas. Rising costs of insecticides, insecticidal resistance of the insect vectors, and environmental contamination have now forced exploration of alternatives to insecticide use.

The use of safe and efficient biological control agents such as *Bti* depends largely on costs and feasibility of production. The *Biological control of malaria* project (88-0213) aims to develop and field-test a simple technique for local production of *Bti* using coconut milk as the medium. Whole coconuts will also be used as a convenient medium for inoculation of *Bti* by the communities themselves and to facilitate transportation and application in different parts of the endemic region.

Tanzania

Community trials of insecticide-treated bed netting result in mass protection from malaria. However, in most malaria regions, the cost of bed nets is beyond the resources of the population. The *Community prevention of malaria* project (89-0216) will test the original and practical idea of using polypropylene fibres from locally available sacking material, used for agricultural products, to make "grass skirt" style bed curtains. It is known that bed nets with holes perform as well as intact bed nets when they are impregnated with insecticide.

The project will compare interventions in three communities — one with impregnated bed nets, one with impregnated bed curtains, and one with conventional control — in terms of reduction of clinical malaria episodes, malariometric indices, vector transmission indices, relative durability of materials, persistence of their effects, acceptability of the measures by the population, and the relative costs.

Leishmaniasis vector control in Peru

A primary health-care strategy was proposed for the control of Andean leishmaniasis (project 90-0081), based upon the epidemiology and ecology of the disease identified during the first phase of the project. In addition to homes and their immediate surroundings other rural sites contribute significantly to leishmaniasis transmission and to the maintenance of *Leishmania* in the environment. Research in the second phase involves early diagnosis and treatment of the disease and insecticide spraying of disease-transmission sites in homes and immediate surroundings. Most significantly, the strategy will also involve insecticide spraying and reforestation of rural areas to eliminate these previously neglected sites of *Leishmania* transmission. The impact of this approach, which will be carried out by members of the community and through the health post with the support of project staff, will be compared with that of classic measures alone in a valley with similar characteristics.

Chagas' disease vector control in Paraguay

Chagas' disease is one of the most serious tropical diseases found in Latin America, both in terms of its prevalence throughout the region and its impact on morbidity and potential employability. About 65 million people are directly exposed to the risk of *T. cruzi* infection, a further 15–20 million are actually infected and, of these, about 10% develop chronic Chagas' disease.

In the absence of drugs and vaccines suitable for large-scale treatment, the only effective measure lies in a preventive approach that focuses on the control of triatomine insects, which transmit the causative agent to man, within the domestic and peridomestic environment. Triatomine-control strategies include insecticide spraying and housing improvements resulting from increased community awareness of the problem.

The *Chagas' disease prevention* project (87-0342) will compare three types of interventions in three similar communities: insecticide application, housing improvement, and a combined insecticide and housing intervention. Pre- and postintervention assessments will be made of changes in human *T. cruzi* infection measured by serology, changes in triatomine infestation levels in houses, and changes in awareness and knowledge about the disease. The generated information will be invaluable, not only to Paraguay's health authorities, but also to the rest of the endemic region.

Schistosomiasis

Egypt

The control of schistosomiasis in the Nile delta, through the use of the plant molluscicide *Ambrosia maritima* (damsissa), has been the subject of IDRC-supported research for the past 10 years. Phase IV of the project (87-0204) will expand the study protocol to a new area, conduct a knowledge, attitudes, and practices (KAP) study, and study the toxicology of *A. maritima*. Specifically, the objectives are:

- To confirm the application dose of *A. maritima* in various water situations in established and newly reclaimed areas;
- To assess an integrated approach to schistosomiasis control using *A. maritima* for snail control, combined with praziquantel case treatment, in an established farming area of high prevalence and in a reclaimed resettlement area at risk of schistosomiasis spread;
- To conduct a KAP study, in both the established and resettlement areas, to determine sociobehavioural aspects of acceptance of *A. maritima* by the community and to estimate the requirements for sustained self-help in *A. maritima* control strategies; and
- To perform toxicologic studies on *A. maritima*, including determination of its effect on aquatic nontarget organisms.

If successful, the investigators will be able to provide convincing evidence that *A. maritima* is an effective and long-lasting plant molluscicide, suitable for use in the Nile Delta and without major toxic effects on humans or nontarget aquatic organisms.

Zimbabwe

Effective synthetic molluscicides have proved to be too costly for most developing countries where schistosomiasis is endemic. Plant molluscicides offer an alternative. Of these, the best known is the soapberry *Phytolacca dodecandra* (endod), a plant indigenous to Zimbabwe. During the past 5 years, the most potent varieties have been identified and field trials have shown that the plant is effective in reducing snail intermediate hosts. The present study (90-0278) is designed to evaluate the efficacy, acceptability, sustainability, and cost-effectiveness of different approaches to reducing prevalence, morbidity, and transmission of schistosomiasis following mass chemotherapy. Approaches include: application of *P. dodecandra* through community effort; through health services effort; and conventional chemotherapy through health services. The project also includes studies of local ecotoxicity, community participation, and health economics of the alternative interventions.

Despite promising results, long-term community participation in vector control must be secured, because operations, such as the control of container-breeding mosquitoes, may have to be continued indefinitely. Little is known about extending pilot projects into permanent national programs. Community volunteers may become victims of political struggles or professional rivalries if their work is not given proper recognition. The best chance of maintaining community support seems to lie in integrating vector control into the primary health-care system, which is now established in many countries (MacCormack 1990). More research is also needed on how to coordinate vector control with work in agriculture, forest and water management, and on the role of migrant workers in disease ecology and control.

Community-based vector control is not a way to reduce government spending. Although local initiatives should be encouraged, each country will still need teams of professional vector-control workers, using well-established methods, to meet its obligations under international health regulations (WHO 1972).

Conclusions

Disease vectors will probably remain with us indefinitely. Optimizing use, doses, and safety of control measures and balancing vector control with consideration for the environment is a challenge we must face.

Future considerations must include such questions as whether an insecticide-free environment is possible, or desirable. All development projects should include ecological planning to prevent increases in vector-borne diseases. Environmental management must be considered on both the large and small scale. The role of the primary health-care system must be defined and intersectoral cooperation obtained.

The goal is to ensure that vector-control strategies satisfy ecological requirements as well as local needs and priorities, that they are shaped around people's lifestyles and living patterns, and that they promote community self-reliance with respect to ongoing development.

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