ARTICLES

PROSPECTS AND PROGRESS ON IPM IN WORLD-WIDE MALARIA CONTROL

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INTRODUCTION

Integrated control and its principles and practices are now widely known in health programs but are not always well understood and practiced. The wide publicity given in recent years to integrated control in agriculture and more recently in health programs, has been more in the form of promotion of research and scientific studies than in real actions and practical field application. The limited field applications that have so far been made in developing countries have not gone beyond a number of field studies and occasionally limited field projects and these almost entirely in agriculture. In health programs a field project planned for and applying integrated vector control approach was launched in the Sudan three years ago, and a first training activity in the form of an Interregional Seminar was organized in November 1981. The slow progress in the health field may be explained by the fact that health programs have emphasized integrated control only recently while agriculture has several years of experience in this field.

Generally speaking, both agriculture and health share the same reasons for this stagnating situation and slow progress achieved. The emphasis in both fields has been focused practically entirely on scientific sophistication and little on practical and modest use of the approach. The greatest share of funds and other resources has been consumed in scientific studies and research that though fully justified, may not be all that essential for the immediate application and practical use of the approach in operating programs.

Integrated control is not necessarily always a complex task to organize. In many situations the available information, methods and resources are adequate for a modest start and in many others perhaps only limited additions would be required. A reconsideration of research needs and practical implementation and reallocation of resources as well as an understanding of principles and practices of intergrated control is essential for speeding up progress in the use of the approach.

INTEGRATED CONTROL IN MALARIA PROGRAMS

DEFINITION. Integrated control in an antimalaria program was defined as "The selection and application of methods of control to optimize results."[2] The three major components of this definition can be expressed briefly as follows:

a) *The selection.* This includes a review of all the available methods of control and an assessment of their effectiveness, cost benefits and risks as applied to local conditions and the program objectives and resources.

b) *The application.* This includes combination of the selected methods to form

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[1] Invitational Paper, 38th Annual Meeting of the American Mosquito Control Association, Sacramento, CA.

[2] "Environmentally-sound integrated methods for controlling parasitic diseases", by H. A. Rafatjah. Presented at International Symposium on Nuclear Techniques in the Study and Control of Parasitic Diseases of Man and Animals, IAEA, Vienna, 29 June to 3 July 1981.

control strategies that are most cost/effective, have the highest benefits and least risks and are compatible with local socio-cultural and economic conditions, as well as application of the strategy and the evaluation of the results.

c) *The optimization.* This applies to both processes of selection and application and aims at achievement of the highest possible degree of effectiveness, operational efficiency, economy and safety and greatest benefits. Optimization must meet with the objectives and priorities of the project. Within the allocated resources greater emphasis will be allotted to priority areas where there is greater effectiveness or increased safety to the environment. The major task is to modify the controllable or partially controllable inputs to maximize outputs.

A combination of methods may not always necessarily ensure optimization of results. In certain situations, a single method may prove adequate.

MAJOR CONSTRAINTS.

a) *Overestimation of the requirements of integrated control.* Many antimalaria programs are among those public health vector control programs that can and do incorporate certain features of integrated control. Many programs, which started with almost complete reliance on residual insecticides for vector control, had to diversify shortly after and utilize other methods of application and other insecticides and, eventually, other methods of control. Technical problems in the control of vectors such as resistance to insecticides and shortage of effective and suitable pesticides, almost forced programs towards a more rational approach in selection of methods of control while operational and managerial difficulties drew attention and emphasis on socioeconomic factors and other elements of holistic approach in program planning.

The present approaches and strategies, however, still far from adequately reflect the concept, principles and practices of integrated control. Nevertheless, improved application of this approach is feasible in many programs and the available methods and data can be used to develop and plan integrated control strategies and gradually introduce and apply them. The problem is that most program managers are unaware of this possibility that integrated approach can in practice be introduced without a need for considerable additional resources and that many of the technical and operational and managerial problems encountered can be eliminated by sustained efforts towards improved application of integrated control. Many species of mosquito vectors of disease are more amenable to integrated control and managers should consider if the species they are concerned with are among them.

b) *Oversophistication of integrated control.* To most program managers integrated control can be introduced only when what they believe is *complete* information on ecology of vectors and epidemiology of the disease, on costs, effects and benefits of the methods is available. Of course, this is a far reaching goal and a complex undertaking, but it is not necessarily a prerequisite for initiating integrated control. It is clear that the kind of technical information that is needed to plan thorough integrated control does not exist in all programs and the kind of studies to collect these take time, need skilled personnel and funds. Thus, the approach must necessarily be modest in technical requirements and finance, with stage-wise development. In short, for many mosquito species enough is already known about their larval habitats and other aspects of their bionomics, including their response to various control measures on which to base the introduction of integrated control.

c) *Insufficient conviction of the advantages of integrated control.* Program managers should not only understand the principles and practices of integrated control but should also be convinced that it is financially advantageous both in the short and long-term and not necessarily less effective than the conventional approach. They should understand that many of their problems faced in a number of important antimalaria programs would not have arisen should the integrated approach have been used from the start and that many of the existing problems could be eliminated or greatly reduced by using integrated control now. They should also be convinced of the long-term effects, simplicity, safety and low cost of many environmental management and biological control measures.

d) *Misconception about the use of pesticides in integrated control.* Project managers need to be assured that integrated control does not nor cannot mean exclusion of pesticides but their more rational and correct use. Residual spraying will still be used and probably as extensively as at present for many years. However, the insecticides to be used and their dosage, cycle and coverage in time and space must be related more closely to local epidemiological and social and environmental conditions and requirements. Other pesticides will be used for larviciding and space spraying to relieve pressure on the residual pesticides and reduce their costs where the biology of the target species allows for such an approach.

Indoor residual spraying has become an undivorceable trend and routine no matter what the epidemiology of malaria or conditions of houses, vector habitats or its longevity and application problems. Other methods of pesticides application are seldom considered because they are more specific and need better consideration of local factors. Other methods of vector control are used only when pesticides are not effective or are inadequate.

The psychological "inertia" of overgeneralization has been hampering the introduction of the integrated control approach which requires careful consideration of *local conditions*.

e) *Insufficient consciousness of comparative costs, effectiveness, benefits and risks.* Pesticides have often been applied with disregard to the current problems and those that might lie ahead. Application of pesticides, especially indoor residual spraying, frequently becomes a routine practice regardless of the results obtained. The notion of cost/effectiveness, cost/benefit or risks is often not taken into account. Program evaluation is geared to collection and analysis of data on epidemiological impacts. Seldom are these results assessed against the objectives set out and the cost, benefits and effects to consider selection of other alternatives and project designs.

PRACTICAL APPROACH TO IMPLEMENTATION

PLANNING. The planning of integrated control should start with a review of the available methods of control and of the experience with their use. An assessment needs to be made of the effectiveness, costs, benefits and risks of each method and the feasibility of their application, taking into account the bionomics of the target species and including acceptability to the local population. Data on benefits, risks and sometimes on effectiveness and cost are not usually available and cannot easily be obtained. The assessment therefore, will need to be based on best estimation and on experience with the use of each method or through small scale field studies and trials.

Often it would be simpler if combinations are made of known methods and subjected to comparative assessments. For instance, it is known that the use of larvivorous fish produces medium to low effectiveness against mosquito larvae and simple environmental management produces high to medium effectiveness, depending on its degree of coverage. Both methods are simple to apply and inexpensive and seldom involve undesirable environmental implications. Additionally they can produce important side benefits and thus still reduce the overall costs. On the other hand, pesticides application produces high effectiveness and quick results but they are costly and require hard currency. They need repeated applications and thus a considerable number of staff of different categories and complex organizational structure and logistic lines. Their safety to man and environment needs stringent monitoring of the biotopes, the use of protective measures and finally, their repeated use may select for physiological and behavioristic resistance of vectors eventually requiring higher dosages or alternative pesticides which increases still further the material and operational costs.

From the above summary characteristics of the available vector control methods, it can be seen that already integrated strategies can be designed based on known features of each method and in full consideration of local conditions and intervening factors whether epidemiological, physical or environmental or socio-cultural and economic. Both short-term assessment and long-term prediction of impacts need to be considered.

If hypoendemic malaria is to be controlled, perhaps a combination of larvivorous fish and simple environmental management would be adequate if the given target species is responsive to such control. If quick control is desired and financing is adequate various insecticidal measures can be included as appropriate to the target species. In tropical situations simple environmental management may need to be applied more extensively than in arid and semi-arid situations and sometimes strengthened by resorting to more sophisticated methods. Biological control should extend to use of species of fish that are herbivorous where larvae are dependent upon the presence of water plants.

In arid and semi-arid situations environmental management is most cost/effective and should be planned for several years and aim at progressively eliminating breeding sites to gradually reduce malaria receptivity and the need for pesticides applications. The role of chemotherapy and chemoprophylaxis is very important in dealing with hypoendemic malaria and should be considered in conjunction with development and strengthening of primary health care programs.

If malaria is at meso- or hyperendemic levels, the campaign must necessarily start with application of residual pesticides to effect an appreciable drop in the prevalence of the disease within a few years. Concurrently other methods of vector and parasite control should be initiated to increase the impact and shorten the duration of pesticide usage.

Indoor residual spraying may be applied widely but should be closely tailored to the local epidemiological and operational needs. It can be supplemented with larviciding and indoor or outdoor space spraying of pesticides where vector mosquitoes have exophilic and exophagic tendencies or to a larger proportion replaced by them in urban situations and where housing conditions and/or peoples' reactions are unfavorable to indoor residual spraying.

Within a few years the malaria incidence can be expected to show a general drop, perhaps more pronounced in responsive areas with a low malariogenic potential and where the quality of the control operations is high.

During this period the biological and environmental management measures being used will have gained strength and appreciable coverage and thus should contribute effectively in overall vector/disease control impacts. Depending on the response of the vectors and the disease to the applied strategy and as soon as an appreciable drop in the malaria transmission and incidence has been noticed, the situation should be reviewed and the control strategy readjusted to new conditions. As early as the second and third year it may be possible to reduce the intensity of indoor residual spraying in certain areas. This can be done by decreasing the dosage and/or cycle of application and by reducing the coverage of spraying operations. Where this is possible other methods of control need to be strengthened to make up for the partial or complete withdrawal of residual spraying. A progressive application of such a control strategy should normally reduce endemicity in the majority of areas to hypoendemic level where the preceding types of control strategies can be applied.

As it can be noted from the above, the major element of success lies in the stringent monitoring of the situation and continuous evaluation of results obtained. Epidemiological, as well as environmental and socioeconomic conditions and their changes need to be regularly checked to allow an assessment of the results and a revision of the control strategies to comply with the needs and prevailing situation as it evolves.

APPLICATION. Concurrent with the review and selection of methods of control and with development of control strategies, the operational areas in which integrated control measures can be or are to be applied need to be the subject of review and assessment. The available information on vectors and disease needs to be compiled as well as on economic and environmental factors related to irrigation, water usage, etc. Additional data may be required and should be collected through surveys and field investigations and the different types of operational areas for control stratified taking into consideration epidemiological, biological, socioeconomic, environmental and cultural factors. Control strategies can then be developed for the operational areas thus stratified and field tested for operational assessment.

Cost/effectiveness of the designed strategies can be estimated using the available experience in the project and completed and updated in field tests as required. While estimation of costs may be feasible in running programs with adequate degree of reliability, the measurement of effectiveness may not be a simple task. The estimation of effectiveness of a method or a strategy against a vector may be practicable and simple, but an estimation of the overall epidemiological impact on the disease may need some years of extended field trials. A decision however can be reached based on the outcome of field tests and on previous experience, taking into consideration that the strategy will be the subject of continuous evaluation and revision as operations progress.

A factual assessment of benefits will be even more difficult than epidemiological effectiveness. Health benefits are not usually tangible and quantifiable. Some social and economic benefits of certain methods of control, especially water and land and vegetation management are known and can be estimated giving adequate credit to other sectors of development, e.g., agriculture, irrigation, housing, education, etc.

The application of integrated strategies may be facilitated if they are first implemented in *pilot operation areas.* These areas, selected in conveniently located regions and easily accessible, can be used to make an intial start, to develop methods of planning and application and to train the staff. Pilot operations can be gradually extended to other operational areas or other pilot operations can be organized in other parts of the program to develop and apply local strategies and then expanded to neighboring areas should they prove successful.

Concurrently a certain reorganization of the malaria service and retraining of staff should be introduced to facilitate the ultimate reorientation of the program.

TRAINING AND RESEARCH. Training of staff and research and development must be incorporated in plans and carried out as an integral part of the program operation.

The pilot operation areas discussed above must have a built-in component of training and research and field investigations. At a first stage, senior staff and planners and designers of the program need to be trained in seminars or training courses organized at national and international levels. Once an adequate number of senior staff has been trained and the principles of planning integrated control are understood, pilot operation areas can be selected and the training activities can be initiated at regional or at local levels to include the field and supervisory staff. Refresher training should be organized for field, supervisory and senior staff and for the staff of pilot operation areas to update their knowledge and acquaint them with latest developments.

Research and field investigations should be initiated as soon as pilot operation areas are selected and the preliminary surveys and collection of base line data are completed. Field research may include assessment of various elements of the control strategies and field investigations and studies of problems encountered in their application. As such, assessment of costs, effectiveness, benefit of the methods of control and their possible risk as well as the necessary safety requirements and measures will be practised and results will be used in planning or readjusting operations.

It will be more productive if a specialized scientific institution at the national level is involved in the research aspect of the program and allowed to participate in planning and evaluation of the outcome.

The research needs must be identified and given the priority they deserve in funding so as to provide the required technical support to program planning and implementation.

INTEGRATED VECTOR CONTROL IN OTHER HEALTH PROGRAMS

The situation in other vector-borne diseases is about the same as in antimalaria programs. In certain programs, e.g., onchocerciasis control in West Africa, the reliance is still solely on application of larvicides. However, there are problems of resistance in respect to the few larvicides available and therefore research and field studies are directed towards the operational use of *Bacillus thuringiensis* H-14 which is very effective during the dry season. Environmental measures have been considered but are not practicable in most areas of *Simulium* breeding.

In schistosomiasis control, the present trend is for snail control by use of chemicals and the use of drugs to treat the infection. Biological means and environmental management have been seldom used and in limited scale; they are now under study and field application in the Blue Nile Health Project, Sudan and elsewhere. The prospect for their wide use is good and thus integrated control in the control of schistosomiasis is quite promising.

Most promising is the control of *Aedes aegypti,* vector of urban yellow fever and dengue haemorrhagic fever and *Culex quinquefasciatus,* vector of urban filariasis. These peridomestic mosquitoes are produced by man's disregard for the most rudimentary hygiene. Mosquitoes breed in habitats created by man. Integrated control based primarily on environmental management, principally source reduction and reduction of man/vector contact, should reduce the use of insecticides and transmission of disease. However, application of such strategy needs the public's understanding and cooperation and participation and therefore health education must be a strong component of the control strategy.

CONCLUSION—PROSPECTS FOR FUTURE DEVELOPMENT AND PROGRESS

There is a need for a) dissemination and exchange of information and training; b) more balanced reallocation of resources for research and field application and c) development and application of modest strategies based on the available methods of control to promote the widescale use of integrated control.

The present trend in antimalaria programs is towards diversification of methods of control and increasingly readjusting the plans to local conditions. The many technical and operational problems encountered imply that more specific and prudent use be made of pesticides and that other methods of vector control be considered more seriously and employed. Also, the scarcity of national and international financing imposes restrictions on generalization and demands consideration of costs, benefits and effects. It happens exactly that these considerations represent the major principles of the integrated control and hence the present trend will lead towards the gradual adoption and application of this approach. To speed up progress and to ensure that this transformation will take place correctly and in an orderly manner, it is essential that the process is well studied and planned, taking into consideration the present and future needs and resources.

AEDES AEGYPTI, YELLOW FEVER AND DENGUE IN THE AMERICAS[1]

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ABSTRACT. Many *Aedes aegypti* eradication and control campaigns are faced with administrative, financial, and technical constraints. At the same time *Ae. aegypti* appears to be extending its geographical distribution and utilizing an increasing number of different larval habitats. Countries such as Brazil, Bolivia and Paraguay have had *Ae. aegypti* reinfestations. Jungle yellow fever has spread into areas closely adjoining urbanizations infested with *Ae. aegypti* and the potential for urban yellow fever remains great. Since 1965 jungle yellow fever has been reported in 12 countries with 228 cases occurring in 1981. All 4 serotypes of dengue occur in the Americas with a major pandemic of dengue serotype 1 beginning in 1977. In 1981 dengue serotype 4 was identified in the Caribbean and it has spread to at least 13 countries. Dengue haemorrhagic fever appeared in Cuba in 1981 with 344,203 cases and 158 deaths. The etiological agent has been identified as dengue serotype 2. The control measures are described.

INTRODUCTION

The success of *Aedes aegypti* control measures used by Gorgas and his associates in 1901 in Cuba is well known. Similarly the measures begun in Panama in 1904 proved equally spectacular. As a result the Rockefeller Foundation in 1915 became committed to eradicate yellow fever from the World.

As the cooperative Brazilian-Rockefeller Foundation Program advanced, Soper and others began to believe that eradication of *Ae. aegypti* was technically feasible. Jungle yellow fever occurring without involvement of *Ae. aegypti* was a set-back in the eradication of yellow fever, nevertheless the countries of the Americas became committed to eliminate *Ae. aegypti*. In 1947 the Pan American Health Organization (PAHO) assumed the responsibility for continental eradication. This responsibility has since been enhanced by a number of resolutions passed by governing councils.

Yet *Ae. aegypti* has not been eliminated and appears to be as successful as ever against control measures. This failure has placed a severe financial burden upon a number of countries. All 4 dengue serotypes are found in the Americas and the first epidemic of dengue haemorrhagic fever occurred in 1981. Equally alarming has been the appearance of

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