

WORLD HEALTH ORGANIZATION
Regional Office for the Eastern Mediterranean
ORGANISATION MONDIALE DE LA SANTE
Bureau régional de la Méditerranée orientale



مَنْظَرُ الصِّحَّةِ الْعَالَمِيَّةِ
المكتب الإقليمي شرق المتوسط

**Regional Committee for the
Eastern Mediterranean**

EM/RC52/3
August 2005

Fifty-second Session

Original: Arabic

Agenda item 5 (a)

Technical paper

Vector-borne diseases: addressing a re-emerging public health problem

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Executive summary

Vector-borne diseases (malaria, leishmaniasis, lymphatic filariasis, onchocerciasis, trypanosomiasis and a number of arboviral infections—Rift Valley fever, dengue fever, yellow fever, West Nile fever, Crimean–Congo haemorrhagic fever and Japanese encephalitis) are a major public health problem in the Eastern Mediterranean Region of WHO. There is potential for these diseases to spread both geographically and seasonally due to ecological and climatic changes, human activities such as development projects, civil strife, urbanization and population movement. Following the malaria eradication era, vector control, one of the key strategic approaches for vector-borne disease control, lost its perceived importance in the majority of countries. This was reflected in the reduction of resources allocated to vector control, with a subsequent loss in national capacities for medical entomology and vector control.

Currently, the implementation of vector control programmes is not coordinated among the different relevant sectors, resulting in a loss of prevention and control opportunities, and duplication and wastage of meagre resources. Generally, implementation of vector control continues to rely on a single tool—the use of insecticides. No new insecticides have been produced over the past 20 years, and this calls for the judicious use of the few effective insecticides (mainly pyrethroids) currently remaining. Opportunities do exist, however, to strengthen national vector control capacities through the integrated vector management (IVM) approach. It was for these reasons that the Regional Office developed a framework on IVM which provides a platform to institute intersectoral coordination and collaboration at all levels and to capitalize on the synergistic effect of evidence-based vector control interventions for a number of vector-borne diseases.

Countries are therefore requested to adopt the regional strategic framework on IVM; to define management criteria and procedures for IVM, and the essential functions of an IVM programme; to re-profile existing vector control programmes to reflect the IVM principles in an optimal distribution of essential functions over different levels; to conduct vector control needs assessment for all vector-borne diseases to identify the needs, gaps and opportunities for vector control using the guidelines and tools developed by WHO for the development of a national IVM strategy and plan of action; to facilitate the intersectoral mechanism for the collaboration and coordination of all health sectors in the country under the leadership/guidance of the Ministry of Health; to ensure that ministries of health have a qualified and competent national focal person for vector control who understands the principles of IVM; and to allocate a specific budget line for vector control to ensure the establishment of appropriate technical, human and physical infrastructures within the Ministry of Health.

Similarly, the Regional Office is requested to establish a mechanism by which relevant units/programmes such as the Roll Back Malaria, communicable disease surveillance, control of tropical diseases and elimination and eradication of diseases are coordinated. Vector control is an important component of all these programmes and IVM is proposed as its new approach; it is essential to allocate sufficient funds for staff and for operational costs to ensure a regional capacity to deal appropriately with the challenges of implementing IVM in the Region; and to support the development of a three-month regional course on IVM—preferably in a country where most of the vector-borne diseases are endemic as capacity in entomology and vector control is lacking in these countries.

1. Introduction

National capacities in the control and prevention of vector-borne diseases are lacking in the majority of the Eastern Mediterranean countries. The factors responsible for this lack of capacity are variable and complex. This paper attempts to analyse such factors as well as provide some evidence-based suggestions to address such problems. The paper therefore looks at the challenges facing vector control programmes at the global and national levels; the burden of vector-borne diseases, including the potential threat of their geographical and seasonal spread; and the constraints in terms of inadequate policy arrangements and allocation of resources (technical, financial and physical infrastructures) for vector control. Countries are called upon to recognize the importance of vector control, especially its implementation through the integrated vector management approach (IVM) as a sustainable and cost-effective method. IVM derives its strength from intersectoral coordination, the balance between regulatory and operational measures and the impact of interventions on multiple diseases.

2. Current situation and challenges facing vector control programmes at the global and national levels

2.1 Magnitude of the disease burden

Vector-borne diseases are responsible for almost 20% of the estimated global burden of infectious diseases [1]. These are diseases transmitted mainly by arthropod species that play an essential role in sustaining part of the life cycle of a pathogen. The WHO definition of vectors is broad and inclusive of arthropod vectors, intermediate hosts and pathogen reservoirs. Eleven per cent (11%) of the total estimated burden of vector-borne diseases affects the countries of the WHO Eastern Mediterranean Region, where only 8% of the world's population lives. The world in general and the Eastern Mediterranean Region in particular, have recently witnessed a significant re-emergence of vector-borne diseases. Some of them are showing an increasing trend to spread to areas where they did not occur before, to expand their transmission season and to intensify their transmission in places where they are already present. Region-wide, the vector-borne diseases of public health importance include malaria, leishmaniasis, arbovirus infections (notably caused by the viruses of Rift Valley fever, dengue fever, yellow fever, West Nile fever, Japanese encephalitis and Crimean–Congo haemorrhagic fever) and lymphatic filariasis. The public health importance of onchocerciasis and African trypanosomiasis is limited to only parts of the Region. The status of these diseases is briefly discussed below and the 2002 burden of disease estimates are presented in Table 1.

Table 1. WHO Eastern Mediterranean Region mortality rates and burden of disease estimates for a number of vector-borne diseases, 2002

Disease	Estimated mortality	Estimated burden (expressed as DALYs lost)
Malaria	59 000	2 250 000
Leishmaniasis	5 000	248 000
Dengue fever	1 000	30 000
Japanese encephalitis	2 000	83 000
Lymphatic filariasis	0	122 000
Onchocerciasis	0	10 000
African trypanosomiasis	1 000	39 000

Source [1].

In the Eastern Mediterranean Region, malaria is caused by two parasites of the genus *Plasmodium*: *P. falciparum* and *P. vivax*. All species of *Plasmodium* are transmitted by mosquitoes of the genus *Anopheles*. Different malaria vector species are widely distributed in all the 22 countries of the Region, but malaria transmission has been effectively interrupted in 10: Bahrain, Egypt, Kuwait, Lebanon, Libyan Arab Jamahiriya, Oman, Palestine, Qatar, Tunisia and United Arab Emirates. Active transmission continues in Afghanistan, Islamic Republic of Iran and Pakistan (main vector species *A. culicifacies* and *A. stephensi*), Djibouti, Saudi Arabia, Somalia, Sudan and Yemen (*A. arabiensis*) and Iraq and Syrian Arab Republic (*A. sacharovi* and other secondary vector species). In Morocco local transmission is about to be eliminated. Most parts of the Region remain receptive to malaria transmission because of the widespread presence of competent vectors. Water resources development (impoundments, irrigation schemes and flood control infrastructure) may significantly enhance the contextual determinants of malaria in what is by nature predominantly a less receptive semi-arid and arid part of the world. Without proper attention in the planning phase and effective management in the operational phase, such projects can become foci of intense transmission. It is estimated that malaria contributes to about 60 000 deaths and to an economic loss of approximately 2 250 000 disability-adjusted life years (DALYs) per year in the Eastern Mediterranean Region.

Three forms of leishmaniasis affect the Region: the visceral form (caused by *Leishmania donovani* in Sudan and by the more widely distributed *L. infantum*), the zoonotic cutaneous form (caused by *L. major*) and the anthroponotic cutaneous form (caused by *L. tropica*). These diseases are focally present in Islamic Republic of Iran, Iraq and Tunisia, and they constitute important national public health problems in Afghanistan, Pakistan, Sudan and Syrian Arab Republic. Leishmaniasis is a lesser problem in Djibouti, Jordan, Kuwait, Lebanon, Libyan Arab Jamahiriya, Morocco, Oman, Saudi Arabia, Somalia and Yemen. In the United Arab Emirates and other member states of the Gulf Cooperation Council it has been eliminated. The ecology in the Region of the over 20 species of the vectors, sand flies belonging to the genus *Phlebotomus*, continues to require elucidation through scientific research. The most widespread vectors of importance are *P. papatasi* (*L. major*), *P. sergenti* (*L. tropica*), *P. perniciosus* (*L. infantum*) and *P. orientalis* (*L. donovani*). A range of rodent species serve as reservoir hosts for the pathogen of the zoonotic form of the disease. The economic loss due to leishmaniasis in the Region is estimated at 5000 deaths per year and approximately 248 000 DALYs.

Six arbovirus infections are endemic to the Region: dengue fever, Rift Valley fever, Crimean-Congo haemorrhagic fever, yellow fever, West Nile fever and Japanese encephalitis. The dengue virus (four serotypes) causes dengue fever, characterized by mild, transient symptoms, which sometimes progresses into dengue haemorrhagic fever or dengue shock syndrome. A dengue vaccine has not yet been developed. Dengue viruses are transmitted by *Aedes* (*Stegomyia*) *aegypti*, which is anthropophilic and breeds in domestic water containers. In some countries in the Region, the lack of reliable drinking-water supplies has, in recent years, induced people to store water in their homes, often inadvertently creating *Aedes* breeding places. In other WHO regions, unsafe domestic drinking-water storage has contributed considerably to an intensification of dengue outbreaks and its spread from typically urban areas to rural settlements. Another vector species whose distribution has spread around the Mediterranean basin is *Aedes* (*Stegomyia*) *albopictus*, further increasing the hazard of dengue outbreaks. Several outbreaks of dengue involving thousands of cases have been registered in the Eastern Mediterranean Region since 1982, from Djibouti, Pakistan, Saudi Arabia, Somalia, Sudan and Yemen. The potential for emergence/re-emergence of dengue and dengue haemorrhagic fevers in the Eastern Mediterranean Region is real.

Rift Valley fever (RVF), caused by the Rift Valley fever virus, occurs in epidemic outbreaks. These are initiated when the dormant eggs of *Aedes* mosquitoes hatch in large quantities in response to rainfall after a prolonged episode of drought. The virus survives in the dormant eggs (vertical transovarial transmission). Amplifying hosts, including sheep and goats, play a critical role in the start-up of such outbreaks and, once an outbreak takes off, various *Culex* mosquito species take over the predominant role in the transmission of the virus. Direct transmission from infected animals to humans is also possible. A vaccine for Rift Valley fever does not exist. Serious outbreaks of Rift Valley fever occurred in Egypt in 1977 (18 000 cases and 600 deaths), Saudi Arabia in 2000 (882 cases and 124 deaths),

Somalia in 1997–98 (huge number of cases and deaths) and Yemen in 2000 (1328 cases and 166 deaths). The severity of Rift Valley fever in humans is related to the virulence of the virus. These outbreaks also caused large-scale mortality in livestock leading to huge economic loss.

Crimean–Congo haemorrhagic fever is caused by a virus transmitted by Ixodid ticks (mainly of the genus *Hyalomma*). Different species of livestock (goats and sheep) are the reservoir hosts of the virus. It is endemic in Afghanistan, Iraq, Islamic Republic of Iran, Pakistan and Sudan: localized outbreaks have been reported annually from these countries since the 1970s. Since the disease is highly contagious, hospital infections have resulted in deaths in humans.

The infection caused by the yellow fever virus is characterized by severe fever and jaundice with a high mortality rate. In tropical Africa, the sylvatic transmission cycle of yellow fever involves monkeys and various aedine mosquito vectors, with *Aedes simpsoni* and some other species linking the sylvatic cycle to the human settlement cycle in rural villages. In urban outbreaks *Aedes aegypti* serves as the vector for human-to-human transmission, as it does for the dengue virus. Vaccination against yellow fever has a long history and is effective in providing protective immunity to the infection. International health regulations make vaccination compulsory for international travellers to and from a number of African countries, including, in the Eastern Mediterranean Region, Somalia and Sudan which are included in the area of distribution of the virus. The potential for an outbreak of yellow fever in Sudan given the prevailing circumstances is highlighted. In addition to the above arboviruses, the following also occur in the Region: the West Nile fever virus with potential for outbreaks in Egypt, Jordan, Morocco, Palestine and Tunisia; and the virus that causes Japanese encephalitis, so far reported only in Pakistan and possibly also in Afghanistan. The full picture of Japanese encephalitis incidence in the Eastern Mediterranean Region remains unclear. However, as the principal vector *C. tritaeniorhynchus* is widespread from South-east Asia to West Africa, the further spread of Japanese encephalitis across the Region should be considered a real possibility.

Lymphatic filariasis is caused by the filarial nematode *Wuchereria bancrofti* and, in its most extreme clinical manifestation, results in elephantiasis. Successful transmission of the microfilariae by *Culex* mosquitoes requires a high level of humidity. Lymphatic filariasis distribution is therefore limited to the relatively rare humid zones in the Eastern Mediterranean Region. Foci of lymphatic filariasis in the Nile delta in Egypt and probably in Yemen are caused by mosquitoes belonging to the *Culex pipiens* complex. A belt of lymphatic filariasis endemicity exists across southern Sudan where the parasite is transmitted by anopheline mosquitoes. There is a potential risk that expanding practices of wastewater treatment and its use in agriculture may contribute to increased *Culex* propagation and to an intensification of lymphatic filariasis transmission in the Region. The estimated burden of lymphatic filariasis (122 000 DALYs lost annually) with zero mortality is probably the best illustration of the important weighting of disability and infirmity in arriving at DALY estimates. Currently the Global Alliance to Eliminate Lymphatic Filariasis aims to reduce infection prevalence and clinical manifestation rates by chemotherapy to nearly zero. As complete elimination of the parasite reservoir is not feasible and the vectors remain present, the addition of an IVM component to the strategy of the Global Alliance to Eliminate Lymphatic Filariasis would introduce a strong element of sustainability to this initiative.

Onchocerciasis (river blindness) is caused by the filarial nematode *Onchocerca volvulus* and is transmitted by blackflies of the *Simulium damnosum* group that breed in fast-flowing, highly oxygenated sections of rivers and streams (rapids). The disease is largely confined to tropical Africa and only two countries of the Region are endemic for onchocerciasis. Yemen harbours small foci in a few highland valleys, while Sudan has foci along several river systems.

African trypanosomiasis (sleeping sickness) is caused by trypanosomes transmitted by tsetse flies (*Glossina spp.*). Although African trypanosomiasis is a public health problem confined to tropical Africa and linked to the distribution of *Glossina spp.*, transmission extends across southern Sudan where many deaths from sleeping sickness occur. The economic importance of the form of trypanosomiasis affecting livestock is of such overwhelming economic importance that a continent-wide campaign to eradicate tsetse flies is taking shape: the Pan-African Tsetse and Trypanosomiasis

Eradication Campaign. Critics question the feasibility of such a continent-wide approach and also the impact it will have on the fragile African ecosystems. The biology of *Glossina spp.* make this vector complex particularly suited to genetic control through sterile male techniques. Experience so far shows, however, that the suppression of one species often induces a population explosion of other sympatric species.

2.2 Potential risks for the expansion and intensification of vector-borne diseases in the Region

Environmental and man-made factors

The Eastern Mediterranean Region comprises various zoogeographical zones (Afrotropical, Oriental and Palaearctic. Each of these zones has its specific cluster of dominant vector species with different ecological requirements. Any imbalance in the contextual determinants related to these requirements may lead to dramatic changes in vector population dynamics with possible dire consequences for vector-borne diseases transmission risks. Such imbalances may arise from extreme weather conditions, floods or droughts, or more insidious shifts in local climates. They can also be man-made in origin: development activities leading to changes in the hydrology and land-use patterns (and often accompanied by changes in human movement patterns) will have an impact on the transmission situation in often complex ways. Also trends and developments in agricultural production systems may affect transmission: increased chemical inputs will not only affect natural predators of mosquito larvae, but will also carry with them an increased risk of insecticide resistance induction in vector species.

Another factor which may directly or indirectly influence the spread and intensification of VBDs is that of changed population movements, especially in conflict situations. The usually unfavourable living conditions of refugees and displaced populations, further exacerbates the risks involved. Recent outbreaks of leishmaniasis in Afghanistan, Pakistan and Sudan are good examples. Population growth, rural–urban shifts and unplanned urbanization create situations characterized by lack of access to safe drinking-water and adequate sanitation, and where proper solid waste management is absent. Such conditions also have a bearing on the transmission risks of vector-borne disease. The coinfection of HIV/AIDS and the *Leishmania* parasite poses an emerging risk as HIV incidence increases in the Region.

Climate change and global warming may contribute to a shift in distribution boundaries of vector species to higher latitudes and altitudes as average temperatures rise [2]. Changed rainfall patterns may also contribute to changes in distribution patterns, and both phenomena may also stretch the period of transmission beyond the traditional season. Climate change affects the transmission of vector-borne diseases through its impact on vector population dynamics, on vector behaviour and abundance, and it may also change the survival rate and incubation period of pathogens.

Inadequate policy environment for vector control

Global policies

Risks and hazards not only occur in the physical environment, but may also result from an inadequate policy environment for disease prevention and control, and for addressing health at large in the context of development decision-making. Retrospectively, three periods may be distinguished in the efforts to prevent and control malaria since the 1898 discovery by Sir Ronald Ross that anopheline mosquitoes transmitted the *Plasmodium* parasite through their bite.

The sanitarian period, until 1945, was the initial period when controlling the transmission of malaria and other mosquito-borne diseases was based on source reduction, species sanitation and other environmental management measures. While successful in specific settings of often unstable malaria or where malaria vector species had very narrow ecological requirements, this approach was mostly capable of maintaining malaria transmission at a reduced level, but not frequently to eliminate it as a public health problem. It was, however, characterized by integrated approaches, involving professionals from other sectors in what was often a holistic rural development approach, and in some parts had clear regulatory aspects.

With the advent of DDT, the potential for massive transmission interruption became feasible and thereby the possibility of eradicating malaria from large parts of the world. The WHO embarked upon a global malaria eradication programme, which was from the outset conceived to be time-limited, considering the resource requirements and the looming threat of insecticide resistance. Initially, the campaign showed spectacular successes, controlling and eliminating malaria (and, in the process, a number of other vector-borne diseases) from a significant number of countries, including countries in the Eastern Mediterranean Region. The vertical structures created for the delivery of this campaign, based on the spraying of small but effective quantities of DDT and other residual insecticides on the inside walls of houses, meant the end of the integrated and multidisciplinary approach to malaria control as well as of basic research on vector ecology and biology. In a number of countries, the eradication campaign became a victim of its own success, in that health authorities shifted health sector resources to other areas when eradication had apparently been achieved, without leaving effective monitoring, surveillance and outbreak response mechanisms in place. At the same time, serious problems of insecticide resistance started to occur and there were increasing concerns over residual insecticide in the environment. In the Eastern Mediterranean Region this is a genuine problem, especially with some vectors having developed resistance to organochlorines (DDT) and organophosphates (malathion and fenitrothion). Information on vector resistance and its distribution in the Region is old and needs to be updated.

From the mid 1970s onwards, malaria control went through a phase of disarray, vertical structures were dismantled and malaria control was integrated into the primary health care model [3]. In 1992, the Global Malaria Strategy aimed to redirect all stakeholders towards a renewed effort that focused on rapid case detection and drug treatment, epidemic preparedness and a role for vector control [4]. In spite of these efforts, and the Roll Back Malaria movement initiated in 1997, the global malaria situation has continued to deteriorate. This has resulted both in increased numbers of malaria cases, and in cases of other vector-borne diseases that previously benefited from the malaria control interventions. For example, India is currently experiencing a resurgence of visceral leishmaniasis, which was previously virtually eradicated as an unplanned side-effect of DDT indoor residual spraying against malaria vectors. To the contrary, those countries that included vector control interventions continued to observe reduction if not elimination of malaria. There are many examples globally, but from the Eastern Mediterranean Region, Oman serves as a good example. Malaria was endemic in the Sultanate of Oman as recently as in the 1980s. However, the political commitment of the Government of Oman from the early 1990s onwards to allocating substantial resources for vector control and to strengthening intersectoral coordination, has resulted in the interruption of local malaria transmission, with the last local case detected in 1998.

Technical and managerial constraints in vector control

At present vector control is faced with a range of problems that include drug and insecticide resistance, increased vulnerability of marginalized groups (the rural and urban poor, displaced people), global environmental change and, at the local level, development-induced changes in hydrology and land-use, and increasing competition for scarce health resources with other, newly emerging diseases. Within this picture, vector control continues to be plagued not only by technical problems, but also, importantly, by managerial deficiencies. The vertical programme management structures dating back to the eradication era proved to be formidable and resilient hurdles in attempts to improve the efficiency of vector control actions, and to re-engage with other sectors.

Technically, vector control has developed a strong dependency on a single tool, that of indoor residual spraying. Yet, of the twelve insecticides recommended for vector control, six belong to the same class of pyrethroids. Their safety record, both for humans and for the environment, make them the insecticides of choice: they can be applied in small quantities and they break down rapidly. There is increasing concern, however, over the development of resistance, stemming from their abundant use in agriculture. Resistance to one pyrethroid implies cross-resistance to the other five. Since 1990, no new public health insecticides have been marketed. There is evidence that the use of insecticides in many countries no longer follows the best practice recommendations and safeguards prescribed by the

WHO, possibly in part as a result of diminishing levels of expertise in vector control. As the arsenal of effective insecticides gets depleted rapidly, it is important to reconsider their use in a broader context.

Singular reliance on insecticides is not desirable, and in fact carries important risks, while insecticides also represent a finite resource that we may want to preserve for future catastrophic situations. It is clear therefore that it is time for a major conceptual shift in vector control, similar to the shift that has taken place in agricultural pest management over the past few decades. From the perspective of insecticide development and use, this means that there should be, in the short term: improved insecticide management in both agriculture and public health through their judicious use; a strengthening in the national capacities for insecticide resistance monitoring and for enforcing regulations concerning the appropriate use of insecticides; promotion of the safe use of insecticides; and the installation of mechanisms to ensure the monitoring and evaluation of insecticide use and effectiveness. In the medium term, the cost-effectiveness of existing products and application techniques needs to be improved and incentives must be created to promote investment into the development and testing of new compounds and formulations.

To face up to the managerial challenges, the place of vector control within the health system and its links with other public and private sectors need reconsideration. Incorporation of vector control into the general health services has left it marginalized as an area of work that is not in tune with the health sector core of more medically oriented action [5]. Decentralization has been a powerful trend in the health sector, which has benefited the case detection/rapid treatment strategy for malaria control. While such activities can be delegated to the levels of community health workers, and district health centres, this is more complicated for vector control functions, some of which require a high level of technical specialization. While some elements of vector control, such as the use of insecticide-treated nets (ITN), have been successfully undertaken at the community level, even here the lack of capacity at precisely that level is perceived to be a major obstacle to the scaling up of these efforts.

Coverage for desired impact of interventions

The impact of vector control interventions is always dependant on the coverage. The recommended coverage rate for most of the interventions is usually 80% and above. To achieve such a high coverage rapidly, the implementation of the two powerful tools currently available may require some form of verticality. Indeed the two success stories of ITN implementation in China and Viet Nam were partly facilitated by the vertical structures remaining from the old insecticide spraying programmes. In Viet Nam the Government organized the free provision of pyrethroid treatment of bednets for 11 million people and, together with improved drug treatment, this has led to a remarkable decline in malaria incidence and the virtual elimination of malaria deaths. These experiences have only been emulated in a few African countries, such as Eritrea (free provision of ITNs and their re-treatment, achieving the Abuja targets for coverage of pregnant women and children), and Togo (provision of 800 000 free ITNs for pregnant women and children in association with child vaccination campaigns) [6].

It should be pointed out that, in the case of the Government of Viet Nam, the vertical approach deployed for malaria transmission interruption by no means reflects an overall rigid and conservative attitude to vector control in general. This is supported by the far more horizontal, community-based approach to dengue vector control, using larvivorous copepods in drinking-water storage vessels. It is a misconception to think that IVM and vertical approaches are incompatible—they are not, provided the basic principles of IVM are adhered to.

The coordinated implementation of various vector control interventions in a way that permits maximum synergies, requires a well-balanced distribution of essential vector control functions over the different levels in a decentralized system, with a clear rationale as to why a given function is performed at a given level. Many countries in the Eastern Mediterranean Region have lost vital expertise and leadership in vector control and it is therefore imperative that the human resources and physical infrastructure are strengthened and updated to meet the vector control challenges of the 21st century.

3. Addressing the problem

3.1 Introduction

For some diseases, vector control continues to be the only feasible public health intervention, for many others it remains a critical component of a sustainable disease prevention and control programme. Of the medical interventions possible in theory, vaccines and drugs, there are a number of vector-borne diseases for which no effective vaccine is available so far, and a number of others (notably the virus infections) for which no drugs are available. In malaria-endemic areas there is evidence that in the absence of vector control interventions, the development of drug resistance is accelerated. In other cases, the available drugs are not affordable for households or public health services. Although a number of factors have been discussed that have contributed to the increased problem and burden of vector-borne diseases, we will concentrate on those factors that are amenable to action and within the health sector's reach.

3.2 Integrated vector management (IVM)

Vector control continues to offer unique options for disease prevention and control, provided the capacity of vector control programmes is strengthened and adapted to new needs. In this section therefore, a new approach and strategy for vector control is presented: integrated vector management (IVM), an approach for which in 2003 the Regional Office developed a strategic framework providing a new vision, the enabling policies and a practical way forward in its implementation [7]. This was followed in 2004 by the development of a global IVM strategy [8]. Implementation of IVM, however, does not negate the importance of the other strategic approaches, such as vector-borne disease surveillance, diagnostic guidelines for specific vector-borne diseases, case management and development of human resources.

Definition of IVM

Integrated vector management is a process of evidence-based decision-making to plan, deliver, monitor and evaluate targeted, cost-effective and sustainable combinations of regulatory and operational vector control measures to reduce transmission risks, adhering to the principles of subsidiarity, intersectoral collaboration and partnership building.

Policy base

Resolution WHA 42.31 requested Member States to strengthen their capacity to ensure the implementation of effective vector control measures, and to develop and maintain, at all institutional levels, the necessary human resources for planning and implementation of vector control interventions [9]. It also requested the Director-General to ensure that the Organization's contribution to the development of safe and effective vector control methods is based on environmental considerations and is in line with the principles of sustainable development.

Resolution WHA 50.13 called upon Member States inter alia "to take steps to reduce reliance on insecticides for control of vector-borne diseases through promotion of integrated pest management approaches in accordance with WHO guidelines, and through support for the development and adaptation of viable alternative methods of disease vector control" and "to ensure that the use of DDT is authorized by governments for public health purposes only, and that, in those instances, such use is limited to government-authorized programmes that take an integrated approach.." [10].

Technical justification

As has been argued in the first section of this paper, well-planned and coordinated vector control interventions can significantly contribute to the reduction of disease incidence and thus to the reduction in vector-borne disease burden. They can also add substantial value to other vector-borne disease interventions through enhanced resilience and sustainability. Effective vector control methods exist, but their synergistic implementation, as part of integrated vector management packages, has been limited. In many countries, decentralization is being pursued either as a political process, or as a result of health sector development. This provides opportunities that may be capitalized on to improve vector control, including intensified community participation, more effective intersectoral action and a

greater emphasis on cost-effectiveness analysis. In some countries, the vector control programmes have focal people at the community level and outreach services that could be employed to implement IVM. In a decentralized structure the responsibilities for specific essential vector control functions can be allocated to their optimal level.

In an IVM approach, there is a clear hierarchy in the deployment of vector control methods, related to the initial ecosystems analysis and epidemiological stratification. Methods of an environmental management and personal protection nature are complemented by biological and, ultimately, chemical control until the desired level of community protection is achieved. The limited financial resources of vector-borne disease control programmes and the depletion of the arsenal of safe and cost-effective pesticides require their selective and judicious application, in the IVM context. The IVM approach also builds on the concept of selective vector control, defined as the targeted use of different vector control methods alone or in combination, to prevent or reduce human–vector contact.

Guiding principles

Development and implementation of IVM interventions is guided by the following principles.

- IVM is an essential element of vector-borne disease control.
- By definition, IVM is economically feasible, cost-effective, sustainable, environmentally sound and socially acceptable.
- Vector control interventions within IVM programmes are also components of integrated vector-borne disease control programmes, deployed in line with national health sector reform.
- In terms of logistics, IVM interventions are planned for multiple vector-borne disease prevention and control (multi-disease impact), whenever feasible.
- Sectors other than the health sector have important roles and responsibilities in IVM, and they may derive considerable benefits from it. This implies the need to design and deploy incentives, and regulatory and/or institutional arrangements to arrive at effective intersectoral collaboration and compliance with vector control standards and norms.
- IVM optimizes programme management by aiming at decision-making at the lowest possible level in a political or administrative hierarchy. This concept of subsidiarity should be considered in the context of health sector decentralization and the need for active community engagement/empowerment.

3.3 Strengthening national capacities (health/vector control systems) for coordinated vector control

Actions in the following areas, which is not an exhaustive list, will contribute to the establishment of an IVM approach at the country level:

- incorporation of IVM principles into national health policies;
- strengthening vector control capability within the national health system;
- capacity-building as the first and essential step to successful implementation of IVM at national level—capacity-building should establish and/or strengthen the capacity for implementation of IVM, including institutional development, definition of decision-making criteria and procedures, a re-profiling of posts with new post descriptions geared to the new priorities and decision-making procedures, the assignment of responsibilities to specific administrative levels and the creation of career opportunities, appropriate reorientation of vector control activities and availability of skilled staff;
- advocacy to ensure political commitment for IVM as an important component of communicable disease control, in order to develop appropriate policies and legislation, so as to enhance community participation and empowerment and mobilize human and financial resources;

- creating an enabling environment and arrangements for intersectoral and intrasectoral cooperation, which are essential elements of IVM implementation, with the aim of optimizing allocation of resources within the health sector (e.g. environmental health and different vector-borne diseases programme), as well as intersectoral collaboration between different government sectors, especially agriculture, environment and local government/municipalities, supported by appropriate policies, legislation and impact assessment of development policies, programmes and projects;
- establishment of partnerships to mobilize public and private sectors, together with civil society, nongovernmental organizations and donors, to optimize allocation of resources and effective implementation of IVM;
- monitoring and evaluation of ongoing vector control activities;
- using entomological surveillance and conducting operational research to provide relevant information for formulation of evidence-based interventions, including post-registration monitoring of pesticide use.

4. Conclusions and recommendations

A shift to a genuine IVM approach offers countries opportunities. However, countries need to recognize the importance of vector control for the public health status of the communities in their countries and the need to address the current problems in vector control with the political will to promote drastic managerial change. This will require a comprehensive analysis of the vector control situation and an assessment of the needs, gaps and opportunities that present themselves in each country, including an ecosystems analysis of the predominant vectors and the distribution/mapping of vector-borne diseases, for targeted and appropriate control. Based on the comprehensive analysis and assessment of vector control needs in each country, national IVM strategies and plans need to be formulated and coupled with the strengthening of the national as well as regional capacities in entomology and vector control, and the allocation of appropriate financial resources to implement all essential elements of such strategies and plans.

Member States

1. Ensure that ministries of health have a qualified and competent national focal person for vector control who understands the principles of IVM.
2. Allocate a specific budget line for IVM to ensure the deployment of appropriate technical and human resources and the establishment and maintenance of physical infrastructures within the Ministry of Health.
3. Establish a functional intersectoral mechanism for the collaboration and coordination of all sectors in the country with a clear recognition that the ultimate authority for public health issues resides with the Ministry of Health.
4. Develop national IVM strategies and plans of actions based on the carrying out of regular vector control needs assessment for all vector-borne diseases to identify needs, gaps and opportunities for vector control.

The Regional Office

5. Establish a mechanism by which relevant programmes at the Regional Office such as Roll Back Malaria, communicable disease surveillance, control of tropical diseases and elimination and eradication of diseases are coordinated. Vector control is a strategic binding component in all these programmes.
6. Allocate sufficient funds to ensure provision of a regional capacity to deal appropriately with the challenges of implementing IVM, including capacity to respond to vector-borne disease epidemics.

7. Support the development of a three-month regional training course on IVM, preferably in a country where most of the vector-borne diseases are endemic.
8. Develop regional guidelines for IVM planning, implementation and evaluation to support national efforts.
9. Present a progress report on the development and implementation of IVM to the Regional Committee every two years.

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