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Report on the

**Consultation on
insecticide resistance
management
in countries
of the Eastern
Mediterranean Region**

Casablanca, Morocco
25–27 September 2012



**World Health
Organization**

Regional Office for the Eastern Mediterranean

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1. INTRODUCTION

A consultation on insecticide resistance in countries of the WHO Eastern Mediterranean Region was held in Casablanca, Morocco from 25 to 27 September 2012. The meeting included representatives from 12 ministries of health, plus other regional entomology training and research institutes, temporary advisers and WHO staff from headquarters, and the Regional Offices for Africa and the Eastern Mediterranean. The objectives of the consultation were to:

- review current information on insecticide resistance in the Region;
- discuss methods to strengthen and coordinate activities for insecticide resistance monitoring;
- develop coordination mechanisms for management of insecticide resistance in countries including a regional database and network.

Dr Hoda Atta, Regional Adviser, Malaria, WHO Regional Office for the Eastern Mediterranean, delivered opening remarks on behalf of Dr Ala Alwan, WHO Regional Director for the Eastern Mediterranean. She noted that the Region continued to face a significant burden of vector-borne disease. Insecticide resistance threatened the gains against such diseases, especially malaria, as well as the response to threats from dengue and chikungunya, Rift Valley Fever and leishmaniasis. Entomological capacity and response in the Region was being developed through the establishment of a regional MSc degree course in entomology in Sudan and shorter diploma courses in Pakistan. As an extension of the integrated vector management framework in many countries, a number of programmes had established multisectoral mechanisms for managing resistance through insecticide rotation. The Regional Office had also initiated the establishment of a regional database for insecticide resistance monitoring and was adopting a multi-pronged approach through support to national strategies and work plans, raising public awareness and political commitment and mobilizing resources.

The meeting programme and list of participants are attached as Annexes 1 and 2, respectively.

2. TECHNICAL PRESENTATIONS

2.1 Insecticide resistance management experiences from the Eastern Mediterranean Region

Dr Hoda Atta, WHO Regional Office for the Eastern Mediterranean

There has been a very large increase in malaria vector control over the past decade, especially in the deployment of long-lasting insecticidal nets (LLINs) with nearly 35 million people in the Region protected by 2010. From the latest reports, 11 of 23 countries submitted insecticide resistance data; five programmes reported resistance to at least two insecticide classes and another three to all four classes.

In 2004 at a regional meeting in Lahore, a regional network for insecticide resistance was established, but not sustained. The network was too geared for research and not for programmes. Now the Region is targeting involving the programmes and not just a network of researchers. There was a subsequent regional meeting in Cairo in 2010, in collaboration with the U.S. Naval Medical Research Unit No. 3 (NAMRU-3), and a regional database begun in January 2012. Test kits were provided to several countries, including Jordan, Egypt, Iraq, Sudan, South Sudan, Djibouti and Morocco and technical support provided by WHO experts, e.g. Jordan and Sudan. There have been a number of country-level initiatives including resistance management through rotations in Sudan and soon, Yemen, and strengthening capacities and routine entomological surveillance in Saudi Arabia, Yemen, Morocco, Egypt and Sudan. The Region sees a number of opportunities. There is global commitment as well as regional resolutions related to integrated vector management (IVM) and sound management of pesticides; there is support and collaboration from a number of partners, such as the Global Fund, the Bill and Melinda Gates Foundation and the Gulf Cooperation Council for countries along the Arabian peninsula and technical collaboration with a number of institutes such as the Liverpool and London schools of tropical medicine and with NAMRU-3. Capacities are being built, particularly through the MSc course at Gezira University/Blue Nile Institute in Sudan and the diploma course in medical entomology at the Health Services Academy in Pakistan. There remain many challenges: lack of human and infrastructural resources, poor coordination and policy support in a number of countries and a limited capacity for resistance data management. Looking to the future the region needs to incorporate resistance management into national health policy, advocate and raise resources, and develop comprehensive national and regional plans for insecticide resistance management, as part of the established integrated vector management strategies.

2.2 Insecticide resistance management experiences from the African Region

Dr Birkinsh Ameneshewa, WHO Regional Office for Africa

Like the WHO Eastern Mediterranean Region, the African Region has seen a massive increase in persons protected through LLINs over the past decade, with a peak of 140 million nets distributed in 2010. There has also been a very rapid increase in the number of people protected by indoor residual spraying, reaching nearly 80 million by 2010. The results have been significant, with an overall reduction in malaria mortality by more than 30% over the past decade. Insecticide resistance threatens these gains. The technical capacity of the programmes is limited; when there are entomologists in the country they are far more likely to working in a research institute or university and not the national malaria control programme. In 2001 the African Network on Vector Resistance (ANVR) was established, coordinated by the Regional Office for Africa. The ANVR includes five subregional networks, each supported by a research institute that helps to build capacity and assist in monitoring and management. The ANVR has developed protocols, updated country entomological profile, trained more than 500 technical staff and renovated and equipped seven national reference laboratories. The number of programmes monitoring insecticide resistance has increase from just three in 2000 to more than 30 in 2011; it has developed a regional database, based at the Malaria Research and Training Centre in Mali and produced an Atlas of Insecticide Resistance in 2005 with an update in 2102. The African Region showed that an initial advocacy and investment was important and that there needed to be links between the national

research institutes and the national malaria control programme, while ensuring that the information was owned and used by the national malaria control programme for programme decisions. There remain many challenges to ensure the information is use proactively and that monitoring be more regular, complete and consolidated for use by the national programmes. Above all, there is the challenge of resources to manage ANVR as the basis of GPIRM in Africa.

2.3 The importance of collaboration in insecticide resistance

Dr Lizette Kiekemoer, WHO Temporary Adviser

The work of Witwatersrand University/National Institute for Communicable Diseases was presented with regard to its support for training in entomological and insecticide resistance monitoring including collaboration with the ANVR, regional universities and private sector partners.

2.4 Overview of the Global Plan for Insecticide Resistance Management

Dr Michael Macdonald, WHO headquarters

While we have seen tremendous success in malaria control over the past decade, much depended on pyrethroids which are now threatened by resistance. The first two pillars of the Global Plan for Insecticide Resistance Management (GPIRM) are country-level actions for developing management strategies and resistance monitoring networks that we are discussing during this workshop. The integrated vector management strategy that has been adopted by countries in the Region provides a framework to address insecticide resistance through the five elements of advocacy and legislation, cross-sector collaboration, integrated approaches, evidence-based decision-making and capacity-building. There is great potential among the countries in the Eastern Mediterranean to expand the networks and develop the human capacity and systems to be a pioneer in the roll-out of GPIRM.

2.5 Insecticide resistance monitoring guidelines for field assays and methods for characterization of resistance mechanisms

Dr Jonathan Lines, WHO Temporary Adviser

The important questions for the programme includes the need to detect the first appearance and spread of resistance and the impact of resistance on vector control. Programmes should investigate comparison of changes over time, between locations and between insecticide classes. Comparisons of insecticides within a class need to be approached with caution, as differences in results may be due to the discriminating doses used in the assay as opposed to an innate difference in the mosquito. Data are needed for decisions; under the previous policy a switch was recommended when resistance levels reached a threshold level of assumed ineffectiveness. Now it is recommended that rotation be pre-emptive, but we still need to select the components.

Bioassays are based on “discriminating doses” to separate individuals that carry genes that confer resistance. Identification of sibling species within morphologically similar sibling species is very important, molecular methods, for example through the MR4 programme is

available for determining both the species identity and the infection status of the individual mosquitoes (see www.mr4.org). While the techniques of the WHO Tube Assay remain unchanged, the “threshold” when interpreting results has shifted to become more sensitive. The CDC Bottle Assay also uses discriminating doses, but these tend to be lower and more sensitive than the WHO discriminating doses. While there should not be direct comparison of the results from the two assays, both will indicate the presence of phenotypic insecticide resistance within the population. Bioassays – either the WHO Tube Assay or the CDC Bottle assay – should be the basis for the resistance monitoring programme. Genetic analysis, e.g. through the polymerase chain reaction (PCR) technique, can track the underlying casual process, but is not possible to use for all mechanisms, is likely to miss new mechanisms, and does not provide an indicator for the practical impact of the resistance. Likewise biochemical assays are important for determining mechanisms, but cannot replace the phenotypic bioassays.

As outlined in the GPIRM there is still a great deal of work to be done in testing and evaluation of resistance and how this relates to control failure. More work is needed on data sharing and capacity-building for the field, for the laboratory, for data management and for strategic management decision-making.

2.6 Establishing mechanisms for information sharing on insecticide resistance among countries in the Eastern Mediterranean Region, and highlights of insecticide resistance in malaria vectors

Dr Ali Hassan and Dr Ahmed Hanafi-Bojd, WHO Temporary Advisers

A database on insecticide resistance and vector distribution has been developed in the Eastern Mediterranean Region through the support of WHO and collaboration among consultants, programmes and institutions in the Region. There is a pressing need for a protocol for transferring data to information that can facilitate proper decision making for insecticide resistance management. A systematic approach was undertaken to develop the protocols and templates, complete the in-country data collection with appropriate quality control; establish the regional database, including the processes of data cleaning, mining and analysis; and then enabling country access and decision making with appropriate technical support. The project is flexible and will adapt to evaluation and feedback. The system components include a searching tool, output reports, graphics, both spatial and non-spatial data analysis and links with publications. There are remaining needs for developing regional rules for data sharing and how to enable data access while still protecting the intellectual property rights of the persons who collected the data. Dr Hanafi-Bojd then presented some highlights from the database which included 3577 records of resistance monitoring in 22 *Anopheles* species involving 24 insecticides in 12 countries, including 94 publications over the period 1947 to 2012. With particular reference to pyrethroid resistance, this was first reported from Sudan in 2004 and has since been documented in malaria vectors in Egypt, Afghanistan and the Islamic Republic of Iran.

There are still many gaps including, inter alia: differences in formats, methodologies, listing of locality names and geo-positioning. There is limited capacity for interpretation and limited cooperation between the research/academia and the vector control programmes.

Moving forward we need to establish a functional and formal relationship between the research and control communities; a unified protocol for resistance monitoring through sentinel sites and a unified template for data collection; and country regional capacity for field and laboratory monitoring, geographic information systems (GIS) and data interpretation and decision-making.

3. PLENARY DISCUSSIONS

3.1 Regional and global insecticide resistance databases

The regional database in the African Region was built upon the work of the Africa Network for Vector Resistance now with five sub-regions headed by five institutions. There has been advocacy from the Regional Office for Africa to the Global Fund to support entomological monitoring as a regular part of the country malaria grants. The Eastern Mediterranean has likewise been building a regional database that will form another element of the overall global database

It was suggested that WHO assign in-country focal points in the Region to search for information in insecticide resistance that may have been published in smaller, national journals, including those that are written in the national language as well as the wealth of unpublished data that exists in national programmes, but was not submitted for publication in any journal. There appears to be a large difference between the internationally published data and the data that are available at the national level. An important part of this process will be to ensure quality of the data that are incorporated into the database

There is a critical question on the need to set limits for the database. For example, how far back should one include data on vector distribution? There has been so much ecological change that historical records of vector distribution urgently need to be updated. Likewise there is new recognition of species identification where what we may have labelled in the past as *sensolato* or a different species name is now something different.

Moving forward, the most important point is to standardize the data collection and reporting, including the exact identification of the specimen and geo-referencing the point of collection.

Most of the emphasis has been on Anopheline vectors, now especially as dengue and other arboviruses spread and there is increased attention to *Aedes* and *Culex* as well as vectors of other vector-borne diseases such as leishmaniasis. A point was made to consider expanding the scope of the database. It was clarified that the generated database already includes all vectors in the Region, but the part presented in the meeting focused only on malaria vectors.

3.2 Rotation of insecticides and financial constraints

A number of countries discussed the financial constraints of switching from relatively inexpensive pyrethroids to carbamates that, at least in the short-term, are more expensive. Again there was discussion on the long-term perspective of maintaining sensitivity to

pyrethroids. There was interest in the carbamate propoxur, but this is no longer being manufactured by the company who had submitted the quality assurance dossier to the WHO Pesticide Evaluation Scheme (WHOPES), and so bendiocarb is the only WHOPES approved product currently available among the carbamates. Included in the GPIRM was the issue of “judicious use” and the importance of reducing unnecessary use of insecticides in general.

From a historical perspective we can see that the first global malaria eradication effort relied too much on a single technology. While there were successes across many of the areas where this was implemented, the malaria eradication effort showed the limits of relying on a single technology and the danger of promising too much too soon. Now we are learning now to combine technologies. We must keep the world’s faith and not lose this opportunity, or it will be a disaster.

3.3 Revised testing guidelines for the WHO Tube Assay

With regard to the revised Insecticide Resistance Testing Guidelines from WHO, the higher cut-off points provides an early warning to programmes to re-confirm and react to resistance genes that may be existing in the local vector population. Specifically the revised guidelines read:

- 98%–100% means mortality (calculated by adding the number of dead mosquitoes from all four exposure replicates and dividing by the total sample size \times 100) indicates susceptibility.
- <98% mean mortality needs further investigation.
 - A. If between 90% and 97% the existence of resistance genes in the population needs reconfirmation. The confirmation of resistance may be obtained by additional bioassay tests on the same population with the same insecticide, by testing the progeny of surviving mosquitoes that can be reared under insectary conditions and/or by molecular assays for known resistance mechanisms. If these additional tests consistently show mortality < 98% resistance is confirmed.
 - B. Below 90% mortality, further confirmation on the existence of resistance genes in the population using bioassays may not be necessary as long as a minimum of 100 mosquitoes of each species has been tested. Further investigations should be conducted on mechanisms and distribution of resistance.
- When resistance is confirmed, pre-emptive action to manage insecticide resistance must be taken to ensure that the effectiveness of insecticides for malaria vector control is preserved.

3.4 Gene flow and the rise of insecticide resistance

There was some discussion on population biology and the rapidity of the rise of insecticide resistance. One hypothesis states that the resistance genes in *An. funestus* in South Africa spread very slowly in that region after many decades of use. This may have been due to the proximity of many other *An. funestus* populations outside of the areas under insecticide pressure, with the analogy of these populations under insecticide pressure, being on the edge of a large ocean of *An. funestus* populations. In contrast, insecticide resistance in *An. gambiae*

populations in northern Sudan and Zanzibar arose very rapidly, possibly because there was more limited opportunities for gene flow with populations outside the areas under insecticide pressure?

3.5 Regional reference laboratories and insecticide papers for WHO test kits

There are a number of strong research and training institutes in the Region, including Egypt, Islamic Republic of Iran, Saudi Arabia and Sudan that provide training and technical support for programmes in the Region; this includes support for molecular and biochemical assays to detect resistance and determine mechanisms as a complement to the phenotypic bioassays. There are more institutes in the Region involved with training and technical support that could be strengthened and utilized.

Related to this, there was extensive discussion on access to the test papers needed for the WHO Tube Assay. Countries reported delays and difficulties in procuring papers; even for some with well-established testing networks it will take four to six months to procure papers. A number of participants felt that there was potential for some of the regional laboratories to produce and provide quality control for test papers used in the WHO Tube Assay. This will become especially important if there is the expected large scale-up of monitoring using the WHO Tube Assay as laid out in the GPIRM.

3.6 Resistance monitoring and management for anopheline larvae and vectors of other diseases

It was noted that while insecticide resistance monitoring of mosquito larvicides is well established, GPIRM does not address resistance management for larvicides, for example the use of rotations or mixtures. Likewise there do not appear to be sufficient guidelines for discriminating doses or emphasis on vectors of leishmaniasis.

3.7 Entomological capacity

Insecticide resistance is a challenge; some countries have seen that building entomological capacity is the backbone develops stronger national programmes. For example Sudan has trained more than 70 MSc entomologists, provide them with WHO test kits and have enabled them to conduct monitoring. Sudan has also been able to establish field insectaries. There are now 78 sentinel sites which will give them a clear picture. For Sudan the investment in capacity has been the key.

For most other countries, capacity is the overwhelming issue. Some are managing resistance monitoring and data management with the use of external funding, including support from the Global Fund and the Global Environment Facility. However, a question arises as to how can countries ensure that support for capacity building comes from a sustained national financial commitment? Several recommendations were provide including strengthening advocacy efforts.

3.8 Programme ownership, institutional reforms and sustainability

In some countries where there are numerous nongovernmental organizations, international institutes and implementing partners present country ownership is a problem as these agencies work independently and without proper prior consent of the government. In order to assure sustainability the national malaria control programme should have a strong and central role in coordination and information sharing. We need to build capacity within the programmes themselves, and not just implementing partners in this is support for better cross-border country collaboration.

There are some countries where the capacity of the central national programme has been diminished. For example in Pakistan, devolution of the Ministry of Health has shifted responsibility to provinces where often there is less capacity for implementing malaria and vector control measures. As shown by the *Aedes* control programme during a recent dengue outbreak in Punjab, the pesticides used for space spraying were procured by the Ministry of Agriculture, without consultation with health officials. There are sometimes poor procurement practices with tenders going to the least expensive, rather than the most appropriate insecticide. There are also problems with smuggling of substandard pesticides, particularly from across the borders of Baluchistan

3.9 Integrated vector management and the implementation of national insecticide resistance management plans

Many of the countries in the Eastern Mediterranean Region have adopted the IVM strategy and have established national IVM coordination committees. These national committees may provide a strong foundation for developing a national insecticide resistance management programme, but may themselves lack the specialized technical needs resistance monitoring, data interpretation and resistance management. In some countries there will need to be external technical support and expertise mediated by WHO to help with the monitoring, the analysis and the management planning. However, countries must be careful in not establishing too many separate committees and strategic plans, but to see how the Insecticide Resistance Management plan may fit within the overall pesticide management strategy, which itself is part of the overarching IVM strategy. In most countries the existing IVM strategy can be updated to specifically address the issues laid out in the GPIRM.

Legislation is included in the first element of the IVM strategy. Here pesticide registration and issues around quality assurance and importation are key for overall pesticide management but it may be difficult to legislate specifically for resistance management. This may be important as resistance management must be seen as a collective activity amongst a variety of partners. For example, there could be the situation where one group involved with vector control decides to switch from a pyrethroid to a more expensive class of insecticide, but another entity in the same geographic location continues to use the less expensive alternative, for a short-term gain and not implement the more expensive resistance management strategies that would benefit everyone.

4. GROUP WORK

Participants divided into two smaller groups to discuss, in three separate sessions: national insecticide resistance management strategies; insecticide resistance monitoring; and data management systems. Within each session, participants discussed a series of subtopics as described below, addressing the current situation; gaps and challenges; opportunities; and priority activities. The following is not comprehensive, but provides highlights of some of the successes and challenges in the Region.

4.1 Planning and implementing insecticide resistance management strategies

Following from the regional committee resolutions on integrated vector management EM/RC.52/R.6 and on sound management of public health pesticides (EM/RC.58/R.10) countries in the Region are developing their insecticide resistance management strategies from their integrated vector management strategies and committees. Some of the countries in the Region: Egypt, Iraq, Jordan, Morocco, Oman and Tunisia are malaria free, but have other vector-borne diseases that they are focusing on, especially dengue and leishmaniasis. Other countries participating in the discussions, Afghanistan, Djibouti, Islamic Republic of Iran, Pakistan, Saudi Arabia, Somalia, Sudan and Yemen were also concerned with malaria.

Coordination among institutions

Most of the countries have a coordinating mechanism through the IVM committees, although the function is variable. In some countries there subcommittees focusing on public health pesticide management, that may be in a position, with some changes in composition, to include specialists on insecticide resistance to spearhead the development of national insecticide resistance management strategies. Universities and national research institutions play an important role, such as in Tunisia, the Institute Pasteur; in Egypt, the Research Institute of Medical Entomology and the Universities of Al-Azhar and Ain Shams; in Jordan the University of Science and Technology. Likewise in the countries with more significant malaria transmission, the insecticide resistance management strategy is to be based on the national IVM coordination, which in most countries involves the Ministry of Health, Ministry of Agriculture, Ministry of the Environment and affiliated agencies dealing with water and sanitation. Some countries, especially the Islamic Republic of Iran and Sudan have a strong collaboration between the Ministry of Health and the Universities. Both Pakistan and Sudan have Master's and diploma courses in medical entomology and IVM, and the Islamic Republic of Iran, at the University of Tehran, has a number of degree courses (PhD, Mater and diploma) and training programmes for students from both inside the country and scholarship opportunities for students from other countries.

Coordination remains a challenge in many countries, both between and within ministries. Sometimes vector control has been devolved to the provinces, as in Pakistan, and sometimes to the municipal level as in Morocco, where vector control functions have been decentralized to more than 1000 municipalities. There is sometimes lack of coordination for insecticide usage between the Ministry of Health and the Ministry of Agriculture as in Pakistan for *Aedes* control and Saudi Arabia for overall pesticide importation.

Current strategy and plan of action for insecticide resistance management

Few of the non-malaria endemic countries have an explicit insecticide resistance management plan. Morocco does have a plan for malaria vectors, and is just now putting in place a plan for other vectors, including recommendations on pesticide procurement. In Saudi Arabia, there is continued reliance on pyrethroids, but there are recommendations to begin switching to other classes of insecticide within the indoor residual spraying programme. In Jordan there is continued insecticide resistance monitoring but not a comprehensive strategy across all vectors. Some countries do have strong insecticide resistance monitoring and management programmes. Sudan for example monitors more than 60 sites every two years and is developing national capacity for detecting resistance mechanisms.

Capacity for developing national strategies

Again there is wide variation in capacity for developing insecticide resistance management strategies among the different countries in the region. In Oman there is good entomological capacity within the malaria programme, but is just now expanding to other vector-borne diseases. Some of the countries that have negligible malaria for a long time are losing their entomological capacity. Jordan for example has been malaria-free since the 1970s and experiences diminished entomological programme capacity. There is a risk of having to conduct focal control without adequate entomological back up for resistance monitoring. Likewise Tunisia is lacking the human and financial resources because of the perceived low risk of transmission. Afghanistan has only three entomologists and faces severe challenges in access and programme implementation; likewise Yemen and Somalia. For most countries integrated vector management and insecticide resistance management have never been priority areas and have been under resourced from domestic funding. Djibouti is further challenged by the large staff turnover in the Ministry of Health. Morocco has good capacity and entomologists at the national level, but needs more capacity at the district level. Overall the low malaria-endemic countries have limited capacity for strategy development and implementation and need technical support from WHO and neighbouring countries.

Advocacy and legislation

Egypt has a good pesticide registration system, but needs better enforcement of legislation and recommendations. In Morocco, before registration of agricultural pesticides their efficacy is studied under field conditions. However in most of the other countries there is no specific legislation related to insecticide resistance as it relates to procurement and registration. Overall for most countries, there is no legislation linking the Ministry of Health and the Ministry of Agriculture in matters of pesticide management, limited legislation for regulation for insecticide use between the government and private sectors and no legislation for pesticide procurements based upon an insecticide resistance management strategy. WHO should advocate that insecticide resistance monitoring needs strengthening, the revitalization of entomology and establishment of insectaries. Insecticide resistance management and quality control of insecticides should be made mandatory before procurements are made.

Cross-border collaboration

Egypt and Sudan have good cross-border collaboration for malaria, but not yet specifically for insecticide resistance management. Throughout the region, one of the strongest examples of cross-border collaboration was with Saudi Arabia and Yemen, although this has now been hampered over the past two years because of the security situation. There is a problem in cross-border collaboration between Pakistan and the Islamic Republic of Iran. As with the devolution in Pakistan there are capacity problems within the Provincial Government of Baluchistan in responding to pesticide management and insecticide resistance.

As discussed at length throughout the meeting, there are more opportunities for WHO to facilitate more cross border support and coordination, including with bordering countries outside the Region such as Algeria, Ethiopia, Eritrea in the African Region and Turkey, Tajikistan, Azerbaijan in European Region.

4.2 Ensuring proper, timely entomological and resistance monitoring

Basic entomological monitoring package and programme capacity

The basic entomological monitoring package is generally well defined, at least on paper, in most of the countries of the region. In Djibouti for example there are 25 sentinel sites in both urban and rural areas for all mosquitoes, including 12 sites for *Aedes* collections in the capital (which since 2010 also includes molecular assays). Egypt has 8 sentinel sites, Afghanistan 5 sentinel sites, Saudi Arabia 34, Yemen 12 sites and Somalia 15 sites. Pakistan is faced with the challenge of devolution where the insecticide resistance monitoring network has been fragmented and is now done ad hoc by academia or projects. Sudan, with support from a number of partners, has the strongest national network in the region with 64 sentinel sites monitoring resistance every two years.

While the basic monitoring has been defined, actual capacity to undertake this monitoring is generally lacking and is seen as a priority by most countries. Djibouti has a good laboratory but it is not well utilized; there is no insectary or doctoral or master's level staff to run the programme. Egypt has capacity, but this resides in the universities and research institutes rather than in the programmes. Somalia has no laboratory. Yemen has five Master's level entomologists and good collaboration with NAMRU-3 along with Djibouti and Somalia but without linkages to national academic and research institutions. Again Sudan appears to have the strongest capacity having made a policy commitment to train and support Master's level medical entomologists as a core part of the vector-borne disease programme, now with more than 75 trained entomologists in the programme.

Most countries report lack of human resources, and in some countries, such as Djibouti, high staff turnover in the Ministry of Health. The one possible exception to the lack of capacity is Sudan. Some countries with leishmaniasis programmes cited the lack resources for monitoring the vector sandflies susceptibility status. Some countries in the Region are faced with security issues (e.g. Yemen) and were not able to do the collections as planned. A number

of countries cited challenges an accessing the WHO test papers for conducting the Tube Assays.

While there are tremendous gaps, there are also opportunities. Some countries, such as Djibouti, Yemen and Somalia, receive technical support from NAMRU-3; there is also support for a number of countries in the region through the Global Environment Facility, and in the case of Sudan, the Bill and Melinda Gates Foundation. Countries such as Somalia have an entomologist, political commitment and funding through Global Fund. Likewise Afghanistan has support from Global Fund and WHO to support the programme.

Collaboration with national research institutions and opportunities for cross-border collaboration

The Region has a number of excellent universities and research institutions providing support to entomological capacity and national vector-borne disease control programmes. There has also been some cross-border collaboration in the past, but there are numerous opportunities, through this initiative on insecticide resistance management, to improve communication and collaboration among the academia and research institutions and between national programmes.

In Pakistan, the Health Services Academy in Islamabad provides has been providing diploma courses in medical entomology, and in former years the International Center for Medical Research and Training in Lahore was a global leader in vector-borne disease research. There had been previous declarations for subregional collaboration, such as those from PIAMNet (the Pakistan, Islamic Republic of Iran and Afghanistan Malaria Network), the Kabul Declaration and South Asian Association for Regional Cooperation, but implementation had been a challenge because of weak programme capacity and the Ministry of Health devolution to the provinces in Pakistan and the difficult security situation in the malarious border areas. The Islamic Republic of Iran has very strong collaboration between the Ministry of Health and Medical Education and the Tehran University of Medical Sciences and the National Institute of Health Research and has supported training courses, including WHO training courses, for international participants for decades. Egypt likewise has had a long tradition of university engagement with Al Azhar University and Ain Shams University, Reach Institute of Medical Entomology (RIME) and the U.S. Naval Medical Research Unit in Cairo (NAMRU-3), which is also supporting entomology and insecticide resistance programmes in Djibouti, Somalia and Yemen. Saudi Arabia is building links with academic and research programmes through the newly established, National Center for Vector-Borne Diseases in Jazan that is planned to support training in medical entomology for international students in near future. Sudan, as mentioned earlier has made a strong commitment to training and support of medical entomology; maintain strong links between the national programme and the Blue Nile National Institute of Communicable Diseases.

4.3 Effective data management

The Eastern Mediterranean Region has made great strides in the development of a regional database for insecticide resistance. This is described in detail in the presentation from

Dr Ali Hassan and Dr Ahmed Hanafi-Bojd. At the individual country level however there remain large gaps and challenges to data gathering, analysis, information use and dissemination.

For example, in Afghanistan, some nongovernmental organizations are developing a database for malaria and leishmaniasis vectors, but the information is fragmented with limited feedback. As with many other aspects of the programme, there is a great need for capacity building and stronger regional links.

Likewise in Pakistan development of a national database is challenging, however there may be opportunities through the infrastructure used for *Aedes* data management and possible links with the Ministry of Agriculture as well as a number of academic and research institutions in the country. Iran has a strong history of insecticide resistance monitoring with a large published literature, but these are largely driven by the university and remain for research purposes. There is a need to develop a more current electronic system that can provide regular updates on susceptibility status that can be used for the resistance management strategy. Djibouti, Yemen and Somalia have nascent systems through support from NAMRU-3 and some financial support from the Global Fund and the Global Environment Facility Project. But as for other aspects of the programme, there is a need to build human capacities and information systems within the country. Somalia has the added challenge in needing to work across three different administrative entities. Saudi Arabia has a nascent system and is beginning to introduce an Arabic version of the “Malaria Decision Support System” developed by the Innovative Vector Control Consortium. Sudan, with the largest entomological monitoring programme does have a system for data collection and analysis, but are still working to improve collaboration with the University and Institute so that data collected as part of a research project could be shared and used for insecticide resistance management prior to its dissemination in a journal publication.

5. PRIORITY ACTIONS FOR THE MANAGEMENT OF INSECTICIDE RESISTANCE IN THE REGION

Using the key challenges, obstacles and opportunities identified by the working groups, further group discussions were held to identify priority actions for the management of insecticide resistance in the Region. They are grouped according to the four main themes of the meeting, and then further directed to Member States and WHO for action.

5.1 Insecticide resistance management

Member States

- Establish/strengthen national IVM committees to facilitate the objectives of insecticide resistance management at country level.
- Review and update IVM strategies and develop a written plan for insecticide resistance management as an integral part of the IVM strategy.

- Ensure the insecticide resistance management strategy includes pre-empted measures to prevent or delay insecticide resistance, depending on whether it is developed or not. Such measures should be based on the guidance set out in the GPIRM.
- In countries where malaria has been eliminated, but where vector control, especially larviciding, is still required for the prevention of re-establishment of local malaria transmission or for other vector-borne diseases, reduce reliance (constant application) on the use of one larvicide (a single active ingredient) alone, either by developing alternative non-chemical IVM methods or by rotating between alternative active ingredients.

WHO

- Advocate for insecticide resistance management as part of the regional strategy for IVM.
- Assist countries in updating country-specific IVM strategies with integrated components of insecticide resistance management.
- Clarify technical recommendations of insecticide resistance management for larviciding.
- Assist countries to develop the capacity for planning and management (decision-making capacity) to implement the insecticide resistance management strategy.
- Develop a roster of experts or task force, in cooperation with countries, on insecticide resistance to provide technical advice and support to the insecticide resistance management programme.
- Once in place, invite members of the insecticide resistance management experts/task force to relevant regional meetings/workshops (such as annual meetings of malaria programme managers) for updates and follow-up.

5.2 Monitoring insecticide resistance

Member States

- Collect and consolidate the data and information on malaria vectors (and vectors of other vector-borne diseases), their distribution, bionomics and relevant information on their insecticide resistance status in accordance with the regional database templates.
- Implement insecticide resistance monitoring as an essential element of the vector control programme and as part of the routine entomological surveillance.
- Take necessary steps to ensure that decisions on the procurement/purchase of insecticides for vector control are taken based on data on insecticide susceptibility for the relevant vectors in the targeted area (nationally and neighbouring countries).

WHO

- Facilitate the prompt supply of test kit materials and investigate the possibility of alternative sources.

- Assist in the identification of collaborating institutes/reference laboratories to assist in the process of the identification of resistance mechanisms (biochemical and relevant molecular assays) in situations where resistance has been detected.

5.3 Capacity for insecticide resistance management

Member States

- Establish formal links and relationships with research/academic institutions to strengthen national capacities in insecticide resistance management and vector control.
- Take necessary steps to establish insectary (s), laboratory(s) for insecticide resistance monitoring, the necessary human resources (trained personnel) and basic laboratory equipment to:
 - conduct field sampling of vectors
 - carry out morphological identification to species complex level
 - conduct WHO bioassay susceptibility testing
 - identify resistance mechanisms (biochemical – molecular).
- If not available within the programme, take necessary steps to secure access to insectary, relevant reference laboratory to conduct molecular species identification (sibling species) and relevant laboratory with capacity for identification of insecticide resistance mechanisms (using molecular methods), either within national research/academic institution or in a neighbouring country.
- Develop capacity for establishing and managing a national insecticide resistance database including field technicians and specialized entomologists.
- In order to maintain sustainability of the programmes, review national vector-borne disease programme structures to ensure proper positions for trained staff.

WHO

- Facilitate and support countries to identify potential research/academic institutions with capacities in entomology, insecticide resistance monitoring, application of molecular techniques for the identification of sibling species and resistance mechanisms, etc.
- Identify potential regional collaborating centres to support Member States.
- Coordinate with Member States and provide capacity building to support the development of country specific IVM strategy integrating insecticide resistance management aligned with GPIRM.
- Develop (in collaboration with relevant partners) training for trainers and short courses/programmes for entomologists on insecticide resistant monitoring methods and principles.

5.4 Data management and enabling environment

Member States

- Nominate a dedicated focal point for insecticide resistance and vector distribution data collection, management and sharing.

- Establish a geo-referenced national database and regularly review, analyse and interpret the data and their implications for vector control policies.
- Collect data on insecticide resistance and vector distribution and report the data annually to the WHO.

WHO

- Finalize assembling into a regional database data on insecticide resistance and vector distribution and establish a mechanism for information sharing among countries.
- Provide Member States with standardized formats for data collection and reporting on malaria transmitting vectors related information.

6. RECOMMENDATIONS

To countries

1. Build upon integrated vector management strategies to design and implement strategies for insecticide resistance management; there needs to be additional consideration for resistance management for larvicides.
2. Establish entomological and resistance monitoring networks within the country and ensure data are used to inform pesticide procurements and resistance management strategies. From this, establish a national, geo-referenced and quality assured database for insecticide resistance and vector distribution data.
3. Focus on capacity-building, programme staffing and improved collaboration within and between institutions and countries.

To WHO

4. Advocate resistance management as part of IVM and support countries to build capacity, plan and implement resistance management programmes; facilitate technical support from expertise and resources that already exists within the Region.
5. Facilitate prompt supply of test materials for bioassays and identification of reference laboratories for biochemical and molecular investigations; strengthen regional database and provide support, standard formats and training and quality assurance for data collection and reporting.
6. Support regional collaborating centres, networks for mutual technical support, training materials and opportunities for country programme staff.

Annex 1**PROGRAMME****Tuesday, 25 September 2012**

- 08:00 – 08:30 Registration
- 08:30 – 09:00 Opening session
 Message from Dr Ala Alwan, Regional Director, WHO/EMRO *Dr H. Atta*
 Message from H.E. Dr El Hossein El Ouardi, Minister of Health, Morocco
 Objectives of the consultation
 Introduction of procedures
 Adoption of the agenda
- 09:00 – 09:20 Experience of the Eastern Mediterranean Region on insecticide resistance management *Dr H. Atta*
- 09:20 – 09:40 Experience of the African Region on insecticide resistance management *Dr B. Ameneshewa*
- 10:10 – 10:30 How serious is insecticide resistance? *Prof L. Koekemoer*
- 11:00 – 11:30 Overview on Global Plan for Resistance Management (GPIRM) *Dr M. Macdonald*
- 11:30 – 12:00 Discussion
- 12:00 – 16:00 Working Groups 1: Plan and Implement Insecticide Resistance Management Strategies
- 16:15 – 17:45 Plenary presentation of working groups and discussions

Wednesday, 26 September 2012

- 08:30 – 09:30 Insecticide resistance monitoring protocol/guidelines for field assays *Dr J. Lines*
 Methods for characterization of resistance mechanisms (genetic, biochemical)
- 09:30 – 12:00 Working Groups 2: Ensure proper, timely entomological and resistance monitoring
- 12:00 – 13:00 Plenary presentation of working groups and discussion
- 14:00 – 17:00 Working Groups 3: Effective data management
- 17:00–18:00 Plenary presentation of working groups and discussion

Thursday, 27 September 2012

- 08:30 – 09:00 Establishing mechanism for information sharing on insecticides among countries *Dr A. Hassan and Dr A. Hanafi-Bojd*
- 09:00 – 10:30 Roles of national/international institutes, universities supporting insecticide resistance management in the Region: NAMRU-3, Witwatersrand University, Jazan Center, Iran School of Public Health, Blue Nile Institute, London School of Hygiene and Tropical Medicine
- 11:00 – 13:00 Plenary session: Development of Regional Framework for Action on Insecticide Resistance Management
- 14:00 – 15:30 Conclusion and recommendations
- 15:30 Closing session

Annex 2

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