

# **Vector Control Monitoring and Evaluation with an Emphasis on Resistance**

By:

**Hossain Ladonni (PHD)**

**Professor of Medical Entomology & Vector Control Department**

School of Public Health & Institute of Public Health Research

Tehran University of Medical Sciences,

Tehran 14155- P.O. Box 6446, Iran

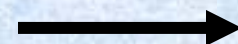
E-mail: [ladonni@sina.tums.ac.ir](mailto:ladonni@sina.tums.ac.ir)

# Vector Control

## Background

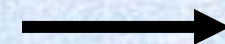
- Malaria remains a major public health problem in some parts of Africa and Asia.
- Global estimates of the malaria disease burden in 2007 indicated that there were at least 350 to 500 million clinical cases annually, of which 90% occurred in sub-Saharan Africa.
- Moreover, around one million deaths are related to malaria every year.
- Malaria in the Eastern Mediterranean Region is endemic in 14 out of the 22 countries.
- *Anopheles* is a mosquito of Culicidae family (Diptera).
- This genus includes 444 formally named and 40 provisionally designated extant species.
- About 30-40 species of this mosquito genus transmit 4 different species of malaria parasites.

**Continued**



- In Iran during last decades the number of malaria cases remain between 15-20 thousand cases. There are 28 species of *Anopheles* in the most recent Iranian mosquito checklist.
- Of them 7 species are designated as the malaria vectors. Among these, *Anopheles stephensi* has the history of resistance to DDT (1957), dieldrin, BHC (1960) and malathion (1977)
- *An. culicifacies*, *An. sacharovi* and *An. maculipennis* to DDT (1957) and dieldrin (1960)
- Insecticide application for adult mosquitos control was started with organochlorine (DDT, dieldrin and BHC) during 1960's, followed by organophosphorous (malathion and pirimiphos-methyl) for 2 decades from 1966 and continued with (carbamate) propoxure during 1977-1990, and since then with pyrethroids (lambdacyhalothrin/deltamethrin)
- Among larvicides, temephos, reldan, pirimiphos-methyl was used from 1970 to 1992 and recently *Bacillus thuringiensis* (Bti) have been used as the larvicides.

**Continued**



- Malaria control in the country is now based on use of deltamethrin (5% WP) as a adulticide and Bti as a larvicide at the volumes of about 15 and 5 tones respectively.
- However regular vector control monitoring, and judicious use of insecticide for malaria control in an IVM programme can certainly reduce further number of malaria cases and avoid the development and spread of insecticide resistance as well.

# Vector Control

## **Difination:**

- **Vector control remains the most generally effective measure to prevent malaria transmission using the candidate and selective vector control methods. It is one of the four basic technical elements of the Global Malaria Control Strategy.**
- **Vector control methods vary considerably in their applicability, cost and sustainability of their results. The choice of vector control will depend on the magnitude of the malaria burden, the feasibility of timely and correct application of the required interventions and the possibility of sustaining the resulting modified epidemiological situation.**
- **WHO recommends a systematic approach to vector control based on evidence and knowledge of the local situation. This approach is called Integrated vector management (IVM).**

# Integrated Vector Management (IVM)

- **Integrated Vector Management is a decision-making process for the management of vector populations using appropriate vector control methods, so as to reduce or interrupt transmission of vector-borne diseases. Its characteristic features include:**
- **Selection of methods based on knowledge of local vector biology, disease transmission and morbidity.**
- **Utilization of a range of interventions, often in combination and synergistically.**
- **Collaboration within the health sector and with other public and private sectors that impact on vector breeding.**
- **Engagement with local communities and other state holders.**
- **A public health regulatory and legislative framework rational use of insecticides.**
- **Good management practices.**
- **An IVM approach takes into account the available health infrastructure and resources and integrates all available and effective measures, whether chemical, biological, or environmental. IVM also encourages an integrated approach to disease control.**

# **Evidence based decisions for Vector Management**

- **In Evidence based decisions for Vector Management we need to break the decision-making process down into logical steps.**
- **We need to continually evaluate the outcomes of decisions and change the decisions if needed.**
- **The important steps in decision-making to solve vector-borne disease problem are:**

# Operational plan for monitoring, Evaluation and management of vector control

## Vector control methods

- |                    |                          |
|--------------------|--------------------------|
| Chemical           | Non-chemical             |
| IRS                | Environmental management |
| ITN                | Biological agents        |
| Larviciding        | Genetics                 |
| Sace spraying      | Personal protection      |
| Repellents & coils | Non organic material     |
| Others             |                          |

Step 1

Describe and analyse the vector-borne disease situation



Step 2

Stratify vector-borne disease problem based on relevant variables



Step 3

Determine whether there is a role for vector control in each stratum



Step 4

If there is a role for vector control, determine which method(s) is (are) suitable



Step 5

Where insecticide use is essential, select method(s) of application



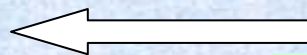
Step 6

Determine what insecticide to use and when, where and how to apply it



Step 7

Establish operational outputs and targets and select monitoring and evaluation methods



# Vector Control Methods

1. Reduce human-vector contact
2. Reduce vector density
3. Increase adult vector mortality

## Reduce human-vector contact

1. Nets and insecticide treated nets
2. Window and door screens, house improvement
3. Repellents
4. Household insecticide products (e.g. coils, mats and aerosol dispensers)

## Reduce vector density

1. Environmental management
2. Larviciding
3. Biological control
4. Adulticiding with space sprays

## Increase adult vector mortality

1. Indoor residual spraying
2. Community-wide use of insecticide treated nets

# What insecticide to use and when, where and how to apply it in a vector control programme

## 1. Determine *what* insecticides

- Efficacy
- Cost-effectiveness
- Safety
- Acceptability
- Availability of quality products

## 2. Decide where they should be applied

- Coverage requirements
- Best targeting

## 3. Establish when to apply them

- Time of application
- Epidemiological requirements
- Duration of effect
- Time required for covering target area

## 4. Decide on how to do so safely and effectively

- Staff skills and training
- Equipment
- Safety

# Monitoring Performance

- **Monitoring and evaluation**

**Definition:**

- Monitoring is a continuous process design to verify step by step the progress of vector control operation.
- Monitoring measures quality and progress of activities using process indicators.
- Monitoring identifies obstacles and aspects for modification.
- Evaluation measures results using impact and outcome indicators of programme goals.
- Impact indicators are entomological measurements. Outcome indicators are health outcomes.

# Monitoring Performance

## Indicators for monitoring and evaluation

### 1. Process or operational

- Determine whether activities are completed in a timely fashion as defined in the operational plan.
- Track the availability of resources and materials needed for the programme.

### 2. Impact or entomological

- Measure the effect of vector control interventions on the vector population.
- e.g. decreased human-vector contact, reduced vector density, or increased mortality of adult vectors.

### 3. Outcome or epidemiological

- Measure the impact of vector control programmes on morbidity and mortality due to disease.

# Classification of Indicators

**Routine monitoring (R):** Susceptibility test, dosage, coverage, timing, equipment, cost and recourses utilities.

**Trends (T):** Persistence (R, T), human biting rate, human blood index, parlous rate, larvae and adult density.

**Selectivity for specific purposes (S):** Sporozoite rate, biting cycle in relation to sleeping habitats.

# Evaluation

## Definition

- Evaluation is used to define the periodic assessment of progress towards the achievement of the objective by measuring impact indicators and the goals of the programme by measuring outcome indicators.
- The impact indicators are the entomological measurements.
- The outcome indicators are the health outcomes or epidemiological indicators.

# Monitoring of resistance

## **Definition:**

- Monitoring is a continuous process design to verify step by step the progress of vector control operation.
- To verify whether activities have been implemented as planned, insure accountability.
- To detect any problem and/or constraints in order to provide local feedback to the relevant authorities and to support them for promoting better planning through careful selection of alternative of future action.
- It require the identification of appropriate process indicators- the operational indicators that assigned to the activities perfumed and targets.

## Monitoring of resistance continued

- Resistance monitoring is a tool to document resistance or to confirm whether or not control failure was caused by resistance.
- Monitoring resistance is mainly relies on monitoring techniques.
- Choosing the appropriate monitoring technique will support the monitoring resistance and ultimately better detection and early warning of an impending resistance problem.

## Definitions and resistance types

- The word **resistance** has come to be applied to any population within a species normally susceptible to a given insecticide that is no longer controlled by the insecticide in the area concerned.
- A population is usually termed resistant when **resistance** has been indicated by control failure in the field and confirmed by the standard test of the insect.
- The development of an ability in a strain of insects to **tolerate doses of toxicants** which would prove lethal to the majority of individuals in a normal population of the same species.

## **Behaviouristic resistance**

The development of the ability to avoid a dose which would prove lethal.

## **Cross-resistance**

Cross-resistance is a term when a population developed resistance in response to the use of one particular -insecticide become resistant to many chemically related compounds which it has never met member of the same group

## **Example:**

Resistance to the chlorinated hydrocarbon insecticides is evidently of 2 distinct types: To DDT and its analogues and to cyclodiene derivatives

## **Tolerance**

- Tolerance is usually coincides with a degree of change in susceptibility level that has not resulted in a detectable loss of control by insecticide.
- usually coincides with a degree of change in susceptibility level that has not resulted in a detectable loss of control by the insecticide

## **Vigour tolerance**

- To enhanced insecticide tolerance resulting from extra vigour of the strain rather than from any specific defense mechanism

## **Single resistance**

- Single resistance, conferred by a single mechanism of resistance which usually protects against the selecting compound and chemically related compounds.

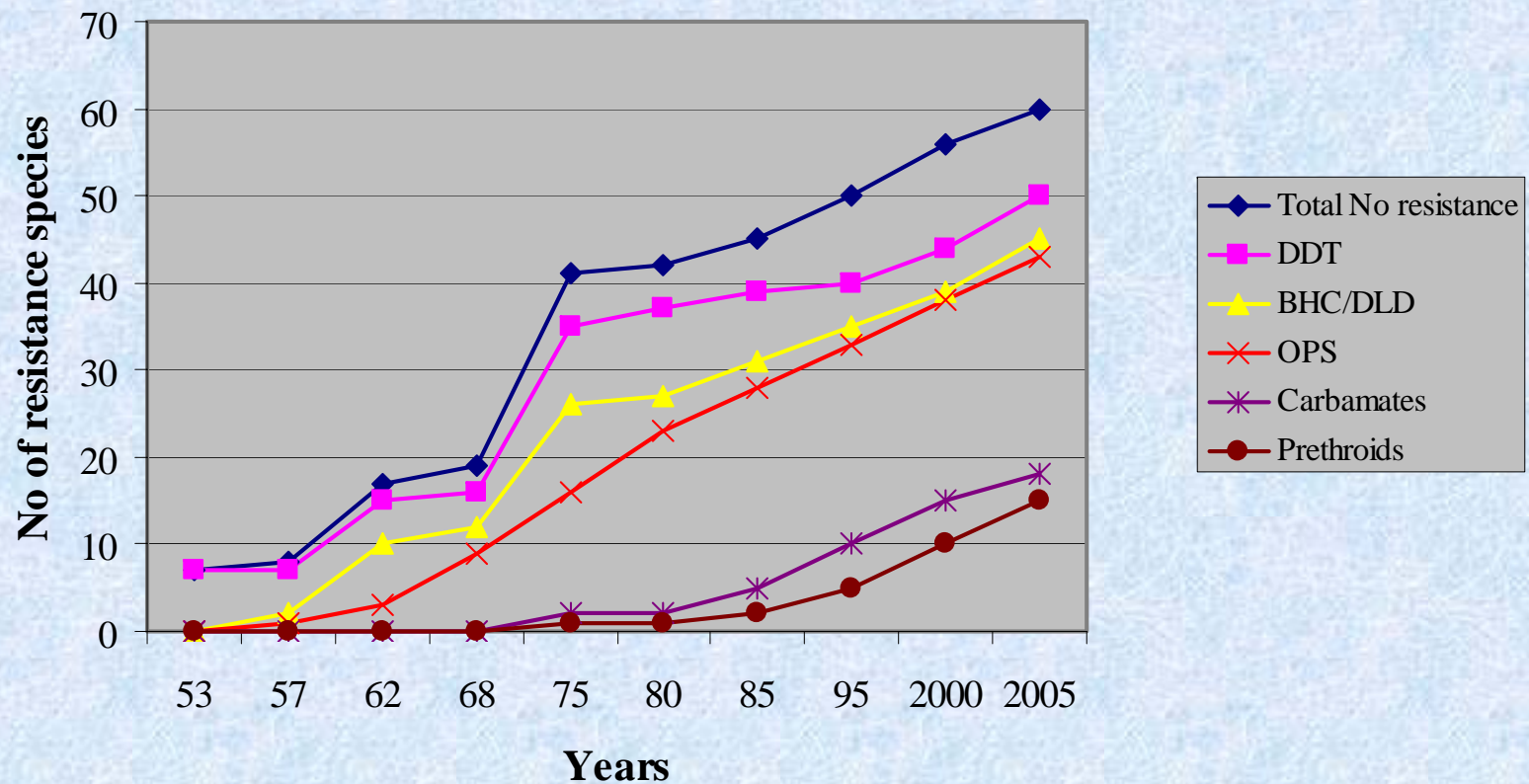
## **Multiple resistance**

- Multiple resistance applied when a population is exposed- to a series of chemically untreated insecticides with distinct mechanisms

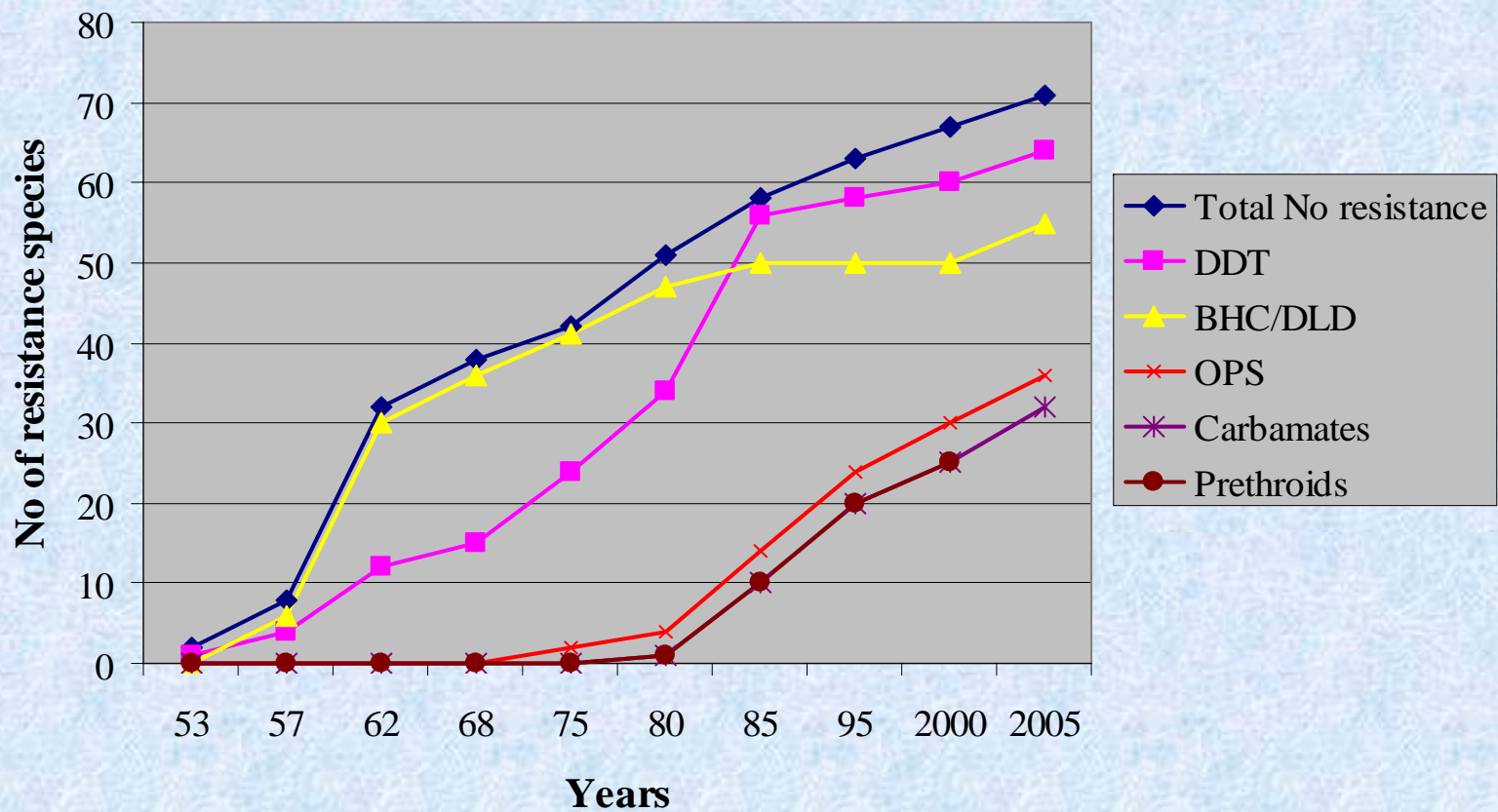
## **Multipelicate resistance**

- Multipelicate resistance occur when resistance to a single chemical group depends on the interaction of several different mechanisms.

## Development of resistance to four main group of insecticides in Culicinae mosquito in the period of 1957-2005



## Development of resistance to four main group of insecticides in Anophelinae mosquito in the period of 1957-2000



## **Resistance management tactics**

- **A number of theoretical (computer mathematical models) and applied tactic methods have been defined in an Integrated Resistance Management (IRM) by different scientists.**
- **The all methods has emphasis on the following criteria:**
- **1- Reduce selection pressure**
- **2- Decrease the frequency of resistance gene/s**
- **3- Discrimination between genotypes.**
- **4- Dilution by immigration.**

## **Insecticide resistance management:**

- Once mosquito resistance has developed, replacement by another insecticide is the only alternative.
- It is advisable to include in the spraying operations plan, every opportunity *for* the incorporation of measures for delaying *or* avoiding the development of resistance such as:
  - Confining the spray application to well defined focal areas of transmission, rather than pursuing a broad coverage *program* encompassing all areas.
  - Reducing the frequency of spray application by scheduling spray round to synchronize with seasonal periods of peak vector activity and disease transmission rather than. maintaining high residual levels of insecticides throughout the year.

# Resistance management tactics

## Techniques:

### 1- Treat the most vulnerable life stage

- Relative fitness's vary with the life stages treated, because some resistance mechanisms are more poorly expressed in some life stages than other e.g. larviciding Vs. Adulticiding.

### 2- Mix pesticides of different modes of action and metabolism

- If resistant alleles at two separate loci exist in the population at very low frequency. It is extremely unlikely that any one individual will carry both alleles.

### 3- Decrease the concentration of insecticide so that some susceptible individuals exposed to the pesticide can survive

### 4- apply insecticide less frequently so that susceptible have a chance to reproduce and to dilute resistance by interbreeding with resistant individual

### 5- Use chemicals with only short residual activity e.g. two peaks of activity vectors in south of Iran, DDT resistance in *An.stephensi*

## **6- Allow refuges for escape of susceptible**

- **Treating only those parts of a field that have malaria transmission.**

## **7- Rotate pesticides**

- **Given two or more insecticides with different modes of action and mechanism (negative cross-resistance).**

## **8- Mosaics**

- **The areas are treated simultaneously with different insecticides.**

## **9- Avoiding the selection of residual insecticides used locally against agricultural pests**

## **10- Not using the same pesticide-or closely associated compounds against both larvae and adults of a target mosquito species**

## **11- Substituting no chemical methods of control for residual spraying whenever feasible**

# Practical approaches of resistance management in vector control programmes

## 1- Limiting the use of pesticides to areas with high levels of disease

- **Socio-economic development areas, bordering on neighboring countries.**

## 2- Use of non-chemical methods. Environmental sanitation and biological control (fish)

## 3- Rotation chemicals by geographical region

- **Example, one area sprayed with OP, the other with PY. The products will then be rotated either seasonally or annually.**

## 4- Alternating chemicals with the season of application. This is particularly useful where there are biannual transmission peaks

**Non-cross resistance compounds are selected and applied.**

- **Spring : Compound (A)**
- **Autumn: Compound (B)**

## 5- Alternating between control strategies (integrated vector control programme)

**Parallel use of different methods with non cross-resistant compounds e.g. ITN's, larviciding, adulticiding (IRS) and space spraying.**