Malaria Decision Support Systems: Entomology
Vector control is difficult – we all know that – DSS make it easier.

Not that running an DSS is easy.

This is,
Quality control
Informed decisions
Informed policy
The emergence of Anopheles species resistant to insecticides widely used in vector control has the potential to impact severely on the control of these disease vectors. This may have a dramatic effect in Africa, as few affordable alternative insecticides are available for vector control. The extensive use and misuse of insecticides for agriculture and vector control has contributed to this problem.
Monitoring resistance

Collection Blood fed females from houses.

F1 generation reared.

Species identification.

WHO susceptibility assay.

Biochemical and molecular assays.

Management / policy change

Impact of insecticide resistance.

Short history of insecticide choice in southern Mozambique

1946 - 1988 DDT
1993 - lambda cyhalothrin became insecticide of choice
2000 – LSDI baseline carried out and pyrethroid resistance found
2000 – Bendiocarb become the insecticide choice
2000 – low level of bendiocarb resistance had been detected
2003 – Bendiocarb resistance spreading
2006 – DDT reintroduced
Resistance mechanisms

Metabolic: Most common mechanism. Insect relies on already existing detoxification pathways to overcome insecticide.

Target site: Insecticides generally act at a specific site, typically in the nervous system. The site of action may alter so that insects are not or less affected.

Reduced penetration: Modifications of the insect cuticle or stomach lining slowing or preventing absorption.

Behavioral changes: Modification in insect behavior, resulting in avoidance of insecticide.
# Resistance mechanisms

<table>
<thead>
<tr>
<th>Change in target site sensitivity</th>
<th>OP</th>
<th>Car</th>
<th>Pyr</th>
<th>DDT</th>
<th>Cyc</th>
<th>Fib</th>
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<tr>
<td>Acetylcholinesterase</td>
<td>✓</td>
<td>✓✓</td>
<td></td>
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<tr>
<td>Sodium Channels</td>
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<td>✓✓</td>
<td>✓✓</td>
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<tr>
<td>GABA receptors</td>
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<td></td>
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</table>

<table>
<thead>
<tr>
<th>Changes in metabolism</th>
<th>OP</th>
<th>Car</th>
<th>Pyr</th>
<th>DDT</th>
<th>Cyc</th>
<th>Fib</th>
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</thead>
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<tr>
<td>Glutathione S-transferase</td>
<td></td>
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<td>✓✓</td>
<td></td>
<td></td>
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<tr>
<td>Monooxygenase</td>
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<td>✓</td>
<td>✓✓</td>
<td>✓✓</td>
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<tr>
<td>Esterase</td>
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<td>✓</td>
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</table>
Vector control is a key component of a malaria control program.

Insecticides play a crucial role as through, IRS, ITNs and larvacides.

Insecticides are made up from a small group of compounds with discreet mode of action. Some of these groups share similar modes of action that allows for cross resistance.

Cross resistance explains why some populations can rapidly develop resistance to a new insecticide.

Resistance can also develop due to historical exposure.
Insecticide resistance database

There are several databases developed in the area of entomology, AnoBase, Vectorbase, ANVR (WHO) and MRC.

Partners met in Durban, to look at possibilities of combining insecticide resistance data sets.

A way forward has been proposed that would result in a single format of databases allowing anyone to access and combine all data.

WHO and the MRC agreed to the concept of single data base.

Ontology and Schema.

Outputs: Ontology, Schema, joint insecticide resistance database with WHO.
Resistance management in Mexican Anopheles; a large scale field trial.


Sponsored by the Insecticide Resistance Action Committee (IRAC; Public Health Section), with further contributions from Agrevo, Bayer, Cheminova, FMC, Mitsui Toatsu, Rhône Poulenc, Sumitomo and Zeneca.
Parasites and vectors in Mexico

Study area

Villages for pre-spray questionnaire

Villages for post-spray questionnaire
Combined agricultural and public health use of DDT resulted in widespread DDT -R in the 1970s.

OP, carbamate and pyrethroid-R were selected in the late 1970s by agricultural insecticides in many areas.
Experimental design

Traditional

Year 1: A
Year 2: A
Year 3: A

Single insecticide

Rotation

Year 1: A
Year 2: B
Year 3: C

Unrelated insecticides

Mosaic

Year 1: A B A A B A B A
Year 2: A B A
Year 3: A B A B A

Two unrelated insecticides
Mortality of *An. albimanus* to WHO diagnostic adult doses of insecticide

<table>
<thead>
<tr>
<th>Insecticide</th>
<th>Concentration (%)</th>
<th>1982</th>
<th>1983</th>
<th>1990</th>
<th>1997</th>
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<tr>
<td>DDT</td>
<td>4</td>
<td>38</td>
<td>39</td>
<td>47</td>
<td>40</td>
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<tr>
<td>Malathion</td>
<td>5</td>
<td>84</td>
<td>93</td>
<td>99</td>
<td>100</td>
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<tr>
<td>Fenitrothion</td>
<td>1</td>
<td>44</td>
<td>57</td>
<td>99</td>
<td>100</td>
</tr>
<tr>
<td>Fenthion</td>
<td>2.5</td>
<td>97</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chlorphoxim</td>
<td>4</td>
<td>98</td>
<td>99</td>
<td>100</td>
<td>100</td>
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<tr>
<td>Propoxur</td>
<td>0.1</td>
<td>89</td>
<td>95</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Deltamethrin</td>
<td>0.025</td>
<td>64</td>
<td>57</td>
<td>86</td>
<td>99</td>
</tr>
<tr>
<td>Cypermethrin</td>
<td>0.1</td>
<td>82</td>
<td>87</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Bendiocarb</td>
<td>0.1</td>
<td>87</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Pirimiphos methyl</td>
<td>4</td>
<td>99</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
Resistance seen by bioassay is an under estimate of actual R gene frequencies

E.g. 100% mortality with 0.1% propoxur, but 8% of the same population carried an altered acetylcholinesterase resistance gene.

The type of resistance mechanism selected is very important in determining what effect the resistance will have on the efficacy of insecticide treatment.
Removal of the relevant insecticide selection pressure sees a reduction in the resistant gene frequency in the mosquito population.

However the impact on malaria and infectivity was not measured as there is very low malaria risk in the region.
• Window traps fitted to 6 houses at each of 16 sentinel sites in December 2003

• Collections done on a daily basis by the homeowner

Sharp BL, Ridl FC, Govender D, Kuklinski J, Kleinschmidt I. Malaria vector control by indoor residual insecticide spraying on the tropical island of Bioko, Equatorial Guinea. Malar J. 2007 May 2;6:52
Species density - Bioko

Temporal information on changes in species composition.

An. funestus
An. gambiae s.l.

$kdr$

Pyrethroid
Carbamate

Average mosquitoes/trap/100 nights.

Months
Years
2003 2004 2005
<table>
<thead>
<tr>
<th></th>
<th>An. gambiae s.s.</th>
<th>An. melas</th>
<th>An. funestus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre spray</td>
<td>6.0 (n=581)</td>
<td>8.3 (n=133)</td>
<td>4.0 (n=372)</td>
</tr>
<tr>
<td>Post spray 1</td>
<td>1.8 (n=790)</td>
<td>3.1 (n=32)</td>
<td>2.3 (n=215)</td>
</tr>
</tbody>
</table>

A, C & D – Inland
B – Costal, brackish water breeder and shown to be very susceptible to insecticides.

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