Outdoor Malaria Transmission
Work Stream

Review of the current situation and magnitude of outdoor malaria transmission, and potential control tools

Marc Coosemans

Outdoor malaria transmission, 8th February 2012
Introduction

Scaling up ITNs and IRS have contributed significantly to a worldwide decrease of malaria, but:

- IRS has little impact on **outdoor resting vectors**
- ITNs do not affect **outdoor and/or early biting vectors**

Outdoor malaria transmission, 8th February 2012
Indoor/outdoor biting behavior is species and location dependent

- southern Vietnam
  - Prov. Bac Lieu
- northern Vietnam
  - Prov. Hoa Binh
- central Vietnam
  - Prov. Binh Thuan
- central Vietnam
  - Prov. Khanh Hoa
- Laos
  - Prov. Vientiane
- Cambodia
  - Prov. Rattanakiry

- An. nivipes
- An. subpictus
- An. vagus
- An. sinensis
- An. philippinensis
- An. aconitus
- An. epiroticus
- An. minimus C
- An. minimus A
- An. dirus s.s.

Trung et al., 2005, Trop Med Int Health, 10:251-62;
Ts & Van Bortel, 2006

Exophagic

ratios indoor/outdoor human landing

Endophagic

Outdoor malaria transmission, 8th February 2012
Early biting behavior is species and location dependent

- **An. nivipes**
- **An. subpictus**
- **An. vagus**
- **An. sinensis**
- **An. philippinensis**
- **An. aconitus**
- **An. epiroticus**
- **An. minimus C**
- **An. minimus A**
- **An. dirus s.s.**

**Trung et al. 2005**

Outdoor malaria transmission, 8th February 2012
High early biting rate (up to 60% before 10 pm) in Ninh Thuan (Vietnam). Van Bortel et al. Malaria Journal 2010, 9:373
Most of the infected *Anopheles* are observed before 10 pm in Ninh Thuan Province, Vietnam (Van Bortel et al. Malaria Journal 2010, 9:373)
Early biting in Cambodia (collections in 2006)

Proportion early biting vs Districts and Regions (error bars are 95% CI)

Proportion early biting vs site (F=forest; V=village)

Outdoor malaria transmission, 8th February 2012
Not only outdoor transmission, but also indoor transmission before sleeping time (Uganda)

<table>
<thead>
<tr>
<th>Site</th>
<th>HLC</th>
<th>Total indoor AEIR</th>
<th>% AEIR BST of total indoor AEIR</th>
<th>Species contribution to AEIR%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>An. funestus</td>
</tr>
<tr>
<td>Arua</td>
<td>Indoor</td>
<td>48.68</td>
<td>397</td>
<td>12.26</td>
</tr>
<tr>
<td></td>
<td>Outdoor</td>
<td>12.44</td>
<td></td>
<td>3.13</td>
</tr>
<tr>
<td>Apac</td>
<td>Indoor</td>
<td>93.81</td>
<td>1586</td>
<td>5.91</td>
</tr>
<tr>
<td></td>
<td>Outdoor</td>
<td>8.35</td>
<td></td>
<td>0.53</td>
</tr>
<tr>
<td>Tororo</td>
<td>Indoor</td>
<td>71.5</td>
<td>562</td>
<td>12.72</td>
</tr>
<tr>
<td></td>
<td>Outdoor</td>
<td>31.66</td>
<td></td>
<td>5.63</td>
</tr>
<tr>
<td>Jinja</td>
<td>Indoor</td>
<td>2.18</td>
<td>6</td>
<td>36.33</td>
</tr>
<tr>
<td></td>
<td>Outdoor</td>
<td>2.91</td>
<td></td>
<td>48.50</td>
</tr>
<tr>
<td>Kanungu</td>
<td>Indoor</td>
<td>0</td>
<td>6</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>Outdoor</td>
<td>1.81</td>
<td></td>
<td>30.17</td>
</tr>
</tbody>
</table>

BST: Before Sleeping Time

Pressure of ITNs and IRS might select outdoor and/or early biting vectors

• Variation in foraging behavior exists between vector species without pressure of vector control measures (VC).


=> VC can thus also result in selection of species and/or subpopulations of vector species more adapted to early and/or outdoor biting.
Tools to address residual transmission

- Topical Repellents (DEET, Picaridine (KBR3023), P-Mentane-3,8-diol, IR3535)
- Spatio-repellents (metofluthrin fan vaporizer)
- Insecticide treated hammocks, nets,
- Insecticide treated clothing
- Treated Plastic sheeting
- Mosquito Coils/ vaporizers
- Others?

Efficacy studies (entomological-epidemiological)?
Acceptability & feasibility studies?
Effect of topical repellents on malaria

Limited number of studies.

House hold randomized trials (with placebo):
- Aversion effect of mosquitoes from repellent users to non users
- Important spill over effect (exchange of products between the HH).
- In Bolivia: combined use of repellents and ITNs: reduced the incidence of malaria by 80% as compared to the use of ITNs alone. But lack of power for Pf.
  (Hill et al 2007, BMJ, 335(7628):1023)
- In Pakistan use of soap 20% DEET + 0.5% permethrin => 56% protection for Pf (not for Pv).
- In Laos: 15% DEET vrs Placebo HH trial=> no effect. Confounding factors: spill over effect, adherence low, intensified follow up.
- In Tanzania: lack of power on clinical malaria (RDT)
Long lasting insecticidal hammocks (Olyset technology)

1. Efficacy against mosquito bites in Cambodia (Sochantha et al. 2010)

<table>
<thead>
<tr>
<th>Species</th>
<th>Period</th>
<th>Interaction treatment</th>
<th>% reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Culicines</td>
<td>• Whole night • Before 22h</td>
<td>Village</td>
<td>28.7 (9.1-44) (95% CI)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Village</td>
<td>36.5 (21.5-48.7) (95% CI)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Village</td>
<td>49.8 (30.9-63.5) (95% CI)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Village</td>
<td>55.9 (35.9-69.7) (95% CI)</td>
</tr>
<tr>
<td>A.maculatus</td>
<td>• Whole night • Before 22h</td>
<td>Survey Vil/Survey</td>
<td>46.3 (25.3-61.5) (95% CI)</td>
</tr>
<tr>
<td>A.dirus</td>
<td>• Whole night • Before 22h</td>
<td>Survey Vil/Survey</td>
<td>45.5 (34.7-54.5) (95% CI)</td>
</tr>
<tr>
<td>A.minimus</td>
<td>• Whole night • Before 22h</td>
<td>No no</td>
<td>44.5 (25.0-58.9) (95% CI)</td>
</tr>
</tbody>
</table>

2. Randomized community based trial in VN: Thang et al. 2009

- malaria infection: 1.6 fold reduction
- incidence: 2 fold reduction

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