Larval Source Management

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What is Larval Source Management (LSM)?

- **habitat modification** (permanent change) e.g. drainage
- **habitat manipulation** (recurrent activity) e.g. flushing
- **biological control** e.g. fish
- **larviciding**, either chemical or microbial

Habitat modification
Historical successes

- Eradication of *An. gambiae* from Brazil;
- Eradication of *An. gambiae* from Upper Egypt;
- Eradication of malaria from Sardinia;
- Essential component of the Onchocerciasis Control Programme.

Larviciding in Brazil
LSM timeline

1900s
LSM main control method

1950s
LSM dropped out of favour

2000
Re-kindling of interest in LSM
Present successes

- Larval control routinely carried out on the River Rhine
- Larval control used for mosquito abatement in large parts of the USA

Bti application by helicopter
Larval control studies in Africa

Gambia River

Western Highlands

Dar es Salaam City
Microbial larvicides for malaria control

- *Bacillus thuringiensis* var. *Israelensis* or *B. sphaericus*
- Safe to humans
- Only kills mosquito larvae
- Developed by WHO

Microbial larvicide application
Larval control in Western Highlands, Kenya
## Entomology

<table>
<thead>
<tr>
<th>Valley</th>
<th>Late instars (larvae/dip)</th>
<th>Adult vector abundance (adults/ house)</th>
<th>Entomological inoculation rate</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Baseline period (no intervention)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No larviciding group</td>
<td>0.19</td>
<td>3.69</td>
<td>12.0</td>
</tr>
<tr>
<td>Larviciding group</td>
<td>0.26</td>
<td>3.49</td>
<td>10.3</td>
</tr>
<tr>
<td><strong>Intervention period</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No larviciding group</td>
<td>0.21</td>
<td>0.60</td>
<td>1.7</td>
</tr>
<tr>
<td>Larviciding group</td>
<td>0.02</td>
<td>0.08</td>
<td>0.4</td>
</tr>
<tr>
<td>% reduction</td>
<td><strong>90%</strong></td>
<td><strong>87%</strong></td>
<td><strong>76%</strong></td>
</tr>
</tbody>
</table>

*P <0.001

Incidence of new parasite infections in children

<table>
<thead>
<tr>
<th>Factor</th>
<th>n</th>
<th>Odds ratio (95% CIs)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITN use</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>4773</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>1592</td>
<td>0.69 (0.48-0.99)</td>
<td>0.047</td>
</tr>
<tr>
<td>Larviciding</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>4890</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>1475</td>
<td>0.44 (0.23-0.82)</td>
<td>0.010</td>
</tr>
</tbody>
</table>

Larval control in Dar es Salaam City, Tanzania
Anopheles adults

- Rainfall
- No larviciding
- Larviciding

GM An. gambiae/night

Rainfall (mm)

Jan-05 Feb-05 Mar-05 Apr-05 May-05 Jun-05 Jul-05 Aug-05 Sep-05 Oct-05 Nov-05 Dec-05 Jan-06 Feb-06 Mar-06 Apr-06 May-06 Jun-06 Jul-06 Aug-06 Sep-06 Oct-06 Nov-06 Dec-06 Jan-07 Feb-07 Mar-07 Apr-07
Prevalence of malaria infection in children

Summary

• EIR reduced by 32%
• Peak reduction in EIR 65%
• Larviciding reduced malaria infection by 72%
• Insecticide-treated nets reduced infection by 24%
• Larviciding & nets together will reduce malaria even more
...and now the cautionary note.
Larval control in The Gambia
Entomological findings

- **92% reduction in anopheline larvae**
  (Odds ratio = 0.08, 95% CIs = 0.06-0.10, p <0.001);
- **91% reduction in late stage larvae**
  (OR = 0.09, 0.05-0.16, p<0.001);
- **28% reduction in adult vectors**
  (OR = 0.72, 0.56-0.91, p = 0.005);
- Larviciding in areas of extensive flooded habitats had a small impact on adult mosquito densities and had little, if any, impact on malaria transmission

Majambere et al. (2010) *AJTMH* 82, 176-184
Clinical findings

• No reduction in clinical malaria or anaemia
## Summary

<table>
<thead>
<tr>
<th>Site</th>
<th>Habitat</th>
<th>Anopheline larvae</th>
<th>Anopheline adults</th>
<th>Parasite prevalence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mbita, Kenya</td>
<td>Rural town</td>
<td>99% ↓</td>
<td>93% ↓</td>
<td>Not done</td>
</tr>
<tr>
<td>Eritrea</td>
<td>Semi-arid</td>
<td>73% ↓</td>
<td>&gt;50% ↓</td>
<td>Not done</td>
</tr>
<tr>
<td>Mwea, Kenya</td>
<td>Rice paddies</td>
<td>↓ unpublished</td>
<td>Not known</td>
<td>Not done</td>
</tr>
<tr>
<td>The Gambia</td>
<td>River floodplains</td>
<td>88% ↓</td>
<td>32-52% ↓</td>
<td>No reduction</td>
</tr>
<tr>
<td>W. Highlands Kenya</td>
<td>Highlands</td>
<td>90% ↓</td>
<td>75% ↓</td>
<td>50% ↓</td>
</tr>
<tr>
<td>Dar es Salaam, Tz.</td>
<td>Urban</td>
<td>96% ↓</td>
<td>&gt;&gt;30% ↓</td>
<td>43% ↓</td>
</tr>
</tbody>
</table>

\( P < 0.001 \)
Conclusions

- Larval control by hand application will not work in areas of extensive flooding e.g. floodplains or large-scale irrigated rice
  - Larval control can reduce anopheline larvae by >90%
  - It can also reduce transmission by 35-75%
  - Findings suggest that prevalence of infection in children can be reduced by \( \approx 50\% \)
  - NB. ITNs have a protective efficacy against parasite prevalence of just 13\% (Lengeler 2007 Cochrane Collaboration, Wiley)
- Great potential to use LSM (larviciding and breeding site reduction) in combination with other anti-vector methods
- Integrated vector management seen as the future
Crucially, we will never have the same evidence of efficacy that one would have with an antimalarial or a vaccine since this is an environmental intervention where we randomise by area, not individual.

Here the justification for LSM is based largely on the historical success of interventions — as is the case for IRS.
Potential uses of LSM

• Adds improved control when combined with LLINs and/or IRS
• Tool for insecticide resistance management
• Effective for reducing biting by exophilic vectors
• May be particularly beneficial for malaria elimination – for removing ‘hot spots’
• Aerial application may be appropriate for elimination in areas with extensive water bodies
• Effective in areas of seasonal transmission, relatively few and well-defined, where habitats are accessible by ground crews, and in cooler parts of Africa where larval development is prolonged
Building the evidence

• Cochrane review on fish – Tom Burkot
• Cochrane review on LSM (not fish) – Thwing, Gimnig, Newman, Fillinger & Lindsay
• WHO review on global use of LSM
• Updated review on LSM – Lindsay & Fillinger
Expansion of LSM – for discussion tomorrow

- Support for NMCPs that are considering or are using LSM
- Monitoring & evaluation of LSM programmes
- Training courses on LSM
- Refinement of where and when to use LSM
- Assessment of different a.i.s & formulations
- Financial support for these activities
Summary

- Historical evidence for LSM success
- Recent evidence confirms success in well-defined habitats
- Need to build momentum & develop the evidence
- Where next? Needs to be discussed