Combined vector control and disease management of malaria using field data from rural Tanzania

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Hypothesis: Disease management (early detection & treatment) and vector management (larviciding) result in differential potential reductions of the malaria burden.

Location: 24 villages in Mvomero District (rural northeastern Tanzania)

Timing: 2010-15 (field work 2011-13)

Partners: National Institute for Medical Research – Tanzania (NIMR), University of Pretoria, Duke, University of Michigan, UT-Dallas, NCSU

Funding: US NIH

Multi-disciplinary approach: ecology, economics, entomology, medicine, risk analysis, biostatistics

Randomized health experiments

<table>
<thead>
<tr>
<th>Disease Management Intervention</th>
<th>No ED&amp;T</th>
<th>ED&amp;T</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vector Control Intervention</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Larviciding</td>
<td>Group 1</td>
<td>Group 2</td>
</tr>
<tr>
<td>Larviciding</td>
<td>Group 3</td>
<td>Group 4</td>
</tr>
</tbody>
</table>

N= 962 (~40 households in 24 villages); 6 villages/arm

ED&T = Early Detection & Treatment (CHWs & RDTs)
Study Area

(a) Tanzania & (b) Mvomero District

Map of Selected Villages

Key:
- Selected Village
- Unselected Village
- Major road
- Study area
- Mvomero District
- Morogoro Region

Scale:
- 30 Km
- 10 Km
Early Detection & Treatment Intervention

- 1 CHW trained in each village receiving intervention
- Trained CHWs visited same households that participated in baseline socioeconomic surveying (~40 per village)
- Households were visited by CHW about once every 2 weeks
- CHWs administered RDTs to HH members with fever (measured or self-reported in past two days)
  - If RDT positive, CHW administered proper treatment (ACT drugs) & gave referral to local health facility
  - If RDT negative, CHW gave a referral to local health facility
Larviciding Intervention

- 2 staff trained in each intervention village
- Mapped breeding sites
- Trained staff applied larvicide in larval habitats in the 12 intervention villages
  - Hand application for smaller sites
  - Spray application for larger sites (e.g., rice paddies)
- Staff monitored larvae counts (dipping) in scheduled rounds and reapplied larvicide as necessary
Surveying at baseline and after 2 rounds of interventions:

- **Socio-economic surveying** (household survey, FGDs, IDIs)
- **Longitudinal parasitological surveying** (blood samples, anemia status, anthropometric data, splenomegaly, temperature, malaria Rx history)
- **Entomological surveying** (light trap and pyrethrum spray collection)

**Intervention data**

- **ED&T** (Number and frequency of household visits, RDT results, malaria Rx history, CHW Rx compliance)
- **Larviciding** (Breeding site type & size, larvae and pupae counts, proper larvicide application compliance)
Survey Participation

- Socio-economic/KAP surveys: 962 households (~40 x 24); 5,385 individuals reported in baseline (2011) KAP
- 12 focus group discussions, 24 in-depth interviews in 2011; 6 focus group discussions, 13 in-depth interviews in 2013
- Parasitological surveys: participants from above households
- Entomological surveying: 72 households across 24 villages, 28,545 mosquitos collected
## Baseline Malaria & Anemia Prevalence

<table>
<thead>
<tr>
<th>2011 (Baseline) Parasitological Survey</th>
<th>participants (%)*</th>
<th>Frequency with malaria (%)</th>
<th>Frequency with anemia (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>100</td>
<td>5.6</td>
<td>52.4</td>
</tr>
<tr>
<td>By sex (&gt;6 months old)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>41.4</td>
<td>4.4</td>
<td>48.8</td>
</tr>
<tr>
<td>Female</td>
<td>58.6</td>
<td>7.0</td>
<td>55.3</td>
</tr>
<tr>
<td>By age category</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 months to &lt;5 years</td>
<td>28.0</td>
<td>4.9</td>
<td>66.5</td>
</tr>
<tr>
<td>5 to &lt;15</td>
<td>34.6</td>
<td>8.9</td>
<td>49.8</td>
</tr>
<tr>
<td>15 and over</td>
<td>37.4</td>
<td>3.1</td>
<td>44.2</td>
</tr>
</tbody>
</table>

- 13% had taken anti-malarials in the past two weeks
- Those with malaria had higher rates of anemia (60.7% v 51.7%)
## Attitudes Towards Larviciding at Baseline

<table>
<thead>
<tr>
<th>Attitude</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge of larviciding</td>
<td>17.8%</td>
</tr>
<tr>
<td>Trust in safety of larvicide</td>
<td>73.1%</td>
</tr>
<tr>
<td>Permission for program to larvicide in bodies of water near home</td>
<td>92.9%</td>
</tr>
<tr>
<td>Confidence that larviciding will reduce risk of getting malaria</td>
<td>91.9%</td>
</tr>
</tbody>
</table>

Willingness to pay

• If a larviciding program is implemented in your community where each household will be required to contribute _____ Tsh every three months, would you be willing to pay that amount?

One of 4 values (1000 Tsh, 2000 Tsh, 3000 Tsh, or 4000 Tsh) was randomly assigned
Willingness to Pay (WTP) for a Larviciding Program, by Contribution Amount per 3-month Period (%)

Mean WTP = 2,934 Tshs.
Probit analysis of the associations between socioeconomic, self-reported malaria, and attitudinal indicators with expressed willingness to pay

<table>
<thead>
<tr>
<th>Variable Type</th>
<th>Variable</th>
<th>Coefficient</th>
<th>95% CI</th>
<th>z</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demographics</td>
<td>Respondent age</td>
<td>−0.003</td>
<td>−0.012−0.005</td>
<td>−0.78</td>
<td>0.434</td>
</tr>
<tr>
<td></td>
<td>Respondent ever attended school</td>
<td>0.449</td>
<td>0.213−0.685</td>
<td>3.73</td>
<td>0.000*</td>
</tr>
<tr>
<td></td>
<td>Number of people in the household</td>
<td>0.027</td>
<td>−0.020−0.075</td>
<td>1.12</td>
<td>0.262</td>
</tr>
<tr>
<td></td>
<td>Respondent’s main occupation–crop farming</td>
<td>−0.122</td>
<td>−0.391−0.148</td>
<td>−0.88</td>
<td>0.377</td>
</tr>
<tr>
<td>Wealth</td>
<td>Improved roof (iron sheets instead of grass/leaves/mud)</td>
<td>0.309</td>
<td>0.104−0.514</td>
<td>2.96</td>
<td>0.003*</td>
</tr>
<tr>
<td>Reported malaria</td>
<td>≥1 recent case of self-reported malaria in household (assessment of each member’s most recent fever if within past 3 months)</td>
<td>−0.048</td>
<td>−0.252−0.155</td>
<td>−0.47</td>
<td>0.641</td>
</tr>
<tr>
<td>Attitudes towards larviciding</td>
<td>Trust in safety of larviciding</td>
<td>0.350</td>
<td>0.107−0.593</td>
<td>2.82</td>
<td>0.005*</td>
</tr>
<tr>
<td>Bid</td>
<td>Larviciding contribution amount</td>
<td>−0.340</td>
<td>−0.429−0.250</td>
<td>−7.42</td>
<td>0.000*</td>
</tr>
</tbody>
</table>

Notes: Willingness to Pay (Y/N); N = 792; Prob > chi² = 0.000. * Significant at the 0.05 level.
Key Findings

- Rich understanding of villagers’ attitudes and practices regarding malaria control, prevention, and treatment

- Heterogeneity of malaria prevalence across villages in the area, the further study of which can inform policy decisions on resource allocation and targeting of interventions / health care infrastructure

- Proven feasibility of successfully training community members as local staff engaged in novel community-level malaria prevention activities

- Generation of new knowledge on the potential and challenges of a rural microbial larviciding campaign, an understudied approach for malaria vector control

- Considerable community support for larviciding at the outset
Malaria Decision Analysis Support Tool (MDAST)

- **Objective:** Develop a user-friendly decision support tool to improve decision-making on malaria control strategies (Decision analysis as the conceptual and modeling framework)

- **Partners:** Duke University, University of Pretoria, Ministries of Health (Uganda, Kenya, Tanzania)

- **Support** from WHO, GEF/UNEP

- **Extensive stakeholder involvement:** surveys, interactive workshops

- **Extensions** through additional projects
MDAST Structure

Each simulation based on:

• Malaria transmission & vector ecology model (from a published paper, Griffin et al 2011 PloS Med)

• Insecticide resistance model (using published paper, Brown et al 2013 J Econ Entomol)

• LLIN demand & diffusion model (developed for MDAST)

• Diagnostic & treatment module (developed for MDAST)
MDAST Structure: Simulation Model Executed in Stages

Diagram - Mathematical model

Tool initialization → Historical simulation of current interventions → Baseline Projection

Alternative I Projection → Alternative II Projection → Alternative III Projection

Results comparison
Iterative Updating of MDAST

- Initial MDAST
- Baseline surveys
- Updated MDAST to reflect Mvomero conditions
- Field interventions
  - Updated again to reflect knowledge gained from field interventions
MDAST – Larviciding Example (I): Set-up

Compare 1, 2, & 3 30-day campaigns/year
MDAST – Larviciding Example (II): Projected costs
Farmer-assisted microbial larviciding project

**Funding:** Pending approval by GEF/UNEP

**Planned Outcomes:**

1. Creation of new knowledge about the cost effectiveness and practicality of farmer application of microbial larvicides
2. improved tools for evidence-based decision-making on the control of vector-borne diseases,
3. strengthened in-country decision-making on IVM for the control of malaria and other vector-borne diseases.

**Approach:** Farmers in lower Moshi area of Tanzania would apply an optimal larvicide-fertilizer mix to rice fields.
- proof of principle studies, experimental plot studies, randomized field experiments
- analyzing local perceptions and attitudes
- guidelines for replication
- Incorporate into MDAST

**Partners:** KCMC (lead), Duke, ICIPE, NIMR, & University of Michigan
Collaborators

Birkinesh Ameneshewa - WHO- AFRO
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