RBM Partnership To End Malaria
30th January, 2019

VBD and the Built Environment

Co-chairs: Steve Lindsay and Lucy Tusting
## Agenda

<table>
<thead>
<tr>
<th>Time</th>
<th>Title</th>
<th>Speaker</th>
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<tbody>
<tr>
<td>14:30 – 14:45</td>
<td>Welcome &amp; review of 2018-2019</td>
<td>Lucy Tusting</td>
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<tr>
<td>14:45 – 15:00</td>
<td>BOVA Network update (Building Out Vector-Borne Diseases in Africa)</td>
<td>Steve Lindsay</td>
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<td>15:00 – 15:45</td>
<td>Research updates (10 minutes each):</td>
<td>Steve Lindsay, Arnold Mmbando, Earl Forlales</td>
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<tr>
<td></td>
<td>1. House entry of <em>Anopheles gambiae</em> changes according to building design</td>
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<td>2. Repellent ribbons along open eaves</td>
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<td>3. New designs for poor communities – the CUBO house</td>
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<td>15:45 – 16:15</td>
<td>Afternoon break / coffee, tea, fruit juices, sweet snack</td>
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<td>16:15 – 18:00</td>
<td>Discussion – All</td>
<td>Led by Steve Lindsay, Lucy Tusting, Fredros Okumu</td>
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<td>• House design recommendations for vector control: what do and don’t we know?</td>
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<td>• The view from the countries. How do the health and building sectors link at local level? How can protective house designs be incorporated into local architecture?</td>
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<td>18:00</td>
<td>End of meeting</td>
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30th January, 2019

Review of 2018-2019

Lucy Tusting
A new name…

from

*Housing and Malaria*

to

*Vector-Borne Diseases and the Built Environment*
Link between insect-borne diseases & the built environment

- Poorly screened houses
- Open water containers
- Polluted still water
- Solid waste accumulation
Our objectives

1. To bring together VBD and housing specialists

2. Identify the best approaches for reducing house entry and indoor resting by mosquitoes and keeping the home comfortable and healthy for residents.

3. Develop methods for scaling-up housing interventions against VBD
The BOVA network: our core activity

- **BOVA** stands for ‘Building Out Vector-borne diseases in sub-Saharan Africa’
- Funded by the UK Global Challenges Research Fund
- Supports two areas of work:
  1. Bringing together VBD and housing specialists
  2. Funding research
Including the built environment within RBM’s new Multisectoral Working Group…

Kick-off meeting in Basel, October 2018
BOVA Network - Building Out Vector-borne diseases in sub-Saharan Africa

Steve Lindsay
What is the BOVA Network?

- Interdisciplinary network of researchers and practitioners working on insect-borne diseases and the built environment
- Aims to establish a new research discipline
Who are we?

Network directors

Prof. Steve Lindsay
Durham University

Prof. Mike Davies
UCL

Co-directors:
Dr Lucy Tusting (LSHTM) and Dr Cassidy Johnson (UCL)

Network Manager:
Dr Fiona Shenton (Durham), formerly Dr Anne Wilson (LSTM)

Network Management Board
(architects, economists, policy makers, urban planners, development practitioners, product developers AND entomologists/epidemiologists)
BOVA Network activities

1. Pump-prime funding
2. Global advocacy
3. Yearly open network meetings for information exchange
4. Grant writing workshops
# BOVA-funded studies

<table>
<thead>
<tr>
<th>PI</th>
<th>Study</th>
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<tbody>
<tr>
<td>Addissee</td>
<td>A transdisciplinary study on the distribution of aquatic habitats of malaria vectors and exploring potential social &amp; cultural measures for reducing transmission in Jimma town, Ethiopia</td>
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<tr>
<td>Fillinger</td>
<td>Designing hard floors for tungiasis control in Kenya</td>
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<td>Lindsay</td>
<td>Investigating whether the height of a house affects malaria mosquito indoor entry</td>
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<tr>
<td>Mutuku</td>
<td>Identifying methods for collecting trash for profit to reduce vector breeding sites in Kwale County, Kenya</td>
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<td>Okumu</td>
<td>Using low-cost mosquito-repellent chairs to provide day and night protection against mosquito-borne illness</td>
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<td>Phiri</td>
<td>Filming the unseen: understanding mosquito flight into houses</td>
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<td>Saute</td>
<td>Screening mosquito entry points into houses with novel long-lasting insecticidal netting to reduce indoor vector densities and mitigate pyrethroid-resistance</td>
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Bringing together VBD and housing specialists

• First annual meeting in London, March 2018
• In partnership with RSTMH
• Speakers included WHO, UN-HABITAT, MRC The Gambia, Royal Danish Academy of Fine Arts, Centre for Affordable Housing Finance in Africa, Habitat for Humanity International, ARCHIVE Global
Bringing together VBD and housing specialists

- BOVA at the MIM conference in Dakar, April 2018...
News

• We’re having our second network meeting on 4th April 2019 in Nairobi! All welcome!
• We have funds for students to attend providing they provide a statement of interest on their vision for moving the field forward
• You can follow our tweets @bovanetwork
What we need you to do is:

• Let us know of any **relevant information** on VBDs and the built environment
• E.g. news, comments, research papers, meetings, symposiums, funding - particularly in the built environment
Thanks for listening
Research Updates
RBM Partnership
To End Malaria

Wednesday 30th January 2019

How house design affects mosquito house entry in The Gambia

Professor Steve Lindsay, Durham University, UK
80-100% malaria transmission in sub-Saharan Africa occurs indoors

How do we keep out mosquitoes from a house and keep it cool indoors at night so people will sleep under a mosquito net?
How do different typologies of housing affect mosquito house entry?
Roofs (& gaps)
Experimental houses

Housing typology 1

Thatched-roof, open eaves, poorly-fitting doors
Thatched-roof, closed eaves, poorly-fitting doors
Housing typology 3

Thatched-roof, closed eaves, screened doors
Housing typology 4

Metal-roof, closed eaves, poorly-fitting doors
Housing typology 5

Metal-roof, closed eaves, screened doors & eaves
Outcome measurements

CDC light trap

Temperature & relative humidity logger
<table>
<thead>
<tr>
<th>Week</th>
<th>House position</th>
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<tbody>
<tr>
<td>1</td>
<td>Metal roof</td>
</tr>
<tr>
<td></td>
<td>Thatched, closed eaves, screened</td>
</tr>
<tr>
<td></td>
<td>doors</td>
</tr>
<tr>
<td>2</td>
<td>Thatched, closed eaves</td>
</tr>
<tr>
<td>3</td>
<td>Thatched, open eaves</td>
</tr>
<tr>
<td>4</td>
<td>Thatched roof, closed eaves</td>
</tr>
<tr>
<td>5</td>
<td>Roo Pfs</td>
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</table>
Moving roofs
Small changes to rural houses can be protective against malaria vectors

**Thatch roof**

- Thatched roof, open eaves, unscreened doors
- Thatched roof, closed eaves, unscreened doors
- Thatched roof, closed eaves, screened doors

<table>
<thead>
<tr>
<th>House typology</th>
<th>No. mosquitoes/house/night</th>
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<tbody>
<tr>
<td>Thatched roof, open eaves, unscreened doors</td>
<td>25</td>
</tr>
<tr>
<td>Thatched roof, closed eaves, unscreened doors</td>
<td>5</td>
</tr>
<tr>
<td>Thatched roof, closed eaves, screened doors</td>
<td>1</td>
</tr>
</tbody>
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Indoor carbon dioxide concentrations

Thatch

Metal
Windows
Small windows

Reference
Small windows
Effect of small windows on *An. gambiae* house entry

- **Metal, closed eaves, door gap top & bottom, with windows gaps top & bottom**
- **Metal, closed eaves, door gap top & bottom, with 1 screened window**
- **Metal, closed eaves, door gap top & bottom, with 2 screened windows**
- **Thatch, closed eaves, door gap top & bottom, with window gaps top & bottom**

*No. mosquitoes/house/night*
Large windows
Large windows
Effect of large windows on *An. gambiae* house entry

<table>
<thead>
<tr>
<th>Description</th>
<th>No. mosquitoes/house/night</th>
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<tbody>
<tr>
<td>Metal, closed eaves, door gap top &amp; bottom, with</td>
<td>x2</td>
</tr>
<tr>
<td>1 screened window</td>
<td></td>
</tr>
<tr>
<td>Metal, closed eaves, door gap top &amp; bottom, with</td>
<td>x2</td>
</tr>
<tr>
<td>2 screened windows</td>
<td></td>
</tr>
<tr>
<td>Metal, closed eaves, door gap top &amp; bottom, with</td>
<td>x2</td>
</tr>
<tr>
<td>2 screened windows, 1 large, 1 small</td>
<td>x1</td>
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No. mosquitoes/house/night
Increasing area of screening reduces indoor entry
Summary

• Closing the eaves reduces mosquito entry into thatched-roofed houses, but not metal-roofed ones;
• Screening doors or windows will help keep the house cooler at night;
• Screened windows may help reduce mosquito house entry if used in combination with solid doors.
How do we keep out mosquitoes from a house and keep it cool indoors at night so people will sleep under a mosquito net?

2 screened windows on opposite walls & solid doors + Long-lasting insecticidal net

After Knudsen
Acknowledgements

Particular thanks to:
Ebrima Jatta
John Bradley
Umberto D’Alessandro
Musa Jawara
David Jeffries
Jakob Knudsen
Margaret Pinder
Anne Wilson
Eave-ribbons treated with spatial repellents, can effectively protect against indoor and outdoor-biting mosquito

Environmental Health and Ecological Sciences

Arnold Mmbando.
Challenges

- Resistance, i.e. parasite and mosquitoes
- Changing of mosquito behavior
- User compliance
- Lack of drugs to treat all forms of parasites
- Poverty which led to poor diagnosis, health system housing.
Housing and Malaria

Importance of Eaves to House Entry by Anopheline, But Not Culicine, Mosquitoes

MYE NJIE,1,2 ERIN DILGER, STEVEN W. LINDSAY,1 AND MATTHEW J. KIRBY1,3

Reducing malaria by mosquito-proofing houses

Steve W. Lindsay, Paul M. Emerson and J. Derek Charlwood

Window screening, ceilings and closed eaves as sustainable ways to control malaria in Dar es Salaam, Tanzania

Sheila B Ogoma*1,2, Khadija Kannady3, Maggy Sikulu1,2, Prosper P Chaki2,4,5, Nicodem J Govella2,4,5, Wolfgang R Mukabana1 and Gerry F Killeen2,4,5

Building malaria out: improving health in the home

Lucy S. Tusting*, Barbara Willey2 and Jo Lines3
Housing in rural Tanzania
Hessian-materials treated with spatial repellents

Spatial repellency of transfluthrin-treated hessian strips against laboratory-reared Anopheles arabiensis mosquitoes in a semi-field tunnel cage

Sheila B. Ogoma1,2*, Hassan Ngonyani1, Emmanuel T Simufukwe1, Anthony Msoka1, Jason Moore1,2 and Gerry F. Killeen1,3

Impregnating hessian strips with the volatile pyrethroid transfluthrin prevents outdoor exposure to vectors of malaria and lymphatic filariasis in urban Dar es Salaam, Tanzania

Nicodem J. Govella*, Sheila B. Ogoma1,2, John Paliga1, Prosper P. Chaki1 and Gerry Killeen1,3

A low technology emanator treated with the volatile pyrethroid transfluthrin confers long term protection against outdoor biting vectors of lymphatic filariasis, arboviruses and malaria

Sheila B. Ogoma1,2*, Arnold S. Mmando1, Johnson K. Swai1, Sebastian Horstmann3, David Malone4, Gerry F. Killeen1,5

1 Ifakara Health Institute, Environmental Health and Ecological Sciences Thematic Group, Coordination Office, Dar es Salaam, United Republic of Tanzania, 2 US National Research Council, National Academies of Sciences, Engineering and Medicine, Washington, D.C., United States of America, 3 Bayer CropScience
Fitting of the eave-ribbons along the eave-spaces of the huts

**Active ingredient/ surface area ribbon**

- a = 15cm wide and 1m long: one pair for fitting left the other pair at the right side
- b = 15cm wide and 2.5m long: for fitting front and back sides of the hut

5% = 62g/m², 1.5% = 19g/m², 0.2% = 3g/m² and 0.02% = 0.3g/m²
Results

Mosquito-biting protection conferred with different set of eave-ribbons

Legend
- ○ actual mosquito catches/night
- ● model estimated means

Indoors

- Control (No ribbons)
- Untreated ribbons
- 0.02% Eave ribbons
- 0.2% Eave ribbons
- 1.5% Eave ribbons
- 5.0% Eave ribbons

Outdoors

- Control (No ribbons)
- Untreated ribbons
- 0.02% Eave ribbons
- 0.2% Eave ribbons
- 1.5% Eave ribbons
- 5.0% Eave ribbons

P.e=32%
P.e=77%
P.e=15%
P.e=56%
Small-scale field evaluation of 1.5% treated eave-ribbons in experimental huts

Outcome measures:
Indoor mosquito-biting risk
  • assessed by Window-exit traps and Backpack aspirators.

Outdoor mosquito-biting risk
  • assessed by using volunteer occupied exposure free (Mini-Double net) trap
Small-scale field evaluation of 1.5% transfluthrin treated eave-ribbons

Indoor biting reduction measured by Window Trap

Outdoor biting reduction measured by Mini-Double Trap

Percentage reduction in mosquito-biting

- An. gambiae
- An. funestus
- Other Anopheles
- Culex species
Evaluation of 1.5% treated eave-ribbons in rice farm huts

Reduced indoor densities of *An. arabiensis* by 56% (p < 0.001), *An. funestus* by 36% (p=0.001), spp. by 72% (p<0.001) and *Mansonina* spp. by 80% (p<0.001).

Outdoors, reductions were evident only for *An. arabiensis* 38% (p=0.034), *Culex* spp. 64% (p=0.001) and *Mansonina* spp. 47% (p<0.001).

*Swai et al* Unpublished
Conclusion and recommendations

- Transfluthrin treated eave-ribbons significantly protected against outdoor and indoor-biting malaria vectors, thus could potentially complement current intervention.

- The eave-ribbons also offered protection against non-malaria vectors in the field settings.

- The technique is simple, low-cost (only 7USD/hut), highly-scalable which make it suitable even in poorly-constructed houses.

- It effectively addresses the problem with eave-spaces being the preferred mosquito entryway, also do not require frequent retreatment.

- Do not require external energy of vaporization and do not restrict people movements, yet it provide significant protection against both indoor and outdoor-biting mosquitoes.

- Additional improvement may include the odour-baited devices to create a stimulodevisionary approach such as push-pull system which could aid to communal level protections.
Acknowledgements

- Fredros Okumu (PhD)
- Halfan Ngowo (MSc.)
- Alex Limwagu (BSc)
- Johnson Kyeba (BSc)
- Khamis Kifungo
- Masoud Kilalangongono
- OMC+ group
30th January, 2019

Discussion
Part 1

Housing design recommendations: what do and don’t we know?
Wednesday 30th January 2019

House design recommendations

Professor Steve Lindsay, Durham University, UK
What we did in 2015

What architectural features are protective?

Could these features be improved further, especially through actions by house owners themselves?
Roofs (& gaps)
What we know works. I eaves

- Closing the eaves will reduce house entry by malaria mosquitoes, but not other types of mosquito, and it will make the house hotter. May not work in metal-roofed housing.
- Weak evidence. No RCTs.
Doors
What we know works. 2 house screening

- Screened doors will also reduce malaria mosquito house entry & keep the house cool
- RCT of screened houses reduce indoor malaria mosquitoes & anaemia by 50% - Kirby et al. The Lancet 2009
What we know works. 3 house screening

- RCT of 20 screened house & 20 unscreened houses in south-west Ethiopia
- 42% reduction in *An. arabiensis*

Massebo & Lindtjorn 2013 Malaria J 12: 139
Problem with house screening

- Indication that house screening was not protective in The Gambia
- Due to damaged screening
- High frequency of door opening before midnight

Jawara et al 2018 ASTMH 99, 1475-1484
Even with self-closing doors mosquitoes get indoors

61-79% reduction in mosquitoes entering houses

Jawara et al 2018 ASTMH 99, 1475-1484
Windows
Large screened windows
Increasing area of screening reduces indoor entry
Summary
How do we keep out mosquitoes from a house and keep it cool indoors at night so people will sleep under a mosquito net?

2 screened windows on opposite walls & solid doors

Long-lasting insecticidal net

After Knudsen
Summary

• Closing the eaves reduces mosquito entry into thatched-roofed houses, but not metal-roofed ones;
• Screening doors or windows will help keep the house cooler at night;
• Screening must be robust & doors closed after dusk
• New materials needed for screening windows
• Screened windows and solid doors may be a better combination than screened doors & windows
House design recommendations - DISCUSSION

- Building high quality housing vs screening existing housing
- Building on traditional and vernacular African architecture
- Window screens – long term solution?
- Solution to door opening at night time – treated beads or strips?
- Tiered system – ideal housing, low-cost immediate solutions – must recognise practical constraints, need for equity
- Incorporating VBD into building regulations
- Housing is an approach involving long-term investment in public health – lack of support from major funders in health sector. So can we identify other funders (e.g. performance-based approach, agricultural sector, DfID). alternative approach – put cost issue aside and use infrastructure funding model?
- Incorporating insecticide into window screens?
- African Development Bank or government funding – many competing priorities
- Resettlement plans and other large scale projects have standard housing specs – opportunity to incorporate VBD
- Recommendations could differentiate between new build and retrofit. Also research questions
- Other models for scale up – copycat houses, incremental improvements/building – housing microfinance supports this
Scale-up of housing interventions

- Modular housing system fits model of incremental building
- Options for incremental improvements, 1) permanent solutions
- Using best practices to improve, health and well being
- ADB seeking suggestions on how to improve their standards
- Need for experts to advice funding partners like ADB, inadequate number of experts to ensure large scale infrastructural developments are safe
- Ministries of health should get involved, multisectoral approaches, global vector control response
- What considerations are needed when looking at personal protection versus communal protection
- Effect sizes for personal and communal protection, even if the improvement is only small, treated curtains could result in massive communal impact
- Investments in innovation to achieve high level effectiveness, and coverage at low cost
- Adapt products for different house designs and communities
- Training local masons to scale up specific architecture
- Nubian
- Housing improvements in Ethiopia
Thank you, find out more visit rollbackmalaria.org @RollBackMalaria
Part 2. The view from the countries:

• How do the health and building sectors link at local level?

• How can protective house designs be incorporated into local architecture?