

**Roll Back Malaria Vector Control Working Group (RBM VCWG)
11th Annual Meeting, 3rd-5th February 2016
Moevenpick Hotel, Rue de Pré Bois, Geneva**

**3rd Housing and Malaria Work Stream meeting
09.00-12.00, Thursday 4th February 2016
Moevenpick Hotel, Rue de Pré Bois, Geneva**

**Chair: Steve Lindsay (Apologies: Mariana Stephens)
Rapporteur: Lucy Tusting**

Welcome – Steve Lindsay, Durham University, UK

Participants were welcomed and it was highlighted how the housing and malaria work stream ties in with socioeconomic development and as such should be considered a long-term strategy. In November 2015 a consensus statement on housing and malaria was released by the work stream.

Progress on the RooPfs study in The Gambia – Steve Lindsay, Durham University, UK

The aims of the study are: (i) to determine whether modern housing provides incremental protection against clinical malaria over current best practice of LLINs and prompt treatment in The Gambia, (ii) to measure the incremental cost-effectiveness of the intervention and (iii) to analyse the housing market in The Gambia to develop systems for scale-up. The study is a two-armed household cluster randomised controlled study. 800 households will receive LLINs and 400 will receive improved housing before clinical follow up. One child aged 6 months to 13 years will be enrolled from each household and followed for clinical malaria using active case detection to estimate malaria incidence for two transmission seasons. Exposure to malaria parasites will be assessed using light traps followed by detection of *Anopheles gambiae* species and sporozoite infection. Ancillary economic and social studies will undertake a cost-effectiveness analysis and use qualitative and participatory methods to explore the acceptability of the housing modifications and to design strategies for scaling-up housing interventions. The intervention has been designed to upgrade traditional mud-walled and thatch-roofed housing to modern housing with metal roofs, screened eaves and a front door that is screened but ventilated. The priority is to keep mosquitoes out, while keeping the house cool and ventilation good to reduce the risk of acute respiratory infections. Preliminary results show that metal-roofed houses are warmer during the day but a similar temperature to thatch-roofed houses during the night and are less humid overall. So far, all 800 households have been enrolled and 201 of 400 houses modified. Clinical and entomological measurements will begin in June 2016.

Discussion

- Costs of the ventilated front door are not yet available.
- The study is geared to demonstrating proof of principle like the early bednet trials. While the prototype housing is very low tech, this is not likely to be the end product.

- There was discussion of community- versus household-level protection. If all houses were modernised, there may be an overall mass effect, for example through greater indoor mortality of adult mosquitoes due to higher indoor daytime temperature.

Innovative house design to minimise contact with vectors - Jacob Knudsen, Royal Danish Academy of Fine Arts, Denmark

Two projects were described: (i) the Healthy Homes project and (ii) Innovative House Design to Minimise Contact with Vectors. There are three alternative concepts when designing housing for malaria control: (i) a fully screened house which is impermeable to mosquitoes but may be hot, (ii) a completely open house with good ventilation to keep the temperature low, where bednet use may be higher, or (iii) a ‘toxic’ house where homes become mosquito traps. Both projects explored the second concept of open houses, learning from the Asian example. Healthy Homes was a scoping study conducted in 60 houses in four countries: Tanzania, The Gambia, Thailand and The Philippines. Homes with open eaves or open eaves and an open floor were found to be the coolest with at least two openings needed for air flow. A screened opening should be three times bigger than an unscreened opening. Findings are presented in the ‘Healthy Homes in Tropical Zones’ book by Jakob Knudsen and Lorenz von Seidlein.

The Innovative House Design to Minimise Contact with Vectors project near Tanga, Tanzania aims to optimise comfort and health while reducing contact with insects. Groups of houses have been built, made of bamboo, wood and shadow netting, with bedrooms raised from the ground, outdoor cooking areas and new latrines. Six basic variations in two different materials have been tested. A lottery was done to select houses. Thai carpenters were flown in to construct bamboo houses in under two weeks. As well as building new homes, some houses were modified with concrete floors, screening and metal roofs. Data collection is ongoing. Preliminary results show that new homes are cooler than reference and modified houses. The cost of modifying homes is around two thirds that of new homes and the new homes cost the same as standard new brick houses in Tanzania. House designs could be scaled up using teachers’ houses as model houses for people to copy.

Discussion

- Microfinance initiatives could be used to scale-up these types of houses.
- Using light materials and raising homes greatly improves air ventilation. Air ventilation can be measured using CO₂ dissipation from CO₂ ice.
- The durability of homes made of screened fabric was questioned; but it is very heavy and durable. Durability of wood with termites in the environment was also questioned. The homes have been monitored for six months so far and while soft wood and bamboo has problems with termites, this can be treated. Raising houses can help prevent termites and rot.
- Publishing standard designs for African housing would be useful.
- Security in open homes needs to be considered.
- The evaluation should also measure whether houses are mosquito proof.

Eave tubes for malaria control in Africa: from concept to market – Bart Knols, In2Care, The Netherlands

Research funded by the European Community was presented. A new type of net with an electrostatic charge can be treated with an active ingredient. Electrostatic netting treated with deltamethrin powder at 3.7 mg AI/m² achieved high mortality in the Tiassale pyrethroid-resistant strain of *Anopheles gambiae*. Repetition of this experiment was done with multiple susceptible and resistant strains. Eaves are the main entry point for *Anopheles gambiae*. Eave tubes exploit the evolution of African housing towards metal roofed, concrete/brick walled homes by turning the home into a mosquito trap. Field tests of eave tubes in a semi-field system has been done in Ifakara, Tanzania. Experimental huts have been used for overnight release-recapture experiments with three nights per treatment and 200 mosquitoes released per night. A 58% reduction in total recapture was achieved with deltamethrin, 52% with wettable bendiocarb, and 67% reduction with dry bendiocarb. Dry fungal spores with silica were also tested to measure total recapture over 20 days post exposure. A semi-field evaluation has also been conducted in Kenya in which average overnight kill was 60% with deltamethrin and 28% with bendiocarb.

Eave tubes have also been tested in the Malaria Village semi-field system in Ifakara. Preliminary results indicate that eave tubes reduce the total adult population (measured by human landing catches) and larval populations. Modelling has further explored the effect of eave tubes on the transmission potential of a vector population relative to no intervention and indicates that eave tubes reduce infectious bites, even for people in unprotected properties, and that deflection does not increase the risk in unprotected houses. The Bill and Melinda Gates Foundation has now funded a two-armed randomized controlled trial (2016-2018) in Côte d'Ivoire that will evaluate the additive effect of eave tubes to LLINs alone. The primary outcome is the incidence of clinical malaria. Secondary outcomes include acute respiratory infections, entomological outcomes and indoor climate. The project will also model implementation scenarios.

Discussion

The eave tube intervention works best in homes with closed eaves. Eaves will reduce house entry even without the treated tubes. It will be necessary to work on doors and windows too to further reduce house entry. It was also queried how protection from outdoor biting mosquitoes will be achieved. Some level of control will be achieved if vectors feed both indoors and outdoors. It was clarified that the Côte d'Ivoire study will modify only houses in the intervention arm; the intervention is a package (closed eaves with eave tubes).

Discussion - All

The following *research priorities* were presented and discussed:

1. What architectural features are protective? Could these features be improved further, especially through actions by house owners themselves?
2. What is the degree of protection against clinical malaria afforded by improved housing quality and modification of the peri-domestic environment and how does this vary across eco-epidemiological, socio-economic and cultural settings?
3. What other critical elements do we need to learn about vector ecology and behaviour in relation to housing and the peri-domestic environment?
4. How does the cost of building improved housing compare with the cost of regular housing? What is the cost-effectiveness of housing improvements?

5. Who is willing to pay for improved quality housing and how can this be tied to the perceived desirability of interventions, local values and market demand?
6. What is the most efficient way to scale-up housing interventions? Can these be integrated into existing local/national government development strategies?
7. Can we develop new materials and innovative ways of protecting people in their homes?
8. What vector-borne diseases other than malaria does improved quality housing and improved peri-domestic environment protect against?
9. How does house improvement interact with indoor interventions like IRS/LLINs?
10. What is the impact of screening and closing eaves against mosquitoes on ventilation and risk of other diseases, such as respiratory disease?
11. How can existing legislation on housing be reviewed/enforced to influence design the projected new housing units for better protection from vector-borne diseases?
12. How do we address the urban and peri-urban environments with regard to housing, infrastructure, water/sanitation and vector-borne diseases?
13. What are community preferences in relation to choice of housing and peri-domestic interventions in different settings?
14. What are the options for protecting specific population groups where they live and work e.g. pastoralists, nomadic groups, migrant workers and other at risk populations?

Based on the discussion, the following *action points* were proposed by participants:

- Advocacy in country, advocate for inclusion in strategic plans, curricula of vocational training schools; work with national housing corporations, NGOs, UN agencies, corporate social responsibly projects.
- What housing interventions should be recommended? More detailed guidance than the recent consensus statement could be disseminated.
- Key funders could be visited to present ideas on malaria and housing. Attendance from broader sustainable development programmes is needed.
- A six-monthly update on housing and malaria could be produced and disseminated through the mailing list and other forums (e.g. SciDev Net, MalariaWorld).
- In Tanzania and The Gambia, stakeholders could be invited to visit study sites, as well as UN organisations to help facilitate links with other ministries.
- Explore linkages between the work stream and the United Nations Environment Program and other organisations working on alternatives to DDT.
- Identify feasibility/funding for establishing demonstration homes and/or malaria-free demonstration areas or identify building fairs in sub-Saharan Africa.
- Identify opportunities to make links with manufacturers in China/India e.g. through building conventions.
- Identify opportunities for social marketing of housing interventions e.g. with Population Services International.
- Advocate for cross ventilation during bednet campaigns and delivery to increase bednet use in hot climates.
- Promote behaviour change communication to increase awareness of mosquitoes including larvae in the peridomestic environment and learn from what has been done for *Aedes*.

Steve Lindsay closed the meeting and thanked all participants.

Day 3: Friday 5th February

Session 3: Feedback from the work stream meetings

Chairperson: Jacob Williams

3rd Housing and malaria work stream meeting – Steve Lindsay, Durham University, UK

Revised research priorities:

1. What architectural features are protective? Could these features be improved further, especially by house owners themselves?
2. What is the degree of protection against clinical malaria afforded by improved housing quality and modification of the peri-domestic environment and how does this vary across eco-epidemiological, socioeconomic and cultural settings?
3. What other critical elements do we need to learn about vector ecology and behaviour in relation to housing and the peri-domestic environment?
4. How does the cost of building improved housing compare with the cost of regular housing? What is the cost-effectiveness of housing improvements?
5. Who is willing to pay for improved quality housing and how can this be tied to the perceived desirability of interventions, local values and market demand?
6. What is the most efficient way to scale-up housing interventions? Can these be integrated into existing local/national government development strategies?
7. Can we develop new materials and innovative ways of protecting people in their homes?
8. What vector-borne diseases other than malaria does improved quality housing and improved peri-domestic environment protect against?
9. How does house improvement interact with indoor interventions like IRS/LLINs?
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11. How can existing legislation on housing be reviewed/enforced to influence design the projected new housing units for better protection from vector-borne diseases?
12. How do we address the urban and peri-urban environments with regard to housing, infrastructure, water/sanitation and vector-borne diseases?
13. What are community preferences in relation to choice of housing and peri-domestic interventions in different settings?
14. What are the options for protecting specific population groups where they live and work e.g. pastoralists, nomadic groups, migrant workers and other populations at risk?
15. Document barriers and enablers of supply chain/market development for housing materials.

Draft work plan:

Activity	Date
1 Advocacy in country, advocate for inclusion in strategic plans, curricula of vocational training schools, national housing corporations, NGOs, United Nations agencies, corporate social responsibility projects.	End Q4

2	What housing interventions should be recommended? Give more detail than consensus statement for advocacy.	Circulate by end Feb 2016
3	Visit key funders (BMGF, UKAid) and present ideas on malaria and housing. Need attendance from broader sustainable development programmes.	End Q2
4	6 monthly update on what's happening in housing and malaria – disseminate through mailing list, forums (e.g. SciDev Net, MalariaWorld).	End Q2 and Q4 (ongoing)
5	In Tanzania and The Gambia, get stakeholders to visit study sites, including UN organisations to help facilitate links with other ministries.	End Q4
7	Explore links between work streams and the United Nations Environment Programme and other organisations working on alternatives to DDT.	End Q1
8	Identify feasibility/funding for establishing demonstration homes and/or malaria-free demonstration areas (invite people and demonstrate bednet use, how to screen a home etc.) or identify building fairs in SSA.	End Q2
9	Identify opportunities to make links with manufacturers in China/India e.g. through building material conventions.	End Q2
10	Identify opportunities for social marketing of housing interventions – e.g. with Population Services International.	End Q2
11	Advocate for cross ventilation during bednet campaigns and delivery to increase bednet use in hot climates.	TBD
12	Behaviour change and communication (BCC) to increase awareness of mosquitoes incl. larvae in house and peridomestic environment – learn from what has been done on <i>Aedes</i> .	TBD
13	Advocate for cross ventilation during bednet campaigns and delivery to increase bednet use in hot climates.	TBD
14	BCC to increase awareness of mosquitoes incl. larvae in house and peridomestic environment – learn from what has been done on <i>Aedes</i> .	TBD

Discussion – All

House design:

- It was clarified that private sector involvement is welcomed in this area.
- India has used house screening interventions and documented this. Mosquito-proofing of water tanks in India would make a good case study.
- While the healthy homes project in Tanzania is testing bamboo as a building material in that setting, bamboo does not grow everywhere. Therefore the Tanzania project is testing multiple materials including different types of wood and concrete. The bottom line is that the building must be kept light, with as little material as possible to store heat and to enable the house to be raised above the ground. This is the major advantage of Asian housing over traditional African houses.

Scaling-up housing interventions

- Since housing is steadily improving alongside development, the challenge for the work stream is to advocate that we should exploit these changes.
- While housing improvements can be expensive, there are many ways to build better housing simply over time, in an incremental fashion. Simple ideas such as closing eaves to reduce mosquito house entry have percolated into practice very quickly in some locations, such as

The Gambia, as has simple screening on doors or windows in other settings. Doors and windows are often tightly fitting in urban areas to improve security and this contributes to a malaria reduction in these areas.

- It is not realistic to improve all existing houses (e.g. entirely thatched buildings); building new homes is an alternative.
- Bye-laws are unlikely to have much effect on changing building design as they are largely ignored.
- Country initiatives to build low cost housing and rural development programs are a possible route to scaling-up.
- Working with the Johns Hopkins University Center for Communication Programs (CCP) could facilitate BCC to improve awareness of mosquitoes, house screening and larval habitats around the home.

Linking with other diseases and the peri-domestic environment:

- It is important to ensure good ventilation to keep homes cool and to reduce the risk of acute respiratory infections.
- At least two randomised controlled trials of housing interventions for tuberculosis and diarrhoeal disease are ongoing and it is important to communicate with these.
- The BMGF-funded project 'Casa Segura' investigated screening and larviciding in the peri-domestic environment.

Multisectoral intervention:

- The Swiss Agency for Development Cooperation has interest in multisectoral approaches.
- A recent Malaria Journal series on 'Reimagining malaria' thinks beyond classical approaches.
- Environmental Impact Assessment (EIA) is prominent in many countries. Advising EIA bodies on how to build good housing would be valuable to feed into housing schemes for workers in oil palm plantations, hydroelectricity projects, etc.

Urban/rural focus:

- The work stream has initially focused on rural housing because urban environments receive considerable attention elsewhere. In the future the work stream can expand its scope to include urban housing more and it may be helpful to produce a concept paper on this.
- TDR has expressed interest in scoping reviews on diseases of poverty in urban environments.