

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

**Co-chairs: Jacob Williams and Gerhard Hesse  
Secretariat: Konstantina Boutsika  
Rapporteur: Lucy Tusting**



**Day 1: Wednesday 3<sup>rd</sup> February**

**Session 1: Introductions and objectives**

*Chairperson: Jacob Williams*

***Welcome and introduction – Gerhard Hesse, RBM-VCWG/Bayer SAS, France***

Gerhard Hesse opened the meeting and invited new participants to introduce themselves.

***Meeting objectives and agenda - Jacob Williams, RBM-VCWG / RTI International, USA***

The priorities in 2015 were to reorient the VCWG to: (i) more effectively address the priorities of national malaria control programmes (NMCPs), (ii) support the development of the global malaria agenda and (iii) consolidate the work streams in the context of the broader RBM realignment. Further to the 2015 objectives, the aims of the VCWG in 2016 are to: (i) identify specific priorities, (ii) map out the VCWG strategy and work plan and (iii) implement the work plan and document results. Specific objectives are: (i) develop consolidated and ‘smart’ work stream plans, (ii) undertake in-

depth evaluation of opportunities for resource mobilization and (iii) enhance the engagement of partners with respect to innovative developments in vector control.

***Evolving landscape of malaria from the Millennium Development Goals to the Sustainable Development Goals - Pedro Alonso, World Health Organization, Switzerland***

The year 2015 saw significant challenges as well as notable developments to controlling malaria. The Ebola epidemic seriously undermined the successes achieved in affected countries and disrupted national systems. Among the noteworthy developments were the approval of the Global Technical Strategy for Malaria (GTS) by the World Health Assembly (WHA); the launch of the Action and Investment Against Malaria document (AIM), Greater Mekong Subregion elimination strategy and new vivax strategy; new guidance on Malaria in Pregnancy and Mass Drug Administration; the launch of a deep review of the WHO Malaria Elimination Manual, last reviewed in 2007; new guidance on piperonyl butoxide (PBO) bednets; the Zika outbreak, which the malaria vector control community must help address; the end of the Millennium Development Goals (MDGs) and the adoption of the Sustainable Development Goals (SDGs). The GTS represents a major step forward with an overall goal to: (i) reduce malaria mortality rates globally by 90% by 2030, (ii) reduce malaria case incidence by at least 90% by 2030, (iii) eliminate malaria in at least 35 countries by 2030 and (iv) prevent a resurgence of malaria in all countries that are malaria-free.

The World Malaria Report 2015 was launched in December 2015. Between 2000 and 2015, there was a 37% decrease in annual global malaria incidence and a 65% decrease in annual global malaria mortality rates. 57 countries have reduced malaria incidence by 75% or more. 68% cases averted since 2000 are attributable to long-lasting insecticide-treated net (LLIN) use (Bhatt *et al.*, 2015 Nature). In 2015, the WHO European Region reported zero autochthonous cases for the first time. There are major challenges remaining with 214 million cases and 438,000 deaths globally in 2015 and 33% of the population at risk had no access to an insecticide-treated net (ITN) in their household.

Within WHO, 2015 saw a revamp of the Global Malaria Programme (GMP) team with the creation of three new units; a recent meeting that brought together all 180 GMP global staff in Geneva; ongoing discussions on the structure of RBM and the disestablishment of the secretariat at WHO. At its 28<sup>th</sup> session in May 2015 the RBM Board established a Transition Oversight Committee (TOC) to develop a new Governance Architecture and Operating Mechanisms for RBM. A proposal was presented and approved in December 2015 that will see a new Partnership Board, Chief Executive Officer, Malaria Council and Partner Committees. The selection of new Partnership Board members is ongoing.

***Bill and Melinda Gates Foundation malaria vector control research agenda – Dan Strickman, Bill and Melinda Gates Foundation, USA***

The overarching Bill and Melinda Gates Foundation (BMGF) malaria strategy is to support efforts to: (i) detect the parasite, (ii) eliminate the parasite from its reservoir and (iii) prevent transmission of the parasite. Within vector control, key themes are: (i) to prevent residual transmission in situations where current solutions are insufficient; (ii) to fill gaps in our understanding of vector biology, with principal investments in vector identification and characterisation, characterising the parasite reservoir and training; (iii) malaria control in very high transmission settings and (iv) preventing the reintroduction of malaria following elimination. Principal investments currently include attractive

toxic sugar baits (ATSBs), eave tubes, gene drive, new active ingredients, push-pull systems and spatial repellents.

#### *Discussion*

- It was queried how insecticide resistance can be managed when many country mitigation strategies were not funded in the last Global Fund round. In response, it was clarified that WHO is working closely with the Global Fund and countries to support insecticide resistance management.
- There was discussion of the role of mapping intervention coverage and vector distribution.
- There was lively discussion around current understanding on the impact of insecticide resistance on the effectiveness on interventions. The need for continued generation of field data to further clarify issues was stressed. The priority is to ensure maximal coverage of at - risk populations with existing tools that are effective in the local settings. Efforts to integrate new tools to address local insecticide resistance must therefore take due cognisance of available resources, cost of implementation and anticipated benefit.
- It was queried whether larval source management (LSM) should be advocated more for controlling outdoor transmission and insecticide resistance management. LSM and integrated vector management (IVM) more broadly can play an important role, especially in elimination settings.
- It is critical to reach less accessible populations and ensure equity in intervention coverage.
- Durability of interventions is important; the move from ITNs to LLINs was key in building towards universal coverage.

#### **Session 2: Current policy and implementation practice**

*Chairperson: Gerhard Hesse*

##### ***Tom McLean – Innovative Vector Control Consortium, UK***

UNITAID and the Innovative Vector Control Consortium (IVCC) have announced a \$65.1m initiative to accelerate the adoption of 3<sup>rd</sup> generation indoor residual spraying (IRS) tools, beginning in Mali, Ethiopia, Ghana, Zambia and Mozambique, expanding to around 16 countries by the end of the four year program. NMCPs interested should contact Tom McLean or David McGuire.

##### ***Membership, information exchange and budget - Konstantina Boutsika, RBM-VCWG/Swiss TPH, Switzerland***

The three VCWG communication channels are: (1) the mailing list, (2) the website and (3) the annual meeting. The mailing list has expanded from 693 entries in 2014 to 1374 in 2015, with many additions from sub-regional networks. A new website was launched in March 2015. Work is ongoing with Abt Associates to improve knowledge exchange on IRS. There were 11,039 website views in 2015, a 10% increase from 2014, accounting for 28% of total page views across all RBM working groups. This year the Annual Meeting had 233 registered participants from 43 countries: including 86 Europeans, 52 Americans and 69 Africans. The largest sector represented is research and academia, followed by the private sector. As of 2015, a registration fee (CHF 250) was introduced to cover meeting expenses, with selected endemic country participants sponsored via leverage funds. The work plan is financed by the partners. Leverage funds were provided by the Swiss Agency for Development and Cooperation, Swiss TPH and USAID. Twelve companies have sponsored an

exhibition on new tools and innovations: Avima Pty Ltd, Bayer, HD Hudson Manufacturing Company, Intelligent Insect Control SAS, In2Care, Mitsui Chemicals Agro, Pulcra Chemicals, Sumitomo Chemical, Syngenta, Vestergaard, VKA Polymers and Westham.

***Action and Investment to defeat Malaria 2016-2030 (AIM) for a malaria-free world: the potential role of VCWG – Helen Prytherch, Swiss TPH, Switzerland***

Together with the GTS, AIM provides a framework for ongoing malaria control efforts. More than 1600 stakeholders from over 90 countries were consulted in its development. AIM provides a clarion call to the global malaria community, shows how reducing malaria is central to sustainable development, promotes multisectoral control and makes the case for investing in malaria control and strengthening health systems. An investment of US\$100 billion will be required to meet the 2030 goals, which will save an estimated 10 million lives and avert 3 billion cases, with US\$4 trillion additional economic output, yielding a 40:1 return on investment. The AIM closely aligns with the goals of the SDGs. Major challenges to malaria control include population mobility, drug and insecticide resistance, sustainable habitats, food security. Potential roles for the VCWG are to assist in the development of AIM and its main messages, advocate for the development/enforcement of malaria smart policies, strengthen the evidence on socioeconomic and environmental determinants of malaria, promote the involvement of non-health sectors, continue to facilitate private sector engagement, conduct operations research to overcome implementation challenges and push for continued innovation.

***Vector control policy updates and priorities - Abraham Mnzava, World Health Organization, Switzerland***

Recent policy recommendations on malaria vector control include the endorsement of the GTS, recommendations on the potential risks of scaling-back coverage of vector control and recommendations on the use of PBO LLINs in areas with pyrethroid resistance. Irrespective of both pre-intervention and current levels of transmission, the scale-back of vector control is not recommended, but where it is needed, it should be based on a detailed analysis that includes an assessment of receptivity, vulnerability, active disease surveillance, capacity for case management and vector control response. With regards to the use of PBO LLINs in pyrethroid resistant areas, two PBO LLINs are available, both with a World Health Organization Pesticide Evaluation Scheme (WHOPES) recommendation as standard LLINs. WHO issued recommendations in December 2015 on the use of PBO LLINs, which states that the evidence on the efficacy of PBO LLINs is still limited and does not at this point justify a complete switch from pyrethroid-only LLINs to PBO LLINs across all settings, that PBO LLINs with a WHOPES interim or full recommendation can be considered at least an equivalent option to other LLINs in all settings and that PBO LLINs should be used only where universal coverage with effective vector control (LLINs and/or IRS) of populations at risk of malaria will not be reduced, or in areas programmed for IRS with actellic CS. Pilot implementation may be undertaken in selected settings.

Current vector control priorities, in line with the GTS, include maximising the impact of current vector control interventions, maintaining adequate entomological surveillance, managing insecticide resistance and outdoor malaria transmission, strengthening capacity for evidence-driven vector control, implementing targeted vector control where transmission has declined and supporting the development and uptake of new tools including quality control of vector control products. Key areas for policy guidance and refinement include: (i) the minimum entomological indicators that control

programs should collect, (ii) addressing the perception that IRS is more effective than LLINs and (iii) speeding up the process of getting products to market and registered in country.

#### *Discussion*

It was queried how the new UNITAD and IVCC program will build on existing country capacity. The program welcomes the inclusion of VCWG partners and WHO.

#### ***MESA malERA Refresh and vector control themes – Janet Hemingway, Liverpool School of Tropical Medicine, UK and Fredros Okumu, Ifakara Health Institute, Tanzania***

The Malaria Eradication Scientific Alliance (MESA)'s malERA Refresh programme is updating the malaria eradication research and development (R&D) agenda that was first published in 2011. The overarching goal is to update the multi-disciplinary R&D agenda for malaria elimination and eradication, which can be acted upon by the malaria community, scientific community and funders. Coordinated by MESA, there are six expert panels with more than 150 international experts: basic science and enabling technologies; insecticide and drug resistance; tools for elimination; combining interventions and modelling; health systems and policy research; characterising the reservoir and measuring transmission. A publication is expected in 2016. The process has been made as transparent and inclusive as possible. An update on the 'tools for elimination' panel was given. In the past 5-6 years, we have made progress in a number of areas including understanding the contributions of LLINs to the reduction of the malaria burden, improvements in transgenesis and para-transgenesis, new complementary new vector control interventions in development and spatial repellents showing demonstrable protection. Remaining gaps include residual transmission not being adequately measured, the narrow diversity and range of active ingredients (AIs) and unclear pathways to market, no efficient application technologies to effectively use new AIs, gaps in our understanding of behavioural resistance, a limited understanding of the epidemiological impact of insecticide resistance, no sufficiently sensitive or scalable tools for measuring vector densities and transmission across settings and a lack of standardised methods for evaluating new vector control tools.

With regards to insecticide resistance, progress has been made in the documentation of multiple resistant populations, a database on insecticide resistance in malaria vectors, an improved understanding of mechanisms of insecticide resistance and characterised collections of resistant mosquito populations. Ongoing research is documented in the MESA Track database; there are currently 162 projects ongoing relevant to malaria elimination and vector control and 44 projects relevant to insecticide resistance.

#### *Discussion*

It was queried why industry was not represented in the tools for elimination panel. It was clarified that the Insecticide Resistance Action Committee (IRAC) was the mechanism for this.

#### ***Announcement of new work streams: Way forward, realigning the work streams, priorities to be addressed – Gerhard Hesse, RBM-VCWG/Bayer SAS, France***

The restructuring of the VCWG was driven by external factors (e.g. wider restructuring of RBM) as well as internal challenges such as the need to more effectively support countries and to facilitate global policy implementation in conjunction with WHO, the Malaria Policy Advisory Committee

(MPAC), Vector Control Advisory Group (VCAG) and Vector Control Technical Experts Group (VCTEG). Reducing the work streams was first discussed at the 10<sup>th</sup> annual VCWG meeting, with the aim of making them more manageable and enabling broader participation. A small working team proposed reduction from nine to five work streams: *Intervention delivery, integration and capacity strengthening* (led by Michael Macdonald, Christian Lengeler); *IRS / IRM priorities* (Dereje Dengela, Mark Hoppé); *Housing and malaria* (Steve Lindsay, Mariana Stephens); *New challenges, new tools in vector control* (Mike Reddy, Fredros Okumu); *LLIN priorities* (Hannah Koenker, Lena Lorenz). Titles may change based on feedback from individual work streams. The system of two co-chairs for each work stream has been retained with a mix of existing and new co-chairs. Kick off meetings should prepare: (i) priorities, (ii) activities for the next 3-5 years, (iii) work plans, (iv) a list of potential deliveries, (v) delegation of activities/responsibilities, (vi) outline budgets (if needed) and potential sources of funding.

#### *Discussion*

It was queried where LSM will fit in the new structure. It is not a new tool and has not been explicitly discussed. There will be a discussion in '*New challenges, new tools in vector control*' on how this can be included and on whether an additional work stream is needed.

#### ***Feedback from the Regional Networks***

##### ***Asia Pacific Malaria Elimination Network (APMEN) – Moh Seng Chang, University Malaysia Sarawak, Malaysia***

APMEN has 18 country partners and 37 partner institutions. The four objectives are (i) advocacy and leadership, (ii) building the evidence base, (iii) capacity building and (iv) knowledge exchange for malaria elimination. There are three working groups which meet annually, including a Vector Control Working Group. The objectives of the APMEN-VCWG are to advocate for the level of vector control capacity at regional and country level required to attain and maintain malaria elimination and to stimulate and where possible to coordinate operational research on vector control. Capacity building activities include three inaugural APMEN fellowships awarded in 2016, supported attendance at IVM training in Malaysia in 2015, and co-funding of the Vector Control in Elimination Settings training in 2016. An annual meeting was held in Kuala Lumpur, January 2015, co-hosted by the Ministry of Health, Malaysia. Recent outputs include publications, pocket *Anopheles* keys and an inventory on guidance for larviciding in malaria elimination settings. Challenges to malaria control in the Asia Pacific include the complexity of vector ecology and malaria epidemiology, artemisinin resistance, mobile and migrant populations, the potential problem of pyrethroid resistance and outdoor residual transmission.

##### ***Pakistan-Islamic Republic of Iran-Afghanistan Malaria Network (PIAM-Net) – Ahmad Raeisi, Ministry of Health, Iran***

Malaria remains an important public health problem in Pakistan and Afghanistan, with 4.5 million reported clinical cases in Pakistan and 83,920 confirmed clinical cases in Afghanistan in 2014. However, in Iran there were only 147 autochthonous cases in 2015. Recent capacity building activities in the region included a 2014 sub-regional training course in IVM for Pakistan and Afghanistan organised in Islamabad by WHO. In Pakistan, three country programs are ongoing to

characterise vivax transmission. Major challenges in Pakistan include political instability, restriction of free movement of sub-national staff for cross-border support, resource constraints and a high turnover of programme management staff. In Afghanistan, challenges to effective malaria control include security, uncontrolled border movement, lack of financial support and a poor knowledge of malaria among communities. Progress has been made in cross-border collaboration between Iran, Pakistan and Afghanistan.

***Pan African Mosquito Control Association (PAMCA) – Charles Mbogo, Kenya Medical Research Institute, Kenya***

PAMCA is a non-profit professional association founded in 2009 and now with over 100 members from 27 countries. The second annual conference was held in 2015 in Dar es Salaam, Tanzania with the theme of emerging mosquito-borne disease in sub-Saharan Africa. Over 130 scientists from 18 African countries and seven countries outside Africa attended and there were 44 oral and 46 poster presentations. Most were focused on malaria. One symposium addressed larvicide application, where it was concluded that advanced larvicide application technologies developed in Asia, Europe and the USA might improve the effectiveness of LSM for malaria vector control in Africa. The number of countries using LSM is steadily increasing, partly in response to insecticide resistance and the recognition that outdoor transmission may impede progress. Several well-established urban malaria control programs in Africa exist and the costs of larviciding are comparable to LLINs and IRS. A one day workshop was additionally held to discuss how to develop partnerships with other organizations including the African Union and other mosquito control associations and to develop a five year strategic plan. The 3<sup>rd</sup> annual conference will be held 6<sup>th</sup>-9<sup>th</sup> September 2016 in Lagos, Nigeria, led by the Nigerian chapter of PAMCA (Dr Sam Awolola). The PAMCA website is [www.pamca.org](http://www.pamca.org) and the contact email is [info@pamca.org](mailto:info@pamca.org).

**1<sup>st</sup> Integrated Vector Management, Evidence and Capacity Work Stream meeting**  
**15.00-18.00, Wednesday 3<sup>rd</sup> February 2016**  
**Moevenpick Hotel, Rue de Pré Bois, Geneva**

**Chairs: Christian Lengeler and Michael Macdonald**  
**Rapporteur: Lucy Tusting**

***Introduction to the work stream – Christian Lengeler, Swiss TPH, Switzerland***

This new work stream combines the former *Optimizing Evidence for Vector Control Interventions* and *Entomological Monitoring and Integrated Vector Management (IVM)* work streams. The overall aim is to generate evidence to promote the effective delivery and integration of vector control interventions and to support related country capacity strengthening. The work stream will not cover areas to be addressed by other work streams including IRS as a standalone intervention, insecticide resistance or new insecticides, housing and socioeconomic development as malaria interventions, multi-sectoral collaboration, new tools in vector control such as ATSBs, ivermectin and repellents, or LLIN-related issues (new nets, durability, delivery, markets). Likewise the overlap with LSM will be more on evaluation frameworks rather than LSM implementation itself.

## **Case studies**

### ***Role of political commitment, inter-sectoral collaboration and community involvement in malaria elimination achievements in the Islamic Republic of Iran – Ahmad Raeisi, Ministry of Health, Iran***

Malaria transmission has declined in recent years in Iran. A national strategic plan for malaria elimination was approved by the High Council for Health in 2010. The responsibility for malaria elimination lies not only with the Ministry of Health but is a broader government program. Inter-sectoral collaboration is evidenced by the Minister of Energy agreeing to prioritise the electrification of malaria endemic areas in three south-east provinces, for example. Community education and involvement is a priority in agricultural areas and to enable *Bti* distribution by communities.

#### ***Discussion***

It is impressive that collaboration between universities and the government has been successful as has multisectoral collaboration. Advocacy to other government departments has emphasised the role of malaria control in reducing poverty as one of the primary drivers of government commitment, among other potential benefits. It was queried what the total budget for the programme is 20% of the cost is supported by the Global Fund and 80% domestically.

### ***Prospects and entomological challenges for malaria elimination in Latin America – Martha Quinones, World Health Organization, Switzerland***

Most malaria transmission in Latin America occurs in the north. Major progress has been made in controlling malaria in recent years with the exception of Haiti, Guyana and Venezuela. For example, malaria has been controlled successfully in Colombia using LLINs and IRS and prompt and effective diagnosis and treatment. The Latin America International Centres of Excellence for Malaria Research (ICEMR) 2000-2017 is being led by the Caucesco Scientific Research Center, Colombia with research ongoing in Colombia, Guatemala, Panama and Peru.

<http://www.niaid.nih.gov/labsandresources/resources/icemr/centers/Pages/latinamerica.aspx>

The study aims to understand the basic biology of malaria vectors and transmission. Seventeen vector species have been confirmed and four new species identified. Most are outdoor and early-evening biting. Since Larval Source Management (LSM) has been used in Mexico among other locations with some success, larval habitats have also been characterised. Most larval habitats are manmade, including fish ponds and wells. Challenges to malaria control in the region are the new species to describe and study, early and outdoor human vector contact, the need for supplementary control measures and the need for entomologists to address other vector-borne diseases including Zika, chikungunya and dengue. Insecticide resistance has to date not been a major problem in the region.

#### ***Discussion***

Latin America has been the forerunner for the elimination of other diseases (e.g. polio); other regions can learn from its approach. The status of malaria control in Venezuela was queried; unfortunately the situation has worsened especially in the Amazon region bordering Brazil. An important point for the VCWG to note is that while LSM is ongoing in some countries it is poorly evaluated.



***The role of vector identification – Dan Strickman, Bill and Melinda Gates Foundation, USA***

Identification changes assumptions into knowledge for (i) risk assessment, (ii) targeting of control efforts and (iii) evaluation. The main elements to characterise for risk assessment are the spatial, seasonal and diel (biting, oviposition, sugar feeding, humidity seeking) distribution of all stages of the insect and vectorial capacity. A case example of Honduras was given. For targeting, vector identification is important to direct control efforts where they are needed e.g. larval habitats for treatment, priority homes for IRS, priority areas for space sprays and the timing for each. For evaluation, vector identification is important to be able to correct failed control efforts and to provide a historical record to justify resources and to understand the changing dynamics of transmission.

***Discussion***

Vector ecology is considered central to mosquito control programs in the developed world and this approach could be transferred to other settings.

***Design and conduct of vector control field trials – Anne Wilson, Durham University, UK***

Vector control intervention development follows a stepwise process from Phase I (including lab assays), Phase II (semi-field and small-scale field trials), Phase III (epidemiological field trials) to Phase IV (implementation pilots). Common problems with vector control studies include non-randomised studies, no or poor control groups, no blinding, short follow-up duration, no sample size calculation, an overreliance on entomological outcomes (rather than epidemiological outcomes) and contamination/spillover effects. Randomised controlled trials are the gold standard. Important study design considerations include the choice of control group, quality assurance of the intervention, appropriate choice of outcomes, standardised measurement of outcomes, the need for sample size calculations even for studies with only entomological outcomes, randomisation, blinding and the choice of appropriate data analysis methods. Key principals to apply to monitoring and evaluation (M&E) of vector control programmes include making sure there is a control group, considering other factors that might be affecting results and quality assurance of interventions.

***Discussion***

It is important to consider how vector species determines the effectiveness of interventions in different settings. Interventions are expensive so money spent on evaluation is well spent.

***Integrated Vector Management (IVM) Manual status update – Steve Lindsay, Durham University, UK***

IVM is a rational decision-making process for optimal use of resources for vector control. World Health Organization (WHO) recommendations on IVM were first outlined in the Global Strategic Framework for Integrated Vector Management in 2004. The new IVM manuals are targeted at program managers at national and first administration levels. Separate toolkits for Sub-Saharan Africa (SSA), Latin America and Asia are being produced and these provide a complete framework for planning and implementation including: (i) disease situation, (ii) selection of vector control methods, (iii) needs and resources, (iv) implementation and (v) M&E. The development process has been collaborative, with contributions from vector control experts, programme managers, the WHO including its Eastern Mediterranean Regional Office, and the Pan American Health Organization, in addition to expert WHO review. The SSA toolkit will be published in Q1 2016. Ideally these manuals

would be translated into a web-based toolkit. An IVM operational manual for India is also in development to assist the National Vector Borne Disease Control Programme, which will be presented to the Prime Minister in February 2016.

***Technical assistance and capacity building for entomology and vector control – Leonard Ortega, World Health Organization, Switzerland***

Despite major progress in global malaria control, there remains much to achieve. Resolution WHA68.2 on the Global Technical Strategy (GTS) calls upon WHO's international partners to mobilise sufficient and predictable funding, to support knowledge generation, research and innovation and to harmonize and integrate the provision of support to national malaria programmes. Key areas for technical support include strengthening of entomological surveillance, insecticide resistance monitoring, malaria program review and situation analysis, updating of national strategic plans, stratification of risk, micro-planning and field operations for malaria vector control, training in entomology and vector control and operational research.

*Discussion*

- Much entomology teaching material is now out of date; bringing together samples from different members of the VCWG would be valuable. Old taxonomy documents also need to be updated and made electronic/interactive.
- The global malaria community should be consulted in developing new manuals and taxonomic keys. MalariaWorld is a good forum for dissemination ([www.malariaworld.org](http://www.malariaworld.org)).
- Capacity building is becoming a buzz word and talked about extensively but 'we know how to do it, we have the money to do it and we should get on with it'. It is important to remember that in many countries there is no entomology capacity and training is a serious issue.
- The name of the work stream does not include monitoring and evaluation. IVM provides a structure within which all the elements of this work stream can be framed.

***Work plan discussion – led by Christian Lengeler and Michael Macdonald***

Comments were invited on the proposed scope of the work stream (to generate and share evidence on effective and efficient deployment of existing and new vector control interventions, to generate and share evidence on integration of all vector control tools and to work with all RBM partners to build entomology and vector control capacity in endemic countries. An updated scope will be circulated for comment.

- There should be a move away from vector control interventions towards vector control practices/programmes as a whole.
- Many elements of multisectoral collaboration go beyond housing and these should be included in this work stream.
- While some countries do have extensive malaria-specific knowledge, we can learn from other disease elimination programmes such as guinea worm eradication.
- Capacity building does not only include program managers but also field staff.

*Proposed SMART actions, stakeholders and potential funding:*

1. Explore the potential of an internet based repository (e.g. VecNet database [www.vecnet.org](http://www.vecnet.org)) and mobile technology to make reference materials and guides available in the field (e.g. mosquito identification, with mapping).
2. Software or an app for mosquito identification would be useful; collaborate with Witwatersrand University in South Africa, the Walter Reed Biosystematics Unit and the UK National History Museum.
3. Share best practices for mosquito surveillance and vector control.
4. Help to ensure that capacity building funding is included in Global Fund concept notes.
5. Explore geographical information systems and risk mapping capacity (overlap of different vector borne diseases).
6. Translate the GTS into a realistic action plan.
7. Support country coordination (see WHO guidance on capacity building for Public Health Entomology).

### **Discussion – All**

#### *Capacity building:*

- The VCWG has endlessly discussed capacity building. There is a need to identify and fund a group of experts to focus specifically on capacity building. It is imperative to have a cadre of malaria specialists. We need to address not only the international ‘brain drain’ but also internal ‘brain drain’ from NMCPs to non-governmental organisations (NGOs).
- It is unlikely that the Global Fund would support a dedicated regional training program for capacity building, but countries could build a capacity building component into their concept notes.
- A template staff structure for NMCPs could be developed / roles in NMCPs catalogued.
- WHO guidance on capacity building for Public Health Entomology is a great resource. [http://www.who.int/malaria/publications/atoz/who\\_guidance\\_cap\\_building\\_entomology/en/](http://www.who.int/malaria/publications/atoz/who_guidance_cap_building_entomology/en/)
- Good practices done by many countries is not documented e.g. Iran. While the VCWG cannot do this itself it would be good for someone with resources to do so.
- The 2010 Directory of African Institutions with Existing Capacity for Training in Integrated Vector Management (IVM) could be updated and expanded to Asia and South America.

#### *Vector distribution/identification:*

- The US Army has produced many useful resources through the Walter Reed Biosystematics Unit (WRBU), including an app for the *Anopheles* of central America which could be expanded to other regions, the mosquito barcode initiative which has a huge repository of samples that are an excellent training resource; the WRBU Vector Map (sample contributions are always welcome). <http://www.wrbu.org/>
- USB-based software for fungi identification exists (see the Fungicide Resistance Action Committee <http://www.frac.info/publications>).
- Simple tools are needed in the field because lengthy paper-based keys are complicated to use.
- A central repository for species, vector bionomics and resistance would be valuable.
- VecNet is no longer being funded by the Bill and Melinda Gates Foundation.

*Communication and role of the work stream:*

- MalariaWorld is an excellent facility for people to give comments anonymously.
- The LinkedIn Vector Control group is also a good forum.
- The main purpose of the VCWG is to translate policy to practice. Policies could be examined systematically and an implementation plan developed accordingly.

Participants were thanked and the meeting closed.

**Day 2: Thursday 4<sup>th</sup> February**

**3<sup>rd</sup> Housing and Malaria Work Stream meeting  
09.00-12.00, Thursday 4<sup>th</sup> 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 CO<sub>2</sub> dissipation from CO<sub>2</sub> 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/m<sup>2</sup> 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.

**1<sup>st</sup> Indoor Residual Spraying (IRS) and Insecticide Resistance  
Management (IRM) Work Stream Meeting  
09.00-12.00, Thursday 4<sup>th</sup> February 2016  
Moevenpick Hotel, Rue de Pré Bois, Geneva**

**Chairs: Mark Hoppé & Dereje Dengela  
Rapporteur: Lucy Tusting**

***Introduction – Mark Hoppé, Syngenta, Switzerland and Dereje Dengela, Abt Associates, USA***

This work stream combines the previous *Insecticide Resistance* and *Capacity Building for Indoor Residual Spraying (IRS)* work streams. Its aims are to: (i) address major challenges and promote best practice IRS delivery in the context of insecticide resistance management (IRM), with the aim of maximising the long term utility of this vector control tool, and (ii) to promote and support the practical implementation of the Global Plan for Insecticide Resistance Management (GPIRM).

***Feedback from IRM workshops - Janet Hemingway, Liverpool School of Tropical Medicine, UK***

Feedback on two workshops on IRM was given. A meeting in January was co-organised by Janet Hemingway and Mike Reddy of the Bill and Melinda Gates Foundation (BMGF). Major topics in IRM were identified and fourteen experts identified and asked to invite further participants, alongside major funders including BMGF, USAID and the US National Institutes of Health. The aim was to map out major outstanding questions, with an operational focus. The planned output is four papers in *The Lancet Global Health*. A multicountry trial is ongoing but complete data are only available for Sudan; a draft manuscript is being expedited. Interpretation of these data is complicated by the increase in pyrethroid resistance that has occurred over this time period. A switch from pyrethroids to pirimiphos-methyl for IRS in Ghana was associated with a reduction in parasite prevalence, and a similar picture is emerging in other locations. It is critical to examine the economic implications of resistance and to balance the trade-off between coverage and effectiveness. There is much to learn from the agricultural sector and antimicrobial resistance field. A second workshop was convened by ISGlobal, funded by the Biotechnology and Biomedical Sciences Research Council (BBSRC) in the UK which brought together experts working on resistance in different areas (e.g. fungicides, herbicides). A BBSRC funding call will be announced later in 2016. A meeting report will soon be available.

***Review of the interdisciplinary insecticide resistance workshop held at Penn State - Matthew Thomas, Penn State University, USA***



An overview of the interdisciplinary workshop ‘Insights from Agriculture for Insecticide Resistance Management’, held in September 2015 was given. The workshop brought together a combined mix of researchers who think about resistance evolution from diverse perspectives: public health, agriculture (insects and weeds), theoreticians, empiricists, lab, field, industry and policy. The findings were structured around five pillars of the current GPIRM plan (i) IRM strategies, (ii) monitoring, (iii) new tools, (iv) knowledge, (v) enabling mechanisms:

- (i) **IRM strategies:** The greater the exposure to an insecticide the greater the selection pressure for resistance. The most far-reaching approach to address this issue in agriculture has been the development of Integrated Pest Management (IPM) strategies that aim to minimize the reliance on insecticides. The pending resistance crisis for disease vectors creates an urgent need to develop and implement integrated, multi-tactic integrated vector management (IVM) strategies that parallel IPM in agriculture. Numerous studies in agriculture show that IRM strategies that utilize diverse insecticide products over time and space can slow resistance evolution (e.g. rotations, mixtures, mosaics). However, which strategy works best depends strongly on the specifics of the insect genetics, population dynamics and behavior. There is no general rule. There are few theoretical examinations of these strategies for disease vectors and next to no empirical tests. In the absence of this information there is no convincing evidence base for recommending one strategy over another.
- (ii) **Monitoring:** The point of monitoring should be to understand what products or actives can be used, rather than what cannot be used due to loss of susceptibility in the target insects. If assays or markers correlate poorly with operationally relevant outcomes, they provide little insight. Demonstrating the impact of resistance and subsequent value of IRM strategies requires appropriate methods for characterizing resistance. IRM needs better assays.
- (iii) **New tools:** Current target product profiles (TPPs) emphasize persistent products with long decay half-lives. This feature could maximize selection for resistance. Defining outcome-based TPPs (where the outcomes are reducing transmission and slowing selection for resistance) could encourage development of a broader range of vector control products.
- (iv) **Knowledge:** Numerous studies in agriculture demonstrate evolution of insecticide resistance with direct links to crop loss. However, the relationship between vector resistance and disease epidemiology can be complex (probably more so than in agriculture). Development of effective IRM strategies requires better understanding of these relationships.
- (v) **Enabling mechanisms:** We need to consider susceptibility as a ‘public good’ and transition to value-based rather than cost-based products and approaches. Achieving this requires a change in national and international policy and development of appropriate regulation.

In conclusion, the key insights from agriculture are that: (i) the best approach to resistance management is IPM (so we need IVM), (ii) if monitoring is to be useful, it needs to tell us something about functional significance of resistance (current resistance monitoring tells us little); (iii) agriculture manages resistance in part through a product pipeline so we need a better pipeline to support development of new products (with ‘outcome-based’ TPPs); (iv) we need a better

understanding of functional significance of resistance and of the impact of potential IRM strategies (the evidence base for current prescriptions is weak) and (v) we need to accept susceptibility as a public good and consider 'value' and not simply 'cost'.

***The NgenIRS programme - Tom McLean, Innovative Vector Control Consortium, Liverpool, UK***

An introduction to the 'Next generation IRS Project' was given. While long-lasting insecticide treated nets (LLINs), IRS and artemisinin combination therapies have helped to avert 663 million cases of malaria in Africa, 2000-2015 (Bhatt *et al.* 2015, Nature), resistance to all four classes of insecticide available for malaria control is increasingly prevalent across Africa and elsewhere. While the entomological impact is understood, the operational impact harder to assess. Longitudinal data showing a reduction in parasite prevalence in children following a switch from pyrethroid to actellic CS IRS in Bunkpurugu-Yunyoo district, Northern Ghana, an area of high pyrethroid resistance, was shown. While IRS coverage in Africa has fallen overall in Africa since 2010, NgenIRS will address the underlying causes of market shortcomings. The overall goals are (i) to increase the use of third generation IRS products and (ii) a growing market for third generation IRS products without intervention of a co-payment. More information is available at [www.ngenirs.org](http://www.ngenirs.org).

*Discussion*

- It is important to remember that we are not only dealing with pyrethroids but the other three insecticide classes also.
- Strong advocacy for maintaining high coverage of IRS should be integral to the NgenIRS programme. The programme will have a communications officer dedicate to this.
- While modelling is used extensively in other areas (drugs, vaccines), it is often dismissed within vector control. Advocacy of the utility of modelling could be improved.

***Tools for improving the effectiveness of IRS in Pakistan - Muhammad Mukhtar, Directorate of Malaria Control, Pakistan***

A total of 95 million people remained at risk of malaria in Pakistan in 2014, with the greatest incidence along the north western border with Afghanistan. Since the Global Malaria Eradication Programme era of the 1960s, IRS has been a key element of the National Vector Control Strategy. Yet despite high (>80%) coverage of IRS in many areas, there was no significant decline in malaria transmission in these locations during 1985-2006. In 2007 the IRS strategy was revised, focusing on system strengthening & capacity building, better timing of application, promotion of only WHO-recommended products, and the introduction of an epidemic response IRS strategy in 2015 supported by the Global Fund, in addition to the general national IRS strategy. Data on IRS coverage in 2014-2015 were presented. Quality Assurance Protocols and Tools for IRS were developed in 2013-2014, which were approved at the state level in 2015. Work is also underway to strengthen vector surveillance and monitoring and evaluation, to support the National IRM Plan (2015); to improve capacity for IRS at all levels, to promote inter-sectoral coordination and to fix responsibilities among ministries, departments and institutes. Remaining challenges to implementing IRS include the political influence over the selection of target areas, funding shortfalls and delays, authority conflicts and technical and human capacity.

***Summary of pre-meeting feedback – Mark Hoppé***

Pre-meeting feedback was sought on questions relating to implementation of the GPIRM, implementation of IRM within IRS campaigns, limitations to achieving full effectiveness and coverage within IRS campaigns. Consistent themes in the responses were: (i) how to move from insecticide resistance mitigation to management and (ii) how to facilitate or simplify the implementation of best practice IRM. Impediments to implementing IRM include its logistic complexity, questions over costs versus benefits of IRS and IRM and the limited list of effective insecticides to choose from. IRM and IRS need to be managed in the context of IVM and the impact of agricultural use of insecticides explored. Looking forward, the work stream needs to decide how to deliver the greatest impact.

### ***Discussion – All***

- New products and active ingredients are emerging and it is important to consider how to preserve their efficacy when introducing them to the market.
- Feedback from NMCPs on the guidance needed for implementing of GPIRM.
- The previous IRS work stream focused on four areas: (i) research and evidence, (ii) procurement and supply management, (iii) training and supervision and (iv) advocacy for IRS and vector control. This work stream could carry forward some of these.
- It was agreed that IR monitoring is critical. It is possible that IR monitoring could be done with existing resources if done differently. We also need to link with the agricultural sector to understand how resistance is emerging in other areas. However, data alone are useless unless acted upon.
- Looking at the system holistically is important; reductions in malaria parasitaemia achieved by vector control may reduce the selection pressure for artemisinin resistance.
- Many suggestions made in the VCWG discussions are already being worked on by other members of the VCWG. Collating a database of all work ongoing, available resources and acronyms used may be a valuable output for the VCWG. Indeed, a major aim of the VCWG is to bring together a network of VC experts and to disseminate information to this network.
- CropLife has previously collated information from different vector control forums; updating this would be useful. The President's Malaria Initiative has a wealth of resources online, including data on how programme decisions have been made based on IR data.
- Malaria control programmes could be made more cost-effective by combining different streams (e.g. durability monitoring, spray teams) and therefore reducing staff and travel costs.
- IRS quality was discussed; it is important to improve quality assurance and to involve the community in this process.

### ***Priority areas for the work stream:***

1. Effectively communicating the GPIRM.
  - *Next step:* Identify existing initiatives.
2. Producing a living directory of resources (organisations, programmes and individuals involved with IRM/IRS).
  - *Next steps:* Identify all interested parties and produce a directory of IRM/IRS partners.
3. IRM training.
  - *Next steps:* Identify target audience and explore opportunities.

4. IRS capacity building: undertake an audit of key factors limiting the implementation of IRS programme, the analysis of which will identify potential actions for the work stream.
  - *Next steps:* Identify key players, solicit feedback with a structured questionnaire/interview, and identify opportunities to support capacity building.

**1<sup>st</sup> New Challenges, New Tools in Vector Control Work Stream meeting**

**14.30-17.30, Thursday 4<sup>th</sup> February 2016**

**Moevenpick Hotel, Rue de Pré Bois, Geneva**

**Chairs: Fredros Okumu and Mike Reddy**

**Rapporteur: Lucy Tusting**

**Welcome and introduction – Mike Reddy, Bill and Melinda Gates Foundation, USA and Fredros Okumu, Ifakara Health Institute, Tanzania**

This work stream will build on the previous *Outdoor/Residual Transmission* work stream activities which included establishing regional networks, developing guidelines for and estimating the importance of residual transmission and estimating malaria risk in specific populations. Moving forward, the key message is that universal coverage of long-lasting insecticide-treated nets (LLINs) (or indoor residual spraying (IRS)) remains an absolute priority and all other methods are supplementary to reducing malaria and achieving elimination. However, we need to generate local evidence on the magnitude of outdoor/residual transmission and industry and others are encouraged to develop new vector control tools to address residual transmission. We are also increasingly moving towards the evaluation of product classes, not individual products. The Vector Control Advisory Group (VCAG) was developed to review new paradigms.

The need for new tools to address residual/outdoor transmission is being addressed partly by the Bill and Melinda Gates Foundation (BMGF) Grand Challenges Exploration Round 14 (new approaches for addressing outdoor/residual malaria transmission) which funded nine Phase I projects. Promising technologies include spatial repellents, Attractive Toxic Sugar Baits (ATSBs) and gene drive. The previous work stream definition of residual transmission was ‘that which persists after having achieved universal coverage with effective LLIN and or IRS interventions’, but a new definition has been proposed as ‘the complete set of transmission events that continue to occur in communities where primary interventions such as LLINs, IRS, case management and larviciding have already been widely implemented at high coverage, but where new *Plasmodium* infections still occur locally. Residual transmission therefore also refers to all new local malaria transmission events in non-naïve communities’. It is also important to measure residual transmission. The entomological inoculation rate continues to be the gold standard measure of transmission but may need to be rethought. It may also be possible to use environmental covariates to identify high-risk households. Additionally, there remains the challenge of maintaining and expanding entomological capacity.

Larval source management cannot be discounted from the work stream as many historical successes were achieved with this. It may be appropriate to modify the work stream name to encompass LSM.

***Revolutionizing vector control for malaria elimination – Allison Tatarsky, University of California, San Francisco, USA***

The project is situated in the context of ambitious new malaria elimination targets, the opportunity to learn from history, growing threats to current vector control interventions and gaps in the *Anopheles* control approach. Funded by the Parker Foundation, the project is responding to an opportunity to accelerate towards malaria elimination and eradication with innovative and aggressive vector control. The four project aims are to: (i) develop partnerships, (ii) elevate evidence, (iii) inform decision making in country and (iv) demonstrate impact of new tools on the ground. The five main activities within Phase I are: (i) a systematic review of the vector control toolbox, (ii) technical analysis of aerial programs and technologies, (iii) cross-country case studies on mosquito control programs, including delivery systems and tools, in Tanzania, the USA, Australia and Indonesia, (iv) geospatial modelling to improve our understanding of factors influencing transmission patterns in sub-Saharan Africa and modelling of the potential impact of different interventions and (v) a proposal for a Phase II demonstration project in multiple sites to focus on an approach to vector control using integrated delivery and tools, rather than a demonstration of individual tools. Building on recent work (Bhatt *et al.* 2015 *Nature*), estimates of residual transmission have identified areas of higher than and lower than expected transmission given LLIN and other intervention coverage.

***Potential role of ivermectin and ivermectin-like compounds in malaria elimination – Carlos Chaccour, ISGlobal, Spain***

Ivermectin is an endectocide with potential for mass drug administration to complement current vector control interventions. An overview of the mode of action and different possible implementation strategies and formulations was given. For endorsement and regulatory approval, efficacy (see preliminary data from Burkina Faso, Foy *et al.*, ASTMH 2015) and safety (total dose and spacing, current versus new formulation) data would be needed. Additionally, acceptability (by the population and other programmes), cost-effectiveness (current costs, procurement through the Global Fund) and feasibility (production needs, sustainability) evidence is needed for a policy recommendation. The next steps are to (i) generate evidence using the current formulation in different eco-epidemiological scenarios, (ii) start conversations for endorsement of the concept with the World Health Organization (WHO), VCAG and Malaria Policy Advisory Committee (MPAC), (iii) start conversations for regulatory approval (new indication), (iv) define what MPAC would need in order to give a recommendation and (v) start the pre-qualification process.

*Discussion*

- It is important to consider the resistance profile of vectors before using ivermectin.
- Ivermectin may have an effect on *Chrysomya* spp. and reduce fly production in pit latrines.

***Potential and cost-effectiveness of LSM – Silas Majambere, Innovative Vector Control Consortium, UK and Eve Worrall, Liverpool School of Tropical Medicine, UK***

There is considerable evidence that Larval Source Management (LSM) works (Tusting *et al.* 2013 *Cochrane Database*) and it is recommended as a supplementary malaria control intervention in Africa, Asia and South America. A cost analysis of larviciding was done for Dar es Salaam, Tanzania; Vihiga, Kenya and Mbita, Kenya (Worrall and Fillinger 2011 *Malar J*). Cost per person protected ranged from US\$1-3 per year. More recently a cost effectiveness analysis was done for the Urban Malaria Control Programme in Tanzania (Maheu-Giroux and Castro 2014 *Malar J*). In a scenario of

relatively high endemicity (227 cases per 1000 per year) LSM cost US\$16.50 per infection averted and in a lower endemic setting (122 cases per 1000 per year) LSM cost US\$31.20 per infection averted. This compares favourably with the cost-effectiveness of primary vector control interventions (White *et al.* 2011 *Malar J*) (although there are difficulties in comparing the two analyses). The number of countries reporting the use of LSM has increased from 27 in 2011 to 48 in 2014. To understand whether this is good from an economic point of view, it is important to understand how these programmes are being financed. There is an opportunity to gather evidence for/against LSM and to support LSM implementation. Domestic funding for LSM should be encouraged. The recommendations of the WHO LSM Operational Manual should be followed and industry engaged for long-lasting actives. There is considerable innovation in LSM today including improved and new spraying technologies and mapping technology.

#### *Discussion*

- Rather than discussing whether or not there is a role for LSM, it is important to move on and support LSM implementation as best possible. We have three proven interventions: LLINs, IRS and LSM and it is important to preserve LSM. An independent work stream is still needed. The definition of residual transmission of being that which persists after high effective coverage with LLINs, IRS and LSM has been achieved excludes LSM from this work stream.
- LSM is the sole intervention in many locations outside Africa including urban India, where it has been used since 1971 and today in 131 cities.
- It would be useful to give countries simple guidelines to follow to implement LSM; the Operational Manual is a long document.

#### ***Targeted spraying of mosquito swarms for malaria control – Abdoulaye Diabate, Institut de Recherche en Sciences de la Santé, Burkina Faso***

New approaches to vector control can exploit alternative behaviours. Mating behaviour currently remains underexploited. It is known that male mating swarms are consistently found in the same location. Pilot work in Vallée du Kou, Burkina Faso has mapped the spatial distribution of swarms and there is clear evidence of clustering, the pattern of which is relatively stable over time. It is not yet known why mosquitoes swarm in particular locations. Swarm collection has been conducted in Sudan, The Gambia and Mali which indicates that swarming behaviour is relatively consistent across different settings and that male swarming behaviour can be manipulated. Targeting swarms is being investigated as a potential means to reduce overall mosquito population density.

#### *Discussion*

It was queried whether elimination of one part of a swarm will cause it to re-form elsewhere. It seems that mosquitoes use visual cues and that swarms will return to the same location. It was queried whether targeting swarms could be applied to *Anopheles arabiensis*. Pilot data indicates that behaviour is relatively similar across species and that through the seasons, different species may inherit the same site.

#### ***Broadening vector control targets for malaria elimination – Matt Thomas, Penn State University, USA***

Data on seasonal malaria transmission patterns and vector densities from Orissa, India were presented. Genetic analyses of species complexes and blood meal analyses indicate a shift to a more zoophilic subspecies which helps to explain the loss of the classic malaria peak in November to January. This species shift mirrors the shift from *An. gambiae* to *An. arabiensis* in parts of Africa. In Orissa today, transmission is thus dominated by *An. culicifacies* and *An. fluviatilis*, both predominantly zoophilic, with higher densities found in cattle sheds than human homes. Modelling of malaria transmission has explored the potential impact of using IRS in cattle sheds in addition to human homes. This indicates that the use of IRS or LLINs in domestic dwellings is not sufficient to reduce transmission below the elimination threshold, even at maximal coverage. Yet the extension of IRS to attack the zoophilic cycle could more transmission towards the tipping point. Funding from the National Institute of Allergy and Infectious Diseases as part of the International Center of Excellence for Malaria Research (ICEMR) program was acknowledged.

***Attractive toxic sugar baits (ATSB): from basic science to product – a new paradigm for vector control – Günter Müller, Hebrew University, Israel***

Both male and female mosquitoes require plant sugar feeding for survival. Location of sugar sources is guided by chemical attractants. The concept behind ATSBs is that once attracted, mosquitoes feed and are exposed to a low level dose of insecticide within the bait. Since ATSB competes directly with natural sugar sources, the quality of the attractant is crucial. Initially, non-attractive toxic sugar baits were applied to highly attractive flowers. While effective at controlling mosquitoes, this is not environmentally sustainable or scalable. Subsequently, extracts of highly attractive fruits and flowers was formulated with a toxin to spray on vegetation. Since these formulations can be washed away by rainfall, a long process of development has been undertaken to develop viable commercial products that fulfil various criteria. These criteria include: readily available ingredients for production, being able to be produced on industrial scale, being easily applied in different environments, having a high bait stability under severe environmental conditions, being potentially combinable with a variety of pesticides and having minimum impact on non-target organisms. Different products have been developed for *Aedes* and *Culex* in developed countries and vector control in Africa. Early trials in Mali demonstrate that 90% *Anopheles gambiae* population reduction could be achieved using both spray and bait stations. Ongoing field trials in southern Mali funded by IVCC and the BMGF Grand Challenges are testing commercially viable bait stations for indoor and outdoor control of *Anopheles*. Products for the US market targeting container-breeding *Aedes* have also been developed.

***Discussion – All***

***The way forward:***

- ***Product/intervention development:*** The IVCC published a framework for the rapid assessment of new vector control tools (VCTs) (Vontas *et al.* 2014 *Trends Parasitol*) and we should explore how the work stream can disseminate information to innovators on the pathways to approval. It is critical to have a route to market that is clear and concise, with recognised hurdles that can be anticipated. It would be helpful to document previous and ongoing experiences of product developers and to document the pathway to approval. The work stream should serve as a forum to develop enquiries on the I2I process.
- ***Implementation of new VCTs:*** We should be clear where and when new tools are appropriate. Position statements on new paradigms may be helpful. It would be good to

consider costing, cost-effectiveness and how to finance new or supplementary interventions. An element of 'learning by doing' could be valuable and the work stream could guide countries in Phase IV evaluations.

- Consolidating evidence on new challenges and new tools should be a key objective.
- It is not only important to develop new tools but also new methods to measure transmission.
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**1<sup>st</sup> LLIN Priorities Work Stream Meeting**  
**14.30-17.30, Thursday 4<sup>th</sup> February 2016**  
**Moevenpick Hotel, Rue de Pré Bois, Geneva**

**Chairs: Hannah Koenker & Lena Lorenz**

**Rapporteur: Lucy Tusting**

***Introduction - Hannah Koenker, Johns Hopkins University Center for Communication Programs, USA and Lena Lorenz, London School of Hygiene & Tropical Medicine, UK***

The goal of the work stream is to maintain high levels of ownership and use of serviceable long-lasting insecticide-treated bednets (LLINs) in endemic countries by focusing on (i) distribution approaches, (ii) LLIN durability and (iii) new and next generation LLINs. Completed 2015 outputs from the *Continuous Distribution of LLINs in the Field* and *Durability of LLINs* work streams include: (i) defining best practices for measuring LLIN durability and (ii) producing tools for national malaria control programmes (NMCPs) that wish to start monitoring durability (including a guidance note on operationalizing durability monitoring in the field for malaria programs to monitor field performance and plan LLIN distributions; tools to collect and use durability data; capacity building training modules/a manual on durability monitoring). Ongoing activities from the *Continuous Distribution* work stream are to: (iii) compare the economic costs of different continuous distribution mechanisms, (iv) identify next steps and research for developing a private sector role/market, (v) understand how to optimize distribution systems over the long term, (vi) publish evidence from continuous distribution pilots and (vii) feed into Harmonization Working Group (HWG) technical guidance to ensure best practices. Ongoing activities from the *Durability* work stream are to: (viii) validate the resistance-to-damage score to inform net replacement decisions, (ix) establish an online repository of durability data for scientific and operational exchange and (x) articulate the link between insecticide resistance and durability issues; these need to be looked at together, especially as resistance grows.

Other important topics include net preferences and implications for procurement (Vector Control Technical Expert Group paper requested), identifying behavioural challenges with nets, improving bed net purchase and usage experience, innovation for more durable LLINs, preparing for effective deployment of new and next generation nets, sharing updates, ensuring partners remain coordinated, identifying key issues requiring normative World Health Organization (WHO) guidance and contributing to their development.

***LLIN market analysis in Kenya - Anne Musuva, Population Services Kenya, Kenya***



This bednet market analysis aimed to understand the scope of the total bed net market (both public and private sectors) and to determine the capacity of and barriers to private sector expansion of the LLIN market and potentially engage in keep-up strategies with the public sector. During April to September 2015, 23 key informant interviews were done with donors, manufacturers (both local and international), importers, regulators and the Ministry of Health. A retail outlet survey was done in all four zones using a semi-structured format to approach 1610 outlets. A stakeholder workshop was conducted also. The study found that the NMCP was the main body responsible for policy and regulation. Overall, mass nets accounted for a 53% share of the market, free routine nets for 31%, social marketing for 9% and commercial nets for 7%. There are 64 net brands in the Kenyan market with 3 LLIN brands. 33.5% of retailers cannot differentiate between LLINs and untreated nets. Retail perceptions and challenges in the commercial sector were discussed. Recommendations are to explore more sustainable approaches to universal coverage, to increase ownership and sustainability, to better target free nets/subsidies through a total market approach, to expand social marketing and to introduce a mid-tier priced LLIN. Additionally, a public-private partnership could aid communication efforts to differentiate LLINs and drive their use, local manufacturers could be engaged to start phasing out untreated nets, particularly in endemic areas and the government could relax the regulation of treated netting imports.

***How can continuous distribution demonstrate value for money? - Albert Kilian, Tropical Health LLP, Spain***

Mass campaigns have been essential to reach current levels of success. Current WHO guidance mentions a long-term shift to continuous distributions, but there is no particular emphasis on this. In practical terms, most countries use mass campaigns with continuous distribution through antenatal clinics (ANC) and the extended programme of immunisation (EPI). Yet as universal coverage is reached and campaigns are repeated, the system becomes inefficient and poor value for money. Using NetCALC it has been estimated that continuous distribution would save 18-25% of the total annual cost of mass distribution in sub-Saharan Africa. It was recently estimated that 21% of ITNs were over-allocated in 2013 (Bhatt *et al.* 2015 eLife). Distribution strategies should reduce waste by better targeting LLINs where needed, filling gaps without oversupply and responding to varying net survival. Countries need to be guided in implementation with a stronger emphasis on more efficient and reactive systems.

***Discussion***

- It was queried whether mass campaigns should be discontinued or whether longer cycles should be introduced. It was clarified that a system that combines both continuous and mass distribution is not optimal and that we need a system that is more flexible overall and that relies only on continuous distribution in certain areas.
- There is a gap between policy and practice in continuous distribution; research by Katherine Theiss Nyland is examining why the policy of distribution through ANC and EPI is not done in many settings.
- We have the technology to manufacture long-lasting netting materials in local factories.

***LLIN durability monitoring toolkit - Hannah Koenker, Johns Hopkins University Center for Communication Programs, USA and John Gimnig, Centers for Disease Control and Prevention, USA***

WHO Pesticide Evaluation Scheme (WHOPES) guidelines on durability monitoring were published in 2011 and the President's Malaria Initiative (PMI) has supported monitoring in eight countries since 2008/2009. A pooled analysis based on existing data is currently ongoing. PMI contracted VectorWorks to develop a toolkit for ITN durability monitoring under PMI, incorporating lessons learned. The rationale was that net durability has been studied using a variety of study designs but it is important to standardize the approach for cross-comparability and simplicity. Durability monitoring allows PMI and others to identify places and/or products that perform under expectations. The toolkit is not for selecting specific nets.

The toolkit contains a Q&A on how to carry out durability monitoring; a durability monitoring guideline; data collection instruments including a template protocol, survey questionnaire, consent and recruitment scripts; field worker training manuals; guides for data cleaning and analysis and report templates. Data to be collected include: (i) the number and brand of nets examined, by years in the field, (ii) the number of nets not found, percent survivorship or attrition, disaggregated by reason for loss, (iii) years (or months) since distribution, (iv) size and number of holes (by WHO hole size category), and location if laboratory analysis is performed and (v) data on household use, care and repair attitudes and behavior and socioeconomic position. Outcome measures include: (i) total estimated area of damage and proportional hole index for each individual net, (ii) proportion of surviving nets in serviceable condition as defined in WHO/Malaria Policy Advisory Committee (MPAC) guidance, (iii) estimated survival at each time point combining attrition and integrity as defined in MPAC guidance, (iv) graph of survival estimates against hypothetical survival curves using the tool provided by the *Durability* work stream, (v) estimation of median LLIN survival if more than two data points with survival <85% are available. Study design considerations and follow-up strategy were outlined. The next steps are to coordinate support for countries carrying out durability monitoring and to further develop the [www.durabilitymonitoring.org](http://www.durabilitymonitoring.org) toolkit.

***Effects and costs of switching from standard to PBO LLINs - Thomas Churcher, Imperial College London, UK and Eve Worrall, Liverpool School of Tropical Medicine, UK***

*PBO LLINs are treated with both a pyrethroid and piperonyl butoxide (PBO).* WHO released guidelines on PBO LLINs in December 2015. Work to estimate the effects and costs of switching from standard to PBO LLINs was presented. First, a meta-analysis was done of all experimental hut trials where mosquito mortality was simultaneously assessed using a bioassay. This indicated that bioassays may be a useful tool for programmatic monitoring of resistance. A second meta-analysis of experimental hut trials comparing pyrethroid-induced mortality with and without PBO nets indicated that for *Anopheles gambiae* there is an added benefit of adding PBO as pyrethroid resistance increases, but not at very high levels of resistance; whereas there is no overall benefit for *An. funestus*. Finally, a meta-analysis was done of experimental hut trials that directly compared a standard LLIN with a PBO LLIN (either Olyset vs Olyset Plus or PermaNet 2.0 vs PermaNet 3.0). Mortality roughly matched what was predicted from the bioassay data. Building on the model outlined in Griffin *et al.* 2010, the epidemiological impact of switching to PBO LLINs has been modelled. While PBO LLINs appear to have an increased efficacy in certain settings, at this point the evidence is too limited to justify a complete switch from pyrethroid-only LLINs to PBO LLINs across all settings. To build the evidence base to support accelerated deployment of PBO LLINs, pilot 'explanatory' implementation is necessary. However, this should only be undertaken in areas where malaria prevalence in children aged 2-10 years exceeds 20% and mosquito mortality in bioassays

with pyrethroids is <80%. Pilot implementation should not be undertaken unless accompanied by robust evaluation.

With regards to costs, the WHO recommendation highlighted that PBO nets are likely to cost more than standard LLINs and that this must not undermine universal coverage with vector control. UNICEF data from 2010-2015 shows that PBO nets are more expensive than standard LLINs. Standard LLIN prices have fallen by 53% (in real terms) since 2010, while PBO prices have fallen by 15%, so the price differential has increased. To consider what this price differential means for LLIN coverage, a simple model has been built, using costs of LLIN distribution from the White *et al.* systematic review of the cost-effectiveness of malaria control interventions. This simple model shows that commodity price alone does not predict the extent of coverage loss; it is necessary to know the ratio of commodity to other costs within the programme. The greater the percentage of total cost that is accounted for by commodities (i.e. LLINs), the greater the coverage loss will be. This model shows that coverage loss increases as the price differential increases. To estimate the epidemiological impact, work is underway using a transmission dynamics model to identify the number of cases averted with each type of net at different coverage levels under different endemicity and resistance scenarios.

#### *Discussion*

- There was extensive discussion over the potential role of PBO LLINs and the need for their appropriate evaluation.
- It was clarified that prevalence, LLIN coverage data and level of resistance measured by a bioassay are the three criteria needed to assess whether there will be an additional benefit of PBO LLINs.
- Investment in monitoring and evaluation will be increasingly critical as new tools enter the market. Recommendations are needed to establish how such evaluations should be funded, whether via ongoing programme monitoring or at the research level.
- Durability monitoring guidance needs to be collated and easily accessible by NMCPs.
- It is increasingly difficult for manufacturers to keep innovating and manufacturing LLINs and policy makers, academics and NMCPs need to be aware of the risk of losing suppliers.
- The discussion highlighted the importance of maintaining durability of LLINs in the field and distributing LLINs more efficiently, in order to translate the savings made into new products where needed.

#### ***Next steps for the work stream:***

1. Assemble all durability guidelines together and recommend updates to durability guidelines as the science develops, including data on care and repair.
2. Work with the Alliance for Malaria Prevention (AMP) to identify LLIN distribution options for low-transmission urban areas.
3. Create maps combining insecticide resistance and prevalence data to inform distribution strategies e.g. to identify areas for PBO LLIN piloting.
4. Provide a decision framework for new LLINs to communicate simply the evidence and recommendations to national program managers.

5. Lay out a clear series of steps are needed to move forward with new LLINs, including description of the minimum data requirements; ensure common understanding of constraints and processes.
6. Identify monitoring and evaluation needs for new LLINs once they are rolled out, including monitoring physical durability, bioefficacy and epidemiological outcomes.
7. Function as a forum to share information and results:
  - Share results of evaluations (including costing) of large-scale continuous distribution.
  - Provide updates on I2I work on the LLIN qualification process.
  - Share results of inter-lab validation of resistance-to-damage scores and make this resource available via the durability toolkit.
  - Share results of work on preferences for LLIN types (post VCTEG).
  - Provide updates on ongoing work on mosquito net fishing and its effects on aquatic life and livelihoods and other net misuse.

### Day 3: Friday 5<sup>th</sup> February

#### Session 3: Feedback from the work stream meetings

Chairperson: Jacob Williams

#### **1<sup>st</sup> Integrated vector management, evidence and capacity work stream meeting – Michael Macdonald, World Health Organization, Cambodia**

The scope of the work stream was summarised as follows: (i) to generate and share evidence on *effective* and *efficient* deployment of prior, existing and new vector control interventions and practices including management, monitoring and evaluation; (ii) to generate and share evidence on the integration of all vector control tools, including lessons from other regions and disease eradication programs and (iii) to work with WHO and all RBM partners to build entomology and vector control capacity at all levels in endemic countries.

#### *Priority areas for the work stream:*

1. Mosquito identification:
  - a. Disseminate improved morphological keys, including electronic applications.
  - b. Facilitate collaboration with national reference centers for molecular identification.
2. Surveillance, evaluation and mapping:
  - a. Best practices for a basic entomological monitoring package.
  - b. With the Monitoring and Evaluation Reference Group (MERG), work towards:
    - i. Including entomology in surveillance and outbreak investigation.
    - ii. Producing an evaluation tool kit.
    - iii. Developing capacity for geographical information systems and vector mapping.
3. Capacity:
  - c. With the RBM Harmonization Working Group (HWG), include entomology capacity component in country concept notes to the Global Fund.
  - d. Collaborate with GMP technical assistance.
  - e. Link with national and regional institutions.
4. Document dissemination:

- f. Support regional IVM toolkits and field trial design guidelines.
- g. Repository for training materials, sharing best practices.
- 5. University linkage for capacity building and reference laboratory services:
  - h. Update and expand the 2010 Directory of African Institutions with Existing Capacity for Training in Integrated Vector Management curated by Clifford Mutero.
  - i. Explore other mechanisms with the WHO Special Programme for Research and Training in Tropical Diseases (TDR), WHO or the National Institutes of Health to re-invigorate the African Network on Vector Resistance model.

### **Discussion – All**

#### *Capacity building:*

- It is important that universities provide the necessary training for junior scientists to specialise in medical entomology and that there is a clear career path for junior entomologists.
- Universities in malaria-endemic countries should be better engaged and this can be achieved through networks such as PAMCA.
- Capacity building could be better supported within the VCWG if separated out from interventions within the work stream structure.
- For several years, TDR has been supporting approximately five regional training centres and seven universities for capacity building, but this support does not cover entomological training; rather it is more for overall university finance, structure and support. A structured entomological proposal could be useful to TDR to guide their efforts. In March 2016 TDR is organising a meeting in Lisbon to provide a forum for those running courses in entomology to meet and discuss.
- TDR can also help guide how universities can more closely link with NMCPs. Sudan is an excellent example of this. Two centres of training offer entomological training courses as does the University of Khartoum. Courses are also organised for people from West and Central Africa which include molecular species identification, field trips, etc. There is clear career progression thereafter as graduates are recruited into the NMCP.

#### *Monitoring and evaluation:*

- Monitoring and evaluation (M&E) should be more carefully focused in-country.
- M&E is critical outside the academic/research sphere to improve the availability of data on products and the effect of different interventions, which is needed to guide product choice and Global Fund decisions. It may be necessary to have a separate work stream to address the financing for this type of M&E and to adequately support NMCPs.
- There is a US\$6 billion dollar deficit for global malaria control. There is a critical need for better program targeting to reduce overall costs. Entomological surveillance has a real economic benefit in supporting such targeting.

#### *Work stream scope:*

- There is a risk that we may lose the momentum that we have worked hard to build behind IVM and LSM. This work stream encompasses all the principles of IVM and the name should reflect this. Similarly LSM also risks being buried if its own work stream is not preserved.

- It was agreed to rename the work stream as ‘Integrated Vector Management, Evidence and Capacity’.
- Within each of the priority areas for the work plan, there are interested individuals who are well positioned to champion these.
- It is important to support entomological monitoring to better guide programme strategy.

### **1<sup>st</sup> IRS IRM priorities work stream meeting - Mark Hoppé, Syngenta, Switzerland**

The IRS IRM work stream combines the previous insecticide resistance and capacity building for IRS work streams. Two overarching priority themes were identified in the meeting: (i) advocacy for the issue of insecticide resistance management and (ii) the need to conduct insecticide resistance management within the context of integrated vector management.

#### *Priority areas for the work stream:*

1. Effectively communicating the GPIRM.
  - *Next step:* Identify existing initiatives.
2. Producing a living directory of resources (organisations, programmes and individuals involved with IRM/IRS).
  - *Next steps:* Identify all interested parties and produce a directory of IRM/IRS partners.
3. IRM training.
  - *Next steps:* Identify target audience and explore opportunities.
4. IRS capacity building: undertake an audit of key factors limiting the implementation of IRS programme, the analysis of which will identify potential actions for the work stream.
  - *Next steps:* Identify key players, solicit feedback with a structured questionnaire/interview, and identify opportunities to support capacity building.

#### **Discussion – All**

- *Training materials:*
  - The Abt Associates/President’s Malaria Initiative (PMI)/Africa IRS (AIRS) reports and information are a useful resource for capacity building.
  - WHOPEs have begun to develop standard operating procedures for IRS methods which will soon be available online.
- *Coordination of IRS in country:*
  - There remains a lack of coordination between those implementing IRS in-country e.g. Abt/PMI and NMCPs. There is considerable scope to standardise methods and programme structure.
  - UNITAID provides a forum for communication to an extent but there may be a need for country IRS steering committees to bring together all stakeholders and agree on common strategies.
  - A recent paper describes how stakeholders within vector control have been brought together in Cambodia through a consortium that meets every two months (Canavati *et al.* 2016 *Malar J*).
- BMGF is interested in IRM and recently convened a meeting of experts to put together a series of papers for the *Lancet Global Health* to set an agenda for IRM.

### **3<sup>rd</sup> 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?
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 populations at risk?
15. Document barriers and enablers of supply chain/market development for housing materials.

#### *Draft work plan:*

<b>Activity</b>	<b>Date</b>
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	End Q4

	UN organisations to help facilitate links with other ministries.	
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.

***1<sup>st</sup> New challenges, new tools in vector control work stream meeting – Fredros Okumu, Ifakara Health Institute, Tanzania and Mike Reddy, Bill and Melinda Gates Foundation, USA***

The main conclusions from the meeting were that the work stream should: (i) help to consolidate evidence on new challenges, new tools and (ii) support countries by providing recommendations, and consensus statements on key issues. It was also proposed that LSM should stay as a separate work stream.

*The way forward:*

- *Product/intervention development:* IVCC published a framework for the rapid assessment of new VCTs (Vontas *et al.* 2014 *Trends Parasitol*). It is helpful to explore how the work stream can disseminate information to innovators on the pathways to approval. It is critical to have a route to market that is clear and concise, with recognised hurdles that can be anticipated. It would be helpful to document previous and ongoing experiences of product developers and to document the pathway to approval. The work stream should serve as a forum to develop enquiries on the I2I process.

- *Implementation of new VCTs:* We should be clear where and when new tools are appropriate. Position statements on new paradigms may be helpful. It would be good to consider costing, cost-effectiveness and how to finance new or supplementary interventions. An element of ‘learning by doing’ could be valuable and the work stream could guide countries in Phase IV evaluations.
- It is not only important to develop new tools, but also new methods to measure transmission.

#### ***Discussion – All***

- I2I will have permanent staff funded by BMGF and hosted by IVCC from June 2016. These staff will organise the inputs from six work streams. The relationship between I2I and WHOPES was clarified: I2I is advisory and there is no obligation for WHO to take up its recommendations.

#### ***Larval Source Management:***

- LSM is clearly supported by WHO and it is now up to NMCPs to implement it where useful and for programmes to be given adequate guidance on how this can be done.

#### ***New interventions:***

- The process of getting new interventions or products approved and recommended is very lengthy. This work stream can help speed up the process by forwarding assessments to WHO (via MPAC) for consideration.
- If products do not get to the market there will be little incentive for future innovation.
- It is important to keep focusing on supporting NMCPs and to help programmes to do correct evaluation frameworks.

#### ***LSM as a separate work stream:***

- The consensus from the work stream meeting was that LSM needs to be kept separate.
- The plenary voted in favour of having a separate LSM work stream.

#### ***1<sup>st</sup> LLIN priorities work stream meeting - Hannah Koenker, Johns Hopkins University Center for Communication Programs, USA and Lena Lorenz, London School of Hygiene & Tropical Medicine, UK***

##### ***Proposed work stream activities:***

1. Assemble all durability guidelines together and recommend updates to durability guidelines as the science develops, including data on care and repair.
2. Work with AMP to identify LLIN distribution options for low-transmission urban areas.
3. Create maps combining IR and prevalence data to inform distribution strategies e.g. to identify areas for PBO LLIN piloting.
4. Provide a decision framework for new LLINs to communicate simply the evidence and recommendations to national programme managers.
5. Lay out a clear series of steps, including description of the minimum data requirements that are needed to move forward with new LLINs; ensure a common understanding of constraints and processes.

6. Identify M&E needs for new LLINs once they are rolled out, including monitoring physical durability, bioefficacy and epidemiological outcomes.
7. Function as a forum to share information and results:
  - Share results of evaluations (including costing) of large-scale continuous distribution
  - Provide updates on I2I work on the LLIN qualification process.
  - Share results of inter-lab validation of resistance-to-damage (RD) scores and make this resource available via the durability toolkit.
  - Share results of work on preferences for LLIN types (after VCTEG).
  - Provide updates on ongoing work on mosquito net fishing and its effects on aquatic life and livelihoods and other net misuse.

### **Discussion - All**

#### *Durability:*

- A recent paper provides a protocol for measuring durability in the field (Sagnon *et al.* 2015 *Trials*). One suggested action point was to assemble a database of protocols online.
- Efforts to predict durability from measurable characteristics (e.g. bursting strength, denier) have proved unreliable. Maybe there should be less focus on methods to measure durability and more focus on monitoring durability in the field.
- Arguably, the more lasting a LLIN the more problematic this is from a resistance perspective.

#### *LLIN advocacy:*

- Work was published this year on impact of LLINs on agricultural productivity. LLINs should be advocated as part of the food security / poverty reduction package.
- Catholic Relief services did LLIN distribution through its food security stream and this has been written up.
- LLINs printed with religious figures or cartoon characters might be better looked after or sought after.

#### *Measuring insecticide resistance:*

- WHO susceptibility monitoring guidelines have been revised.
- We need to be able to better characterise resistance to understand where problem areas exist and the intensity of resistance in those settings.
- There was a call for the VCWG to stop its lengthy discussions and to take action.

### **Summary – Gerhard Hesse, Jacob Williams, Konstantina Boutsika**

In summarising, it was reiterated that members of the VCWG are ambassadors and are responsible for spreading messages into different vector control networks. The work streams are still evolving and individuals will be kept involved throughout the year. Since some objectives will need funding, possible sources should be considered. Meetings outside the annual meeting, e.g. at ASTMH, are encouraged.

### **Any other business – All**

- There was a request for translation at the VCWG, but this is beyond the budget of the VCWG. Feedback suggests that most francophone members have good working knowledge of English and therefore understand discussions, but that some members may need support to translate their points from French to aid communication.

*Learning resources/information:*

- *LSM:*
  - Larviciding is critical for *Aedes* control; it would be valuable to extend the WHO Operational Manual on LSM to include *Aedes* for the control of Zika, dengue, etc. Peter DeChant ([Peter.DeChant@valentbiosciences.com](mailto:Peter.DeChant@valentbiosciences.com)) should be contacted for additional material on larval control including *Aedes*. There is much guidance available for *Aedes* from WHO and considerable experience available from South East Asia among other settings.
  - A condensed version of the WHO Operational Manual on LSM was requested; however, this document is already concise and would be hard to shorten.
  - India has been using LSM for the control of malaria and dengue since the 1970s and has full guidelines on LSM that can be shared.
- *Insecticide resistance management:* IRAC will provide an e-learning module.

*Corporate support:*

- Those working in the public sector should be aware that the current global economic situation which means that resources previously invested by the private sector may soon not be available. It is important to recognise that we are operating with limited funding. The private sector should not be considered an ATM and the same applies to donor communities.
- It is important to focus on the value added to malaria control efforts so that corporates can relate to this.

*VCWG next steps:*

- Position statements on key issues that require further attention or clarification should be prepared and forwarded to MPAC and VCAG.
- It is important to improve the representation of NMCPs in the VCWG, so that end users are aware of the issues discussed. Since many NMCP managers feedback directly to national leaders, this is also a means to ensure that important issues are raised in-country. The VCWG funds some NMCP attendance and is working on new ways to support attendance.

In closing, Members thanked Konstantina Boutsika for the excellent organization of this year's meeting, especially given the various challenges of finding new locations and developing new fee payment system for the meeting. VCWG Co-Chairs thanked all members for continued commitment and attendance.

Sponsorship of affected-country participants is provided by Swiss Agency for Development and Cooperation (SDC), Swiss TPH, USAID, Avima Pty Ltd, Bayer, HD Hudson Manufacturing Company,

Intelligent Insect Control SAS, In2Care, Mitsui Chemicals, Agro, Pulcra Chemicals, Sumitomo Chemical, Syngenta, VKA Polymers, Westham.

### List of acronyms

AI	Active ingredient
AIM	Action and Investment to Defeat Malaria 2016-2030
AIRS	Africa Indoor Residual Spraying Project
AMP	Alliance for Malaria Prevention
ANC	Ante-natal clinic
APMEN	Asia Pacific Malaria Elimination Network
ATSB	Attractive toxic sugar bait
BBSRC	Biotechnology and Biomedical Sciences Research Council
BCC	Behaviour change and communication
BMGF	Bill and Melinda Gates Foundation
Bti	Bacillus thuringiensis subsp. israelensis
CD	Continuous Distribution
EIA	Environmental Impact Assessment
EPI	Extended programme of immunisation
GMP	Global Malaria Programme
GPIRM	Global Plan for Insecticide Resistance Management
GTS	Global Technical Strategy for Malaria 2016-2030
HWG	Harmonization Working Group
I2I	Innovation to Impact
ICEMR	International Centres of Excellence for Malaria Research
IR	Insecticide resistance
IRAC	Insecticide Resistance Action Committee
IRM	Insecticide resistance management
IRS	Indoor residual spraying
IPM	Integrated Pest Management
ITN	Insecticide-treated net
IVCC	Innovative Vector Control Consortium
IVM	Integrated vector management
LLIN	Long-lasting insecticidal net
LSM	Larval source management
M&E	Monitoring and Evaluation
MDG	Millennium Development Goal
MERG	Monitoring and Evaluation Reference Group
MESA	Malaria Eradication Scientific Alliance
MPAC	Malaria Policy Advisory Committee
NGO	Non-governmental organisation
NMCP	National Malaria Control Programme
PAMCA	Pan African Mosquito Control Association
PBO	Piperonyl butoxide
PIAM-Net	Pakistan–Islamic Republic of Iran–Afghanistan Malaria Network
PMI	President’s Malaria Initiative

R&D	Research and development
RBM	Roll Back Malaria
RD	Resistance to damage
SDC	Swiss Agency for Development and Cooperation
SDG	Sustainable Development Goal
SSA	Sub-Saharan Africa
TA	Technical assistance
TDR	WHO Special Programme for Research and Training in Tropical Diseases
TOC	Transition Oversight Committee
TPP	Target product profile
USAID	United States Agency for International Development
VCAG	Vector Control Advisory Group
VCT	Vector control tool
VCTEG	Vector Control Technical Experts Group
VCWG	Vector Control Working Group
WHA	World Health Assembly
WHO	World Health Organization
WHOPES	World Health Organization Pesticide Evaluation Scheme
WRBU	Walter Reed Biosystematics Unit