

**Roll Back Malaria Vector Control Working Group (VCWG)
10th Annual Meeting, 28th-30th January 2015
International Labour Organization (ILO)
4, Route des Morillons, 1211 Geneva, Switzerland**

**Co-chairs: Jo Lines and Jacob Williams
Secretariat: Konstantina Boutsika
Rapporteur: Lucy Tusting**

Day 1: Wednesday 28th January 2015

Session 1: Introductions and objectives

Salle II

Chairperson: Jacob Williams

Welcome and introduction – Jo Lines, RBM-VCWG/London School of Hygiene & Tropical Medicine (LSHTM), UK

Jo Lines opened the 10th Annual Meeting and invited all participants to introduce themselves.

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

The aim of the 10th Annual Meeting was to identify current and emerging issues that should be addressed by the VCWG and to establish a 2015 work plan, with the overall goal of working to more effectively support countries and to facilitate global policy development through interaction with the Vector Control Technical Expert Group (VCTEG) and Vector Control Advisory Group (VCAG). He noted challenges such as increasing insecticide resistance, the lack of effective interventions against outdoor transmission of malaria, and growing expectation for improved efficiency in the use of resources, imposes an urgent need to effectively translate policy to practice and support malaria endemic countries to further improve on disease control. Work Streams were asked to individually address three objectives: (1) to identify opportunities to enhance VCWG's technical support to countries, and facilitate policy/guidance development at the global level, (2) to realign their agendas and activities to more closely match the overarching VCWG priorities and (3) to identify possible funding sources to support VCWG activities, including the possibility of soliciting targeted funding support for individual Work Streams.

Welcome remarks from WHO-GMP - Pedro Alonso, World Health Organization, Switzerland

Pedro Alonso opened with a reflection on his first few months at the WHO Global Malaria Programme (GMP). Dr Alonso emphasised the importance of partnership between RBM and WHO. He acknowledged the great progress made in malaria control since 2000, as outlined in the World Malaria Report 2014, but then also noted that the global efforts at malaria control is at a critical juncture, since significant gaps still remain in coverage. For example, as at 2014, 50% households were still not covered by adequate vector control. Dr Alonso then gave an update on the development of the new Global Technical Strategy for Malaria (GTS), which has been underway for 18 months. The aim of the GTS, he said, is to complement the second Global Malaria Action Plan

(GMAP-2), under development by RBM. Both the GTS and GMAP-2 will guide malaria control from 2016-2030. Goals include a 90% reduction in malaria morbidity and mortality and elimination in a further 35 countries by 2030. The outlined targets are based on consultation with countries and modelling, but do not account for new innovation, such that actual progress may be greater. He emphasized that from his perspective, vector control is the most critical component of the GTS and therefore stressed the need for joint efforts to further enhance support to endemic countries to improve on vector control efforts. USD 105bn is needed to finance the GTS until 2030, with approximately 50% needed for vector control. Additionally, USD 1bn will be needed for vector control research and development. The GTS was recently approved by WHO for submission to the World Health Assembly (WHA). The ongoing need for collaboration between country managers, academia and industry was also emphasised, with insecticide resistance posing the greatest challenge to success in malaria control. In the past year GMP has worked to strengthen the policy process for vector control, develop guidelines for entomological surveillance and provide new technical assistance to countries.

Membership, information exchange and budget - Konstantina Boutsika, RBM-VCWG/Swiss Tropical and Public Health Institute (Swiss TPH), Switzerland

The three VCWG communication channels are: (1) the mailing list, (2) the VCWG website and (3) the annual meeting. The mailing list has expanded from 500+ entries in 2014 to 693 entries in 2015, with recent additions from West Africa, South America and South East Asia. James Banda was introduced as the new RBM Secretarial Focal Point. The website has been live since 2011 and hosts all VCWG documents. During 2014 the VCWG site was visited 10,756 times, a 19% increase on 2013, accounting for 28% of total page views for all working groups. The Continuous Distribution Work Stream had the most visits and the Housing Work Stream had the longest mean visit time. Most visitors were from Europe (34%), followed by the Americas (25%), Asia (23%) and Africa (15%). This year the Annual Meeting has 199 registered participants from 34 countries: 79 Europeans, 53 Americans, 47 Africans, 19 Asians and one participant from Oceania. The largest sector represented is research and academia (23%), followed by the private sector (21%), endemic countries (including academic) (19%) and NGOs (18%), with an increase in endemic country participants since last year. Since the VCWG received no funding from the Secretariat this year, a registration fee (USD 250) was introduced to cover meeting expenses, with few endemic country participants sponsored via leverage funds from Swiss TPH and the Swiss Agency for Development and Cooperation (SDC). The Alliance for Malaria Prevention (AMP) and International Federation of the Red Cross (IFRC) were thanked for the pre-meeting apero.

Discussion

- Funding allocation for specific outputs of the VCWG that were previously approved by the RBM board and included in the annual programme of work of the RBM for 2014-2015 are still available to complete those specific activities.
- VCWG will need to rely on internal efforts to mobilize resources to fund its activities going forward as it is unlikely that the previous situation of Board allocation to fund work group activities will continue.
- Going forward, consideration will be given to equity in membership registration fee, to ensure that members from developing malaria endemic countries are not disadvantaged. The participation of endemic countries in the VCWG is very critical.

- A more suitable option will be explored to reduce the overhead bank transaction charges in the payment of registration fees.
- The increased value of the Swiss franc following its uncoupling from the Euro will have implications for budgets managed in USD.

Lessons learned and charting the way forward - Jacob Williams/Jo Lines, RBM-VCWG

Key outputs of the VCWG in previous years include: (1) data generation in LLIN durability, (2) Cochrane reviews of vector control interventions, (3) multisectoral collaboration and (4) contributions to World Malaria Day. Implementation of the Global Plan for Insecticide Resistance Management (GPRIM) has been very slow. There is no funding available for the VCWG apart from that raised by the registration fee; Swiss TPH was thanked for backing the meeting before registration fees were collected. Many outputs have been funded on external grants, for example through NetWorks/VectorWorks and the Innovative Vector Control Consortium (IVCC). However, the work of the VCWG remains largely 'upstream', rather than focused on supporting implementation and this need rebalancing, to ensure that the VCWG is adequately providing needed technical support to address priority implementation needs as well.

Topical issues for the VCWG-10 include (1) GPIRM (with issues of product choice and field monitoring including the identification of resistance mechanisms), (2) long-lasting insecticidal nets (LLINs) (specifically: durability, continuous distribution, gaps in coverage), (3) the combined effect of indoor residual spraying (IRS) and LLINs, (4) the evidence base for vector control as a whole (insecticide-treated net (ITN) trial evidence is now 20 years old, however insecticide resistance has changed the context). Long-term issues include insecticide resistance, stabilising elimination in Africa, integration of vector control and multisectoral collaboration.

Jacob Williams was elected this year as co-chair to replace Michael Macdonald. A second election will follow in 2015 to replace Jo Lines.

A new RBM Task Force was convened in September 2014 to review the role of RBM in the context of budget cuts, led by Halima Abdullah Mwenesi and Carlos C. (Kent) Campbell. The Task Force will report in May 2015. Its aim is to define the role of (1) RBM, (2) the Board and (3) RBM mechanisms. The Task Force will also document how malaria control can complement the Sustainable Development Goals (SDGs) and the broader goals of the Global Fund for AIDS, TB and Malaria (GFATM). The Task Force has asked the VCWG to help by recommending three to five key potential contributions from a global partnership.

The future of VCWG was discussed. Currently, VCWG is largely a technical annual general meeting for the vector control community, with a large representation from academia and the private sector. It is mainly self-supported and could continue as such without RBM support. Implementation support must be a key future focus; currently there is no technical assistance function. While countries have been supported in their Global GFATM proposals (largely by the Harmonization Working Group (HWG)), countries are increasingly asking for support for GPRIM and other vector control issues.

Discussion

- RBM Task Force members who actively participate in the VCWG include Nancy Nachbar (Nancy Nachbar and Associates, LLC), Matthew Lynch (Johns Hopkins University), Elizabeth Juma (Kenya Medical Research Institute), Alastair Robb (U.K. Department for International Development), Lisa Goldman-Van Nostrand (Sumitomo Chemical), David Brandling-Bennett (BMGF) and Pedro Alonso (WHO-GMP). These individuals have witnessed the value of the VCWG at first hand yet need written evidence of this and of the types of technical assistance (TA) that is provided.
- It is vital for the VCWG to continue to meet annually since it brings together many sectors: It represents a very unique forum where comprehensive perspectives and expertise are brought to discussions.
- It is important that VCWG invest some efforts to increasing its in younger members, as it is important for the future.
- LLINs and IRS will not be sufficient for malaria elimination in many settings; especially in the context of insecticide resistance (IR) and very high transmission; additional tools are needed such as housing and Larval Source Management (LSM). VCWG must therefore continually review opportunities to expand the malaria vector control, especially to address the challenges of residual transmission.
- There remain key gaps in normative guidance on vector control and in the translation of this guidance to the field. In addition to providing upstream support and TA, there is a need to adjust the packaging of guidance documents and to think more about how policy is translated into implementation. The HWG conducts country support works well; the VCWG should explore how it can complement existing TA efforts by the HWG. The VCWG might also consider supporting the development and implementation of one overall set of WHO guidance for countries.

Welcome remarks from the RBM Partnership - Fatoumata Nafo-Traoré, Roll Back Malaria Partnership (RBM), Switzerland

The focus of the VCWG has shifted from solely LLINs to broader vector control, with a great diversity of backgrounds and expertise; this is a considerable asset to RBM. It is encouraging that this year's meeting has been self-funded, given the absence of financial support from RBM. This highlights the dedication and enthusiasm among partners. In 2015 the VCWG should aim to identify specific countries to receive TA and work more closely with HWG. The co-chairs will engage with VCWG partners to collect information for the Task Force. It is important to illustrate to RBM the achievements and value of the VCWG, and the value of partnership in adding to the work of individual partners. Nafo-Traoré closed by thanking those present for their continued efforts.

Session 2: Current policy and implementation practice

Salle II

Chairperson: Jo Lines

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

First, the work of GMP in insecticide resistance management (IRM) and global tracking was discussed and the main recommendations of the Malaria Policy Advisory Committee (MPAC) background document *Update on the implementation of the Global Plan for Insecticide Resistance Management*

(GPIRM) in malaria vectors (September 2014) presented. To summarize, some progress has been made in implementing GPRIM, however implementation in country has generally been poor due to a lack of political will, together with financial, human and infrastructure constraints. Challenges to reporting and mapping of insecticide resistance include: (1) data quality, with few established national insecticide resistance monitoring plans, (2) data management, with no established national insecticide resistance databases and (3) data sharing, given the lack of an effective mechanism for disseminating up-to-date information between partners. Future plans to improve global IR tracking include support to countries for developing national management plans and the development of an online interactive platform for mapping country-level resistance.

Second, an update on new tools was given. In the context of IR, VCAG has proposed that combination nets might constitute a new paradigm for fast-track approval by the WHO Pesticide Evaluation Scheme (WHOPES). Combination nets are an adaptation of an existing paradigm that may reduce vectorial capacity, infection and disease in humans where there is pyrethroid resistance. For example, Permanet-3 (PN3) has demonstrated greater mosquito mortality and reduced human infection than previous models. VCAG guidelines on this new paradigm were finalised in November 2014, including recommendations for an independent review of existing data and/or implementation of decisive trials, which is needed to define operational conditions. This will be considered by MPAC for presentation in September 2015. While current VCAG recommendation may not shorten the process of getting new products to market, such nets should at a minimum pass a WHOPES interim recommendation and minimum quality standard.

Third, GMP has been working to evaluate whether the evidence from LLIN durability studies is sufficient to inform LLIN procurement. Two studies have sought to evaluate Resistance-to-Damage (RD) scores. Key draft recommendations are: (1) that WHOPES should coordinate inter-laboratory validation of research methods, subject to the availability of funding and (2) that WHO should coordinate multi-centre comparative studies.

Fourth, sustaining LLIN and IRS coverage was discussed. ANC and EPI remain the major channels for continuous LLIN distribution. Global guidance on prioritization and targeting in the context of resource constraints was developed by WHO in 2014, updating existing recommendations (www.who.int/malaria/publications/atoz/who_recommendation_coverage_llin/en/), however this contradicts the principle of universal access to health. Partners should work with individual countries to address short-term gaps as resources are mobilised. With regards to sustaining IRS, while GPRIM recommended the pre-emptive use of IRS to manage IR, this is not being conducted apart from in a handful of areas with high LLIN coverage. IRS coverage declined from 5% of the total population at risk in 2010 to 3.5% in 2013. Alternatives to pyrethroids are expensive. While waiting for new tools, countries should tap domestic resources (through advocacy), consider pooled procurements and global forecasting (as is done for LLINs) and negotiate for price reductions.

Maintaining effective vector control in light of increasing insecticide resistance - Christen Fornadel, USAID – President’s Malaria Initiative, USA

IRS and ITNs are key strategies supported by the Presidents’ Malaria Initiative (PMI). Since IRS is expensive and requires an intense effort, it is not implemented everywhere in-country, but PMI supports targeted coverage. In 2014, PMI conducted IRS in 13 countries, protecting >20 million

people. Given widespread pyrethroid resistance in all PMI countries, IRS programmes have needed to adapt. While budgets have remained static, absolute coverage has declined due to a shift to more expensive organophosphates or carbamates. Due to DDT resistance and the short residual life of Bendiocarb on mud surfaces (e.g. 1-2 months in Mali and Ethiopia), Actellic CS remains the only option for IRS in many countries, at a considerable cost (USD23 per bottle versus USD2-3 for a pyrethroid sachet). The switch to Actellic CS has been associated with a reduction in parasite prevalence and entomological inoculation rates (EIR) in several countries. Moving forward, IRS programmes are being made more efficient, research is being conducted into focalised spraying and support to government IRS programs is being provided.

ITNs are distributed by PMI through campaigns and continuously through country-specific mechanisms. >31 million nets were distributed in 2014. Monitoring LLIN durability is a critical quality control activity for countries. RD scores are a promising method to evaluate the field longevity of LLINs in the laboratory. Validation across laboratories and field settings are needed. New PMI guidance recommends that all countries monitor LLINs distributed, in line with WHO guidelines. PMI is supporting new trials of new active ingredient (AI)/combination nets. Entomological monitoring is supported to complement IRS and LLIN programs at 190 sites using the WHO tube test and CDC bioassays. Resistance intensity is also being increasingly monitored, for example in Zambia. The key future question for PMI is how to best target new and existing VC tools to maintain effective coverage, given budget constraints and (likely) more expensive products.

Discussion – All

- IRM must be proactive, not reactive.
- There is considerable research and development underway with both Sumitomo and Bayer developing new active ingredients. Innovation in IRS should complement work to develop new combination nets. VCAG guidance on the new LLIN paradigm should be followed closely to ensure rapid approval by WHOPES.
- LLINs remain the key outlet for funding for vector control; IRS is conducted with any remaining funds. Perhaps this needs to be re-thought, for example, by not aiming for universal LLIN coverage in large cities.

Session 3: Donor strategic perspectives

Salle II

Chairperson: Matthew Lynch

Supporting accelerate to zero: the BMGF malaria vector control research agenda - Dan Strickman & Mike Reddy, Bill and Melinda Gates Foundation, USA

The Bill and Melinda Gates Foundation (BMGF) strategy aims to 'Accelerate to Zero', with three overarching goals for the period 2014-20, to: (1) accelerate to zero now (new strategies using current tools), (2) prepare for the future (new strategies using new tools) and (3) sustain progress (current strategies using current tools). Six initiatives support these three goals: (1) 'eliminate', (2) 'infection detection', (3) 'achieve radical cure', (4) 'prevent transmission', (5) 'last mile' and (6) 'mobilize'. To eradicate malaria, the strategy is to (1) detect the parasite, (2) eliminate the parasite from its reservoir and (3) prevent transmission of the parasite. Measures to prevent pathogen transmission by a vector include: (1) source reduction, (2) biological control, (3) chemical control and

(4) genetic approaches. Major new initiatives include addressing outdoor/residual malaria transmission (a second call for proposals will open soon) and bringing integrated vector management (IVM) into the fold.

***If you want to walk fast, walk alone. If you want to walk far, walk together - Alastair Robb, UK
Department for International Development (DfID), UK***

Alastair Robb gave a donor perspective on international partnerships. RBM was originally an African initiative - stemming from the African Initiative on Malaria (AIM) - and its original mandate emphasised the need for a partnership between stakeholders to support national priorities and to achieve sustained reductions in malaria. This was to be achieved through (1) high quality, practical advice, (2) research and development of new tools and (3) advocacy to cement political commitment. Has RBM worked? Available tools have been strengthened through public-private partnerships, facilitated in part by RBM. Future threats to RBM include the economic downturn and the move away from the Millennium Development Goals (MDGs) to SDGs, which do not actively mention malaria. The Ebola epidemic suggests that the global health architecture needs strengthening. However, the epidemic has also turned global attention to infectious diseases and this is an opportunity to advocate for malaria. What is the future of the RBM partnership? The options are to disband, to continue as before or to reorientate. If RBM is to be reoriented, should this be the function, structure, principles or behaviour? Do we have a purpose? Where are we on the pathway to a malaria free world? GTS and GMAP-2 provide a helpful framework for monitoring this and the RBM Task Force will examine how to improve efficiency.

DfID investments are very much defined by political interest. Thus, it remains important to make the case for the importance of malaria control and to demonstrate the value of investments to account to taxpayers. Thus, it is important to provide evidence of the value of the partnership. The VCWG can survive on its own, however it would be more effective to work within a broader partnership (see title). It is critical for members of the VCWG to advise the Task Force on the future purpose and structure of the VCWG.

Session 4: Supporting activities

Chairperson: Charles Mbogo

Perspectives from CropLife - Egon Weinmueller, CropLife, Germany

There are serious challenges to the future of vector control product development. Annually, USD 1bn is spent on vector control while USD 47bn is spent on crop protection products. Although vector control constitutes a small part of the pesticide industry, changes in that industry have important implications for vector control. While the probability of discovering a single new pesticide has increased since the 1950s, with a larger number of compounds being screened, mean time and cost from discovery to market use has increased. The availability of non-resisted modes of action for adult mosquitoes has decreased to around five. Regulatory pressure has increased in the past 10 years, with a substantial decline in the number of EU-registered insecticides and acaricides. A further challenge for the research industry is the increase in per cent market share of generic versus patented products. Partly for these reasons, the number of companies producing public health pesticides has declined from over 30 to <10 companies, and will likely reduce further.

With each extra year that it takes to gain a WHOPES approval, return on investment (ROI) decreases and risk for companies increases. Currently, for products within existing paradigms, R&D costs are <USD10m and WHOPES evaluation costs USD1m, with an overall time to market of around 5 years. WHOPES costs substantially reduce for subsequent products submitted within the same class; this discourages innovation. For products within new paradigms, R&D costs are >USD10m and WHOPES evaluation costs >USD1m, with a total time to market of around 10 years.

Currently there are only four classes of WHO-approved adulticides. No new classes have become available since 1990. Resistance is problematic not just for malaria but other vector-borne diseases including Chagas, dengue and lymphatic filariasis (LF). A number of new AIs are in development (IVCC Annual Report 2013-2014). Priorities for vector control are outlined in Innovation to Impact (I2I), which constitutes a number of new commitments. It is also important to drive data quality improvements in collaboration with WHO.

TDR strategy in vector control: past achievements, on-going projects and future opportunities/ challenges - Florence Fouque, TDR/World Health Organization, Switzerland

The TDR malaria vector control strategy was outlined. TDR is a UNICEF-UNDP-World Bank-WHO joint programme, the overall vision of which is to use research to improve the health and well-being of those burdened by infectious diseases of poverty. Within vector control, the goal is for communities to have advanced access to improved control interventions that will ultimately contribute to a reduction in disease transmission and burden. It is envisaged that this will be achieved by promoting research, building capacity and collaboration with countries and institutions. Major achievements of TDR within malaria control were presented, for example in 2014 TDR promoted guidance framework for testing genetically modified mosquitoes. Three of five currently TDR-funded projects are relevant to malaria: (1) reducing the vulnerabilities of sub-Saharan African dry land populations to the risks of climate change in Botswana, Cote d'Ivoire, Kenya, Mauritania, South Africa, Tanzania and Zimbabwe, funded by IDRC-Canada, (2) investigating the mechanisms of malaria vector resistance and its link to control failure and (3) strategies for community case management. Sustainable health is the major aim for the work plan through to 2017. New projects related to malaria were outlined, such as research into alternative methods for controlling vectors (2015-2016). TDR is open to suggestions from the VCWG for its future work.

Discussion – All

- Manufacturing of new application equipment is subject to similar constraints to insecticide manufacturing. Coordination with chemical manufacturers is needed to ensure that new equipment is operationally suitable. The focus within manufacturing is to build equipment that is resilient to the future.
- There are clear Insecticide Resistance Action Committee (IRAC) recommendations on managing insecticide resistance; these can be applied within vector control but need field testing. For example, combining AIs in mixtures is used instead of alternating AIs in crop science, so perhaps this would be appropriate for vector control.
- Capacity building in vector control is essential and will become more so as insecticide resistance becomes more prevalent. TDR should be investing heavily in capacity building. Applications for training grants in vector control should be encouraged. TDR should specifically fund malaria entomology training courses.

GMAP-2 - current status and next steps - Helen Prytherch, Swiss TPH, Switzerland

In developing GMAP-2, over 1300 stakeholders have been consulted directly to date, including over 100 respondents to an online survey, more than 250 stakeholders participating in six regional consultations and over 800 stakeholders in ten 'first wave' national consultations. A second wave of national consultations has now begun. There has also been social media engagement. The purpose of GMAP-2 is to advocate for malaria control, align malaria control in the post-2015 context and accelerate progress. The draft structure of the document, with its introductory 'Call to Action' and five chapters, was outlined. The next steps are to update the draft based on feedback; to undergo a one month public review in English, Spanish and French; to prepare a pre-final version; to develop a high-level advocacy pull-out; to carry out GMAP-2 related advocacy and to finalise the document with a view to a joint launch in September/October 2015. Deloitte Consulting supports the development of GMAP-2. GMAP-2 Task Force members were also acknowledged.

Discussion - All

It was questioned whether the GMAP-2 will consider the risk of malaria resurgence, post-elimination; this is a major concern in the Asia-Pacific region and is something that should be addressed. Historically, there have been many examples of resurgence of malaria. It is critical to address how to prevent this. The costing underlying the GMAP-2 was led by Imperial College, London; it was questioned whether this has been critically reviewed.

MESA track database: research projects relevant to the malaria elimination and eradication agenda - Mar Velarde Rodríguez, Institute for Global Health (ISGlobal), Spain

The Malaria Eradication Scientific Alliance (MESA) Track database was described. MESA Track is a living database of research projects relevant to malaria elimination and eradication, launched during 2014 ASTMH with over 200 projects registered in 68 countries across nearly 400 institutions. Information is available on the MESA website: www.malariaelimination.org/mesa-track/

Discussion - Summing up the 1st day - Jacob Williams/Jo Lines

- *VCWG structure:*
 - There was discussion of the possibility of dissolving and/or redesigning the Work Streams.
- *Promotion of VCWG outputs and benefits:*
 - The importance of the VCWG within the portfolio of all RBM working groups needs to be emphasised to (1) justify its existence and (2) to attract funding.
 - Dissemination of findings must be rapid in an increasingly globalised world.
 - VCWG is not expensive for RBM and it has a large number of participants willing to self-fund. It is also an excellent forum for collaboration.
 - It is important to emphasise the role that VCWG can play in addressing the gaps in understanding implementation.
 - VCWG has a role to play in helping WHO to develop normative guidelines.
 - The influence of the VCWG in the GMAP-2, GTS, VCAG and MPAC was discussed. There are only two vector control specialists in MPAC, but many in VCAG. The situation could likely lead to under-consideration of vector control issues.

- There is now more funding available for RBM Working Groups than in the last round, but this is for specific outputs that have been approved and included in the current RBM programme of work. Task groups could be convened to develop a target list of outputs.
- There is a need to map out where primary contacts are, the tools needed to engage them and the people needed to coordinate this mechanism.
- *Endemic country participation:*
 - The VCWG needs greater input from country programme managers. Hence greater participation from endemic country nationals must therefore be encouraged/facilitated.
 - The sub-regional networks have a role to play in this; perhaps there is an agenda that can be forwarded to the SRN meeting in March 2015. The MAWG and HWG are working with program managers to feedback to the SRN.
- *Supporting endemic countries:*
 - The VCWG has not actively distributed its outputs (e.g. findings and publications) to endemic countries and opportunities should be actively explored to do so. Mention was made that the HWG publishes quarterly reports.
 - The VCWG should have a strong influence on GMAP-2, GTS, VCAG and MPAC, which help guide countries.
 - One annual meeting may be insufficient to support countries. Regional officers may be needed.
 - VCWG should make specific recommendations on improving the time-to-market for new products and a framework for implementing GPIRM.
- *The end of malaria control:*
 - It is helpful to think forward to post malaria elimination: how will this be sustained with vector control?
 - Countries that have eliminated malaria have set a precedent e.g. USA which continues its mosquito abatement programs.

2nd Housing and Malaria Work Stream Meeting
16.00-18.00, Wednesday 28th January 2015
Salle II, International Labour Organization, Geneva

Chairs: Steve Lindsay and Mariana Stephens
Rapporteur: Lucy Tusting

Housing & malaria: new opportunities for control and elimination - Steve Lindsay, Durham University, UK

Steve Lindsay welcomed participants and presented (1) a review of the case for housing as a malaria control intervention, (2) recent work to estimating the effect size of 'good' quality housing and (3) an ongoing trial to measure the protective efficacy of housing against clinical malaria. First, the potential role of housing in malaria control was outlined. Traditionally, housing was one of the three pillars of public health, alongside water, sanitation and hygiene (WASH). Today, WASH is integral to

the global health agenda, but housing is overlooked. Housing has great potential since up to 80% malaria transmission occurs indoors, alongside transmission of other major vector-borne disease such as lymphatic filariasis. In Africa, traditional architecture is being replaced by modern housing (e.g. Korogwe, Tanzania; Liu 2014). An estimated 115m houses will be built in rural Africa by 2050. Housing may be a long-term *additional* strategy to help manage insecticide resistance and eliminate malaria, in the context of increasing focus on multisectoral collaboration and Integrated Vector Management (IVM).

Second, the findings were presented from a new systematic review of housing and malaria led by the London School of Hygiene & Tropical Medicine, University of California San Francisco and Durham University. This review aimed to (1) characterise all published and unpublished data on housing and malaria and (2) assess the strength and quality of the evidence. In brief, the review found that 'good' quality housing was associated with a substantial reduction in clinical malaria and infection, but that there was a high risk of bias within and across studies. The paper is currently under review.

Third, only one randomised controlled trial (RCT) of housing has been carried out to date (Kirby et al 2009, Lancet). This was a three-armed trial of screened ceilings and fully screened homes (with screened doors and windows and closed eaves), compared to no screening. Screening was associated with a 50% reduction in house entry and anaemia in young children. A new study has now begun in The Gambia: 'Can improved housing provide additional protection against clinical malaria over current best practice? A household-randomised controlled study' (Roopfs), funded by MRC-DfID-Wellcome Trust Global Health Trials. The study will compare traditional versus modern housing, with LLINs provided to both arms will have LLINs, with a two-year follow-up. There will be 400 houses in each arm with a maximum of 5 houses per village. The main outcomes are: (1) incidence of clinical malaria measured by active case detection and (2) number of *Anopheles gambiae* collected indoors using light traps. In addition to the RCT, a key complement is a study of scaling-up these interventions.

Discussion

While it was suggested that housing interventions will select for outdoor biting, housing quality is changing anyway, especially in urban areas. Housing interventions may alter the indoor climate and increase respiratory infections. However, metal-roofed housing is likely to be cooler at night. Roopfs will measure respiratory infections in children.

Malaria and the built environment – Mariana Stephens, USA

Habitat for Humanity (HFH) works in many countries outside the USA, helping to document and support incremental housing improvements and to build new housing that meets HFH housing quality standards. 2014 was the first year of HFH representation at the VCWG. HFH work relating to malaria includes: (1) a study on housing and malaria in 2001 in 300 households, (2) the provision of technical assistance on the ground (e.g. training local masons on how to screen windows, how to block eaves, how to make door screens) and (3) the inclusion of a malaria chapter in the HFH 2011 Shelter Report 'Housing and Health: Partners Against Poverty', which concluded that *"To have long-term impact on global health, interventions that combine health and housing are essential. Addressing the issue of adequate housing and healthy communities together is a key in any*

successful health-focused strategy". Moving forwards, many questions remain: Will 'good quality' housing be equally protective everywhere? What architectural features are protective? Could these features be improved further? Do people understand the relationship between housing improvements and malaria reduction? How do local people finance housing improvements/modifications?

Discussion

Insecticide-based vector control protects indirectly by reducing mosquito density. Housing interventions must be carefully implemented so that protecting part of the community does not increase risk to others. HFH has a strong mandate to do no harm thus interventions such as housing support services, micro-loans and vouchers aim to bring housing interventions to all. *Roopfs* will not be able to measure overall reductions in mosquito density due to randomisation at the household level.

Housing modifications as a malaria control strategy in per-urban Cameroon – Peter Williams, ARCHIVE Global, USA

There is a need to think more broadly about malaria control; the VCWG is already moving towards this. ARCHIVE aims to prioritise housing design as a key strategy to improve health, with a particular focus on communicable disease. In 2011-12 a global design competition on Building Malaria Prevention was run to bring non-traditionalists to the fore, to encourage designers to collaborate with health practitioners and to encourage new ideas. Cameroon was chosen as the focus for this work due to its high malaria burden, high prevalence of slums (unsuitable housing) and low productivity. Key design features of the intervention being trialled there include: (1) screened doors and windows, (2) closed eaves and (3) increased ventilation. The trial has both entomological and clinical outcomes. Instrumental to the success of the Cameroon program is a suite of partners from multiple sectors. Training is another key component, with over 3000 people trained by December 2014. The trial will not complete until 2016. However, preliminary results have identified specific housing features associated with reduced malaria prevalence.

Portable mosquito-proof housing for itinerant rice farmers in rural Tanzania – Kyeba Swai, Ifakara Health Institute (IHI), Tanzania

Malaria morbidity and mortality was historically high in the Kilombero Valley, Tanzania. There has been a dramatic reduction in malaria transmission since 2000 due to improved living standards and malaria-specific intervention. However, residual transmission remains and a longitudinal study in two villages from 2008-2011 showed that despite high long-lasting insecticidal net (LLIN) and indoor residual spraying (IRS) coverage, there remained a need to improve housing conditions (Lwetoijera 2013). In Kilombero, subsistence rice farmers are mainly itinerant, spending up to six months in distant rice fields where they live in shambas (temporary houses) far from roads, health facilities and schools. As such, mainstream vector control methods are not always appropriate.

This study aimed to develop a portable and low-cost mosquito proof hut design to protect itinerant rice farmers from infectious mosquito bites and mosquito-borne illnesses when living in rice fields. First, biting exposure in main houses and shamba houses was quantified using CDC light trap and M-trap catches. The mean number of *Anopheles* caught indoors was found to be higher in shamba houses. Second, a prototype portable hut was developed with local manufacturing firms and tested

in semi-field conditions. This gave complete protection against biting by mosquitoes, when used with both intact and damaged LLINS. Third, a full field trial was conducted which showed complete protection against mosquito entry compared with traditional shamba housing. Qualitative work was undertaken to assess the views, experiences and behaviours of itinerant farmers. The results suggest strong acceptance of the prototype mosquito-proof huts. The next steps are to ascertain the protective efficacy when in actual use, to commercialise the prototypes into products, to reduce the cost of the final product and to target nomadic communities.

Discussion

It was queried whether cheap off-the-peg tents may be an alternative. The current cost of the Kilombero tents is USD 1500, with a target price of USD 900. Portable housing may be useful at border posts. There may be scope for encouraging housing improvements through behaviour change and communication (BCC) and collaboration with governments. For example, thatch has been replaced by iron roofs nationwide in Rwanda because the government recognised the health potential.

Discussion – All

- *Housing and malaria research:* In summary, research is needed to identify specific protective modifications, evaluate their cost and establish how best to scale-up:
 - Existing modes of building should be documented and protective features identified through small-scale studies.
 - The cost-effectiveness of housing in different settings should be evaluated.
 - Research into how housing improvements change mosquito behaviours via altered odour plumes and indoor environments would be valuable.
- *Implementing housing interventions:*
 - There are over 1bn people worldwide with inadequate housing, creating an overwhelming need for improvements. As these improvements occur, small changes that can both improve health and increase the value of a home (e.g. screening windows and doors) should be identified.
 - It was also suggested that there exists sufficient convincing historical and contemporary evidence to support housing as an intervention, and that research should be focused on scaling-up before waiting for the research to come through the pipeline.
- *Encouraging multisectoral collaboration:*
 - The long mean visit time on the Housing Work Stream webpage demonstrates the interest in housing.
 - An annual housing forum occurs every year; malaria should be added to the agenda.
 - Companies operating in Africa and elsewhere could provide better housing for their workers. This has worked well against chikungunya within Caribbean tourist resorts and Chagas disease in Honduras.
 - There is a need to work with the International Federation of the Red Cross (IFRC) and United Nations High Commissioner for Refugees (UNHCR) who work with refugees and itinerant people.

- *Advocating for housing and malaria:*
 - It would be useful to produce case studies of how housing has been scaled up successfully elsewhere.
 - Housing can create synergy between the Sustainable Development Goals and the second Global Malaria Action Plan (GMAP-2).
 - It is important to identify the type of evidence needed for the different stakeholders (e.g. Global Fund for AIDS, TB and Malaria, house owners).
 - We must ensure that the housing aspects of GMAP-2 are appropriate.
 - Housing can play a role in IVM, in targeting *Aedes (Stegomyia)* and in reducing nuisance biting.

Next steps:

- It was suggested that a position statement on housing would be useful, referencing previous WHO thinking on housing. This could be linked with the UN position on intersectoral work.
- Suggested funding sources included the Chinese (who have a heavy Africa presence), cement companies (e.g. Lafarge cement in Uganda has worked on housing improvements as part of corporate social responsibility (CSR)) and housing developers in the USA and Europe as CSR.
- Similar evidence to the housing and malaria systematic review on other diseases could advocate for multisectoral input into housing.
- Working with governments is important. Some countries have ideal housing profiles (e.g. Tanzania) which might be influenced. Local government authorities are key to targeting remote communities, especially once blueprints appropriate for the locality are established.

Day 2: Thursday 29th January 2015

11th Continuous LLIN Distribution Systems Work Stream Meeting

8.30-10.30, Thursday 29th January 2015

Salle XI, International Labour Organization, Geneva

Chairs: Kojo Lokko and Jayne Webster

Rapporteur: Gabrielle Hunter

Welcome – Kojo Lokko, Johns Hopkins University, USA

Kojo Lokko opened the meeting noting that the topic of continuous distribution (CD) of long-lasting insecticidal nets (LLINs) is at an important juncture. Since its introduction as a concept several years ago, CD is now seen throughout vector control discussions and documents. CD can improve and maintain universal coverage over time. Despite this recognition, there are still several open questions on how CD can work in different settings and how it can be costed. There is still a need to build evidence for the different CD channels, for example to understand how and when to combine CD with mass campaigns. This meeting is a call to broaden the conversation and to set the agenda, develop the evidence, feed this concept and integrate it at the country level.

***Continuous LLIN distribution in Pakistan: strengths and challenges - Muhammad Mukhtar,
Directorate of Malaria Control, Pakistan***

In Pakistan, malaria is a major public health problem, with 29% of the population living in highly or moderately malaria endemic areas and 71% in low endemic areas. Since 2006, 8.7 million LLINs have been distributed, using community distribution, ante-natal clinics (ANC) and special campaigns. Mostly pregnant women and children under-five were the major beneficiaries, until 2012 when the program shifted to universal coverage. Another 4.9m LLINs, supported by the Global Fund, will be distributed in 2015-17. The community distribution channel is based on households requesting coupons from Lady Health Workers (LHW); LLINs are distributed free of cost, with one LLIN for every two people. Through a special campaign, the Pakistan program is distributing LLINs to internally displaced persons and refugees moving away from militants on the western borders, which is the most endemic part of the country. The outlets include basic health units, rural health centres, mother and child health centres, private clinics, and LHWs. Displaced people are registered as they come from the border past a registration point, where they are given two LLINs for every family. The strengths of the Pakistan program include working with a very large, well-established, motivated, and respected cadre of LHWs, which are a natural fit for LLIN distribution at the community level. With the help of a needs assessment tool, the program is able to accurately calculate the quantification of LLINs required in each area. With research findings on behavioural aspects of net use, the program has improved its communication strategy to promote proper net use. The Pakistan program will soon be implementing a school-based continuous distribution program. Funding for the malaria program is diversified to help move towards sustainability; while the majority is supported by the Global Fund, the government of Pakistan contributes nearly USD4m and the private sector contributes as well. Challenges faced by the program include political influence in LLIN procurement and over burdening of LHWs.

***Technical update on CD of LLIN pilot evaluation - Hannah Koenker, Johns Hopkins Center for
Communication Programs, USA***

The use of CD is based on the assumption that sustained high coverage of LLINs is necessary and that dips in coverage between mass distributions threaten gains. CD requires channels that are effective, efficient and equitable and a combination of push and pull strategies can be used. Strong communication is important to successful CD. Every context is different, and CD strategies need to be flexible. In addition, accountability is important; CD systems that use coupons can help with accountability so long as the system separates coupon issuers from redeemers. The Continuous Distribution eToolkit (<http://www.k4health.org/toolkits/continuous-distribution-malaria>) contains many resources including CD guides, the NetCALC tool, and social and behaviour change communication (SBCC) materials. It is a comprehensive toolkit and a great place to get started for countries. Recent pilots have added to the knowledge base on CD. For school distribution, pilots in Nigeria, Ghana and Tanzania have found that LLIN ownership has increased significantly and across all households and is equitable and complimentary to the ongoing ANC/extended programme of immunisation (EPI) distribution in those locations. Lessons learned from the school-distribution pilots are: (1) it is a channel that allows for flexibility as programs can add or remove classes year after year, (2) it is important to start shortly after mass campaigns to avoid deep drops in coverage, (3) it is necessary to establish strong relationships with schools, teachers and parents and (4) if many classes are included, encourage a way for communities to re-distribute excess nets to households without students.

Pilots in community distribution have also produced meaningful results in South Sudan, Nigeria, and Madagascar. All pilots were based on the similar concept of household members requesting a net, obtaining a coupon from a health worker, and exchanging the coupon for a net at a specified location. These pilots have also demonstrated potential to significantly increase household ownership of nets. Lessons learned from community distribution pilots are: (1) it is critical that net demand is built so that people take the first step to request a coupon, communication must empower the most vulnerable to make this request, (2) community distribution can work in a low-infrastructure setting, (3) logistics support is critical to success, in particular stock-outs of nets or coupons can hinder a program significantly and (4) more communication was needed to encourage and empower poorest to request coupons. There also appears to be little overlap between channels of both school and community distributions, so each channel is serving different populations. This evidence is encouraging and should motivate countries and programs to test more CD systems. There remain some outstanding questions for CD, including whether CD can sustain universal coverage over longer periods of time, which populations are being missed and costing of CD.

Update on AMP activities - Jason Peat, Alliance for Malaria Prevention and International Federation of Red Cross and Red Crescent Societies, Switzerland

AMP supports both mass and CD, and works closely with VCWG. AMP has three core activities: (1) partner coordination and advocacy, (2) responding to country and partner requests and (3) sharing operational guidance and documenting best practices. AMP has themed conference calls weekly and welcomes any member of VCWG to present their work on the call. In 2014, AMP has supported 16 countries with the distribution of more than 53 million LLINs and in 2015, nine countries are requesting support. In February 2015 AMP is holding a three day training for technical assistance providers, to be sure they are giving aligned and consistent support. Country support will continue, especially for household registration. AMP is also exploring what may be its role in supporting insecticide resistance monitoring surveys that are fast and low-cost. AMP also plans to work on influencing upstream decisions on LLIN procurements.

Role of private commercial sector in building sustainable continuous distribution systems: current status and next steps needed – Matthew Lynch, Johns Hopkins Center for Communication Programs, USA

When does it make sense to form public-private partnerships (PPP) to support LLIN distribution? Evidence suggests that ANC/EPI alone is not a sufficient channel to maintain universal coverage between campaigns, as data shows that coverage drops even with these systems in place. Evidence also suggests that pull systems (where community members request nets when needed) do work and can be equitable, efficient and effective. In general, markets are good at providing products that people need, when they need it and in their communities. As opposed to several years ago, most households in Africa now have experience having a net and like sleeping under nets. Public awareness of nets as a product has grown. At the moment, the 90% of LLINs are publically funded, which makes for a daunting market for a private company. However, there is increasing concern that current levels of donor financing may not be sustainable. As this level of financing is not secure, it would be prudent to begin constructing a process that can mitigate risk and allows households that can afford it to pay for the nets they need. Certain elements are needed to establish a market in a rational way that minimizes risk. Financing options include subsidies for those who cannot pay for a

net, at an appropriate level so that families that can pay for some of the cost can also have that opportunity. Rules and regulations will be needed. There is a call for much more field experience to provide the data on how this model may work. Issues that need to be considered are: (1) creation of an enabling environment, (2) strong communication between the public and private sector to foster partnership, and (3) how to target subsidies (risk, vulnerability, ability to pay). An upcoming pilot study in Ghana on subsidized sales may produce helpful data.

Discussion

- *Continuous distribution pilots*: It is not necessary to have the backbone of ANC/EPI structure for community pilots, although it does help streamline the process because community-distribution nets can be transported along with ANC/EPI nets.
- *Pakistan*: The Global Fund requires the government of Pakistan to contribute a certain amount of funds. Net use was estimated at 34%, and the SBCC strategy has been improved to target increased utilization. Nets arrive by sea and are inspected by the national malaria control programme, after which a private logistics company takes on the primary responsibility of moving the nets through the country. Currently LLINs are free, however in 2006 nets were available at a subsidized rate, but had trouble with the more well-off people in neighbouring areas purchasing them all while the target population could not access them.
- *Role of private sector*: Discussions regarding the role of the private sector should also include manufacturers. In Ghana, the project is working with manufacturers. It is under consideration whether it will be possible to engage the manufacturer to also move the supply in-country to retailers or if only suppliers and retailers will be involved.

Discussion on the Work Stream and proposed work plan 2015 - All

1. Conduct operational research to look at cost issues to compare different CD mechanisms, considering what structures already exist and where you have 'packages of interventions', such as iCCM, and what can be leveraged with 'economies of scale'.
2. Produce a standard methodology (templates, spread sheets) to help countries log the cost of their CD and do some modelling to see what could work with an economy of scale. The system would need to allow for comparability of costs.
3. Produce an algorithm to compliment NetCALC in helping countries move through a decision tree to figure out the best CD strategy for their context.
4. Bring together a small group that includes manufactures to come together on next steps and research needs for developing a private sector role/market.
5. Summarize the data to date on the question: What is the right mix of mass campaign and CD distribution?
6. Collect and disseminate more data that shows that high coverage can be maintained over time with CD.
7. Operational research to understand: What populations are being missed by the existing CD strategies commonly used? Tools to figure out who is missed, and guidance on how to reach them, as this is often a political or equity issue.
8. Examine and summarize the experiences of the Mekong region in using CD systems to reach special populations that are missed by campaigns, disseminate this summary widely (website, more).

9. The Harmonization Working Group (HWG) technical guidance on CD needs to be clarified. Review HWG guidance to ensure that the latest on CD is reflected, such that countries can use the most up to date recommendations to plan their CD strategies and that countries are incorporating evaluation and costing activities into their CD.
10. Train HWG consultants on the latest CD technical guidance for their work with country teams to write concept notes that have more robust CD strategies.
11. Continue to collect experiences and evidence: Call to ALL members to share their CD experiences with the group as we are still building the evidence base and urgently need more data and experiences. For example, experience from Pakistan can be documented and shared.

Aligning the Work Stream to the VCWG goals

- The CD Work Stream feels that it continues to be very aligned with the goals of the VCWG and supports the working group considerably through a large number of products and useful tools over the last several years, such as case studies, guides and data on CD.
- However, these tools need to be disseminated more and better.
- There is a need to do a better job of reviewing the HWG documents from a VCWG point of view, as this is an opportunity to translate policy and field studies into programming – need to do more to work closely with the HWG and capitalize on opportunities to inform country concept note development and technical guidance.
- The CD Work Stream should align more with AMP, the new toolkit and the HWG
- Manufacturers can be approached as a source of funding for VCWG (bearing in mind potential conflicts of interests).
- The “cost-share” of other systems that contribute to CD should be recognized, i.e., the support of teachers in school-distribution programs is not paid for by malaria programs or donors.
- Can we consider the value that CD may add to the structures through which it operates?

6th Insecticide Resistance Work Stream Meeting
9.30-12.00, Thursday 29th January 2015
Salle II, International Labour Organization, Geneva

Chairs: Janet Hemingway and Maureen Coetzee (represented by Basil Brooke)
Rapporteur: Lucy Tusting

Update on GPIRM implementation – Janet Hemingway, Liverpool School of Tropical Medicine, UK
 Six countries currently have plans for implementing the Global Plan for Insecticide Resistance Management (GPIRM), representing less than 10% of countries that need them. These plans are mainly reactive rather than proactive. The World Health Organization (WHO) is assembling a framework document for countries to use as a template for their insecticide resistance management (IRM) plans. Two examples of countries with well-developed plans are Bioko, Equatorial Guinea and Zambia. Despite having good plans the operational implementation of these plans remains challenging. In Bioko, large scale long-lasting insecticidal net (LLIN) distribution and island-wide

pyrethroid-based indoor residual spraying (IRS) were conducted before a switch to bendiocarb IRS for eight years, after the detection of kdr-based pyrethroid resistance. Despite kdr, there is evidence that pyrethroids remain operationally effective. Therefore a bendiocarb-deltamethrin annual rotation has been implemented. Pirimiphos-methyl remains a reserve option should this rotation fail, but was considered too expensive to include initially despite the greater treatment longevity. In Zambia, two major vectors (*Anopheles funestus* and *An. gambiae sensus stricto*) are resistant to carbamates and pyrethroids and pyrethroids alone respectively. A mosaic pattern of insecticide use, driven by the prevalence of the different vectors has therefore been implemented. However, due to the increased cost, coverage has been reduced in a format that may adversely impact on disease transmission.

Widespread pyrethroid resistance is now a major problem. Getting new active ingredients (AIs) to market quickly is imperative; large-scale Randomised Control Trials over many years to document efficacy may be unrealistic given the urgency. The increased cost of new strategies needs to be budgeted for. With regards to testing for insecticide resistance, there has been considerable debate over whether to use the WHO bioassay or CDC bioassays, but both these assays in their current formats are only an indicator that a problem may be developing. Given the recent emergence of 100-fold plus resistance in some countries we need to have some form of field based intensity assay to differentiate low level non-operational kdr resistance and higher level resistance that will impact operationally. There are also quality control issues with the current assay system; some WHO bioassay tubes are unusable even when new. It is unacceptable that good quality basic equipment is not available to countries at a time when we are pushing them to test and report on resistance.

Discussion

- *Advocacy for GPIRM:*
 - Many in the malaria control community have previously focused on resistance to artemisinin. However, it is now more widely recognised that IR poses a greater threat. Other health concerns (Ebola) have demonstrated that the global health infrastructure can react rapidly to health emergencies. Thus, it may be helpful for the VCWG to submit a position statement to draw attention to IR and to encourage rapid action.
 - The issue is not simply technical; it is highly political. While we have a sound technical document (GPIRM), we have failed to advertise this. Artemisinin resistance management plans have been well implemented through political support and resource allocation. Politicians in country and especially within ministries of health need to understand the seriousness of the situation. A new Lancet paper representing academia, the Global Fund (GFATM) and CDC amongst others will draw attention to this also.
- *Bioassay quality control:*
 - WHO must be informed of any quality issues in its bioassay products and should consider alternative manufacturers.
- *Supporting GPIRM implementation:*
 - The VCWG should support additional countries in developing IR management plans. However, more than a gap in technical support, the additional cost is also an issue. It is critical to plan for the increased cost of switching AIs. Global Technical Strategy

costing account for this increased expense. Strategizing and prioritising countries in terms of severity of IR may help.

- A new call for GFATM proposals will soon be announced. Although the amounts awarded will be relatively small (USD10-20m), an IR proposal could be put forward.
- A request was made for the development of specific guidelines for resistance intensity assays to be made available as soon as possible.
- *Alternative products:*
 - There are two bottlenecks in the system; both at the product development level and also in establishing how effective products are and where and how they should be implemented. An emergency testing plan for new AIs and products could be developed.
 - We may be at a good juncture to introduce fungi and other biological control agents in addition to or instead of chemical control. These have been shown to be effective and at reasonable cost. However, issues of formulation stability previously highlighted by proof of concept work funded by IVCC have yet to be resolved.

Insecticide resistance: global status and databases – Tessa Knox, WHO-GMP, Switzerland

A brief overview of the draft WHO Global Technical Strategy for Malaria 2016-2030 was given, in which IR is highlighted as a major obstacle to achieving malaria control targets. There remains poor awareness of GPIRM among member states, despite it being released nearly three years ago (in May 2012). Therefore continued advocacy for GPIRM is essential. GPIRM has a five pillar strategy, a major component of which is effective data management. In 2014, data consolidation for the period 2000-2014 was undertaken using a standard data form with major input from academia, other partners and NMCPs, in particular the Malaria Atlas Project (MAP) and President's Malaria Initiative (PMI). After data cleaning, georeferencing and validation in collaboration with countries, specific outputs include detailed reports and maps of subnational data, automated data and map summaries and data for the World Malaria Report 2014. Country entomological capacity and IRM plans were also reviewed.

The most recent findings were presented. Although data validation and confirmation is ongoing, 81 countries have so far reported data from 1947-2014, with a total 13,533 bioassay data points. Applying a standard filter to the data to include only standard insecticides and doses, the number of data points reduces slightly to 11,932. The greatest gap in the database remains data on mechanisms of resistance. A map of reported insecticide susceptibility status for malaria vectors was presented for 2010-2014. Reporting is good for west, east and central Africa, with fewer data for Asia and the Americas. Six countries have comprehensive national IR management plans. Many countries with confirmed resistance have yet to finalise plans; this is especially so outside Africa. 45 countries and 58% surveyed sites have confirmed resistance to pyrethroids (Figure). 49 countries and 33% surveyed sites have confirmed resistance to multiple insecticide classes. Preliminary analyses indicate an increase in resistance testing for all four insecticide classes. It is difficult to ascertain whether the distribution and intensity of resistance have increased. Poor data quality, management and sharing remain a challenge to documenting IR. A new WHO *Framework for Development of National Resistance Monitoring and Management Plans* has been drafted and feedback from the VCWG is welcomed. Future WHO plans for addressing IR and entomological capacity were outlined; these include support to countries for developing IR plans, the inclusion of

additional mechanisms data in the global database, bi-regional training, the development of a global insecticide resistance response plan and advocacy for action and resource mobilization. The VCWG has a key role to plan in supporting IR management plans, data collection and advocacy.

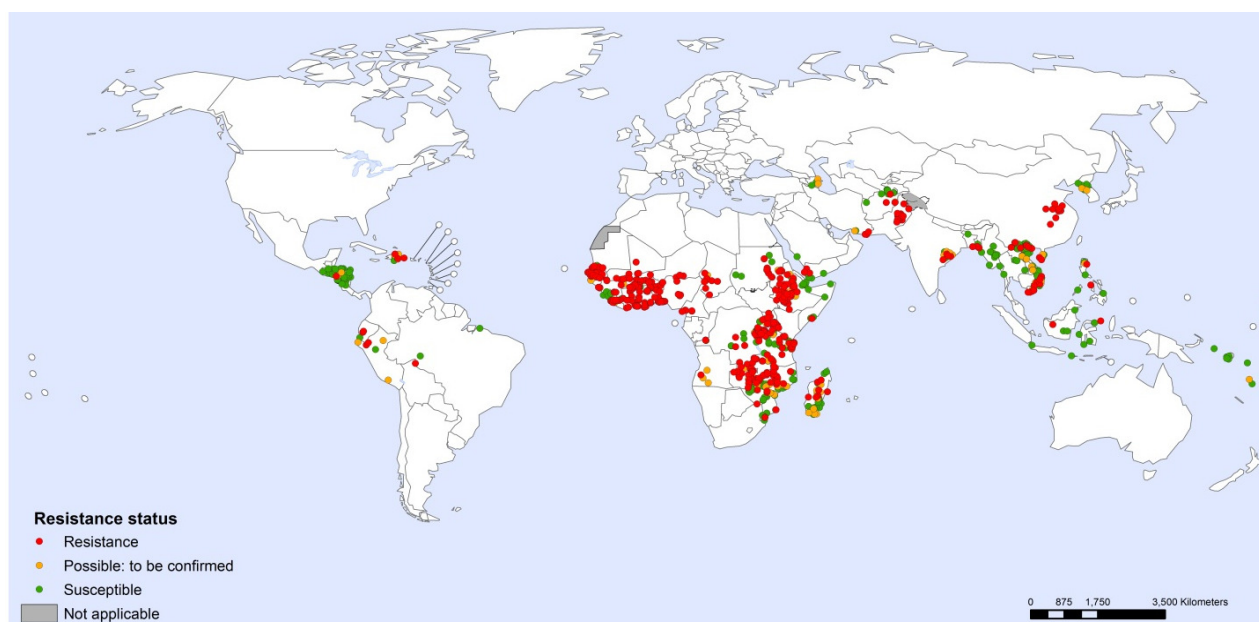


Figure. Reported pyrethroid susceptibility status for malaria vectors (2010-2014). Source: WHO.

Discussion

- *IR data:*
 - Many countries lack the human and financial resources to collect IR data and this account for the lack of reporting. However, it is important that these countries confirm that there are no data.
 - Introducing additional concentrations into IR data collection gives some indication of intensity.
 - IR Mapper is a freely available database with information on resistance and susceptibility (<http://www.irmapper.com>). However, this mainly uses published data.
- *Selection of AIs:*
 - There is a critical need for specific recommendations on which AIs to use and when. Detailed advice in this regard may incentivise country data reporting. While there is a large body of IRM data from the agriculture sector, there is very little to support specific recommendations for *Anopheles*. Despite this, it is important to make rapid decisions based on currently available data.
 - The Kenyan IRM plan remains in draft form because not all classes have been registered for public health in country. It is important to keep country registration updated.
- *Training:*
 - Regional training should be focused in areas of high resistance intensity. Due to the Ebola response, a recent training was cancelled however a meeting is planned for 2015.

- A request was made for capacity development/training in the central African region (CAR, DRC, Congo-Brazzaville, Angola) from where there is no data.

Serious gaming for resistance capacity development – Marlize Coleman, Liverpool School of Tropical Medicine (LSTM), UK

Dissemination and communication is critical on the pathway from the collection and synthesis of evidence to its translation into policy, practice and impact. How can the success of dissemination and communication be improved and measured? Serious gaming uses entertainment to further government or corporate training and education. While serious games are used for education in the military, history and some areas of science (e.g. genetics), nothing exists for vector control. Yet meta-analyses have shown that serious gaming can have a major impact on learning and knowledge. To investigate whether end users within vector control would embrace gaming, a pilot game was developed and trialled in Zambia (15 participants) and Malawi (8 participants). The results suggest that serious gaming may be well received and that it may help to improve the understanding of IRM and its role in vector control. Moving forwards, the aim is to develop a communication and learning tool to support traditional training and IRM. The pilot game is available online and VCWG feedback is welcome. A demonstration of the game was given.

Discussion

It was clarified that the game can be played on both Macs and PCs. It was suggested that a different name might be more serious. It was agreed that the tool will make IRM more interesting to control programme managers.

Discussion – All

- *Data collection and interpretation:*
 - IRM planning tends to be reactive and is also complex since the IR situation is constantly changing and is not uniform across a country. An explicit plan and country support for data interpretation is needed, while ensuring that unnecessary complexity is not introduced.
 - Since some countries introduce new AIs without baseline testing, it is important to continue advocating for data collection.
- *GPIRM implementation:*
 - While planning must be partly reactive, proactive planning is also crucial to preserve new tools.
 - Monotherapy should not be used in vector control since it is a guarantee of resistance in due course. GPIRM recommends combinations and rotations and we must strongly advocate for this.
 - It was suggested that GPIRM should be revisited to emphasise biological agents, housing and larviciding as IRM tools. For example, larviciding uses different classes of chemical insecticides and biological agents with different modes of action to the four classes available for adult vector control and can reduce overall density. In addition, two companies have developed combination LLINs as interim tools (Olyset Plus and Permanet-3). Since these are already available, it would be helpful to have consensus on their use.

7th Durability of LLINs in the Field Work Stream Meeting
13.00-15.00, Thursday 29th January 2015
Salle II, International Labour Organization, Geneva

Chairs: Albert Kilian and Steve Smith
Rapporteur: Gabrielle Hunter

Introduction – Steve Smith, Centers for Disease Control and Prevention (CDC), USA

Stephen Smith opened the meeting with an overview of progress of the Work Stream over the course of these meetings. In 2008, physical durability of LLINs became recognized as a determinant of net lifespan in addition to insecticidal residue and effectiveness. The Work Stream has sought information that can be useful for programs and procurement. The field has moved from collecting data on net age, holes, size and location, to using a composite score of net condition ('proportionate hole index'), to developing mechanisms to account for loss of nets in the field. Over the years we have seen that several environmental factors have a major effect on physical durability and different performance of brands in same setting. As a result, it is recognized that programs need to routinely monitor net condition. There is also research on behavioural aspects of net use, care, and repair. Research on mosquito entry through holes of differing shape, size, location, and residual insecticide, as well as on the causes of damage has been looked into now, and this has moved us towards lab tests to attempt to predict durability in the field. The topic is very complex, but it is hoped that it will yield information that is useful for procurement. The question for this meeting is: What steps do we need to complete this process?

Mosquito entry through holes - Jim Sutcliffe, Trent University, Canada

Jim Sutcliffe shared initial findings from the Failed Net Project, researching how to assess the correlation between degradation of a net and the risk of mosquito entry. These results can help assess net serviceability. The two primary research questions are: (1) how do mosquitoes interact with holes on a bed net? and (2) where on a net do mosquitoes tend to 'go' (mosquito 'pressure' on the net)? For both questions, video footage of mosquito behaviour in a lab setting was analysed. It was found that *Anopheles gambiae* do not actively orient to holes but encounter them by chance during their two dimensional searches across the net surface, and may fly across holes several times before entering by chance. The most important characteristics of a hole that correlate to mosquito entry through it are hole circumference and width. Monte Carlo simulations indicate that the larger the hole in width and circumference, the greater the probability of entry. The experiments also detected that sticky paper placed on a roof of a net captured 40 times more mosquitoes than sticky paper placed on any other section of the net, corresponding to greater probability of mosquito entry through holes in the roof. In summary, a small hole anywhere on the net has very little chance of permitting entry, while a medium hole will let in a few if on the side of a net, but much more if on the roof. A very large hole will allow entry no matter where it is and a highest number of mosquitoes if on the roof. Future research will be done to estimate the effect of insecticide on a net with holes, address irregularly shaped holes, and to test in semi-field conditions. Combining this data with EIR will give a fuller picture of malaria risk posed by holes in nets. Note that mosquito density needs to be taken into account for all of these trials. Four data points are proposed for estimating mosquito entry risk into a damaged net in the field: hole circumference, hole location, hole width, and mosquito density (the latter being the only data point that cannot be collected by simply observing the net). Ideas for the future include developing an image processing method to extract this data

from photos of net holes and developing a spread sheet application to help apply this method in the field.

Discussion

- Mosquitoes are attracted to the roof of a net because body odour and heat rise through the roof.
- It is expected that the presence of insecticide will not affect the locations of mosquito pressure on a net, but likely will affect mosquito entry probability.

Textile testing: the resistance to damage index and its potential application -- Steve Russell, presented by Albert Kilian, Tropical Health LLP, Spain

There are four facets of net durability in a place and time: behaviour, environment, textile properties, and insecticidal properties. What is currently needed is a way to use laboratory textile tests to predict field performance of nets. The scope of the R4D study is to determine real mechanisms of damage in the field, create a library of net damage categories, generate a suite of textile test methods, and use these to quantify a net's resistance to damage (RD score) to provide better performing LLINs. The study has examined 526 damaged nets collected from the field and found that in all settings, mechanical damage to nets was the most common. Studying the different types of mechanical damage, such as snags and tears, has led to the development of four textile tests of resistance to mechanical damage: snagging, tearing (bursting strength), abrasion resistance, and hole propagation. These tests are intended to represent a reasonable force comparable to daily use. In the absence of data to inform otherwise, each of the four will contribute 25% of the total RD score. At this point, this proposal as a textile lab test is with WHOPES. After that, RD score will need to be validated against field data to evaluate the longevity expected for a certain RD score. To accelerate the process, operations research in an experimental setting is proposed, in which standardized stress can be applied repeatedly and allow for comparison in a short time, as opposed to field testing, which requires 3-4 years and behavioural and other factors may 'dilute' the correlation with RD. In addition, in experimental setting promising new prototypes can be used, too. The RD score is still in its early stages, but there is much potential for it to become a metric to inform procurement and development of new products.

Update on ABCDR study in Tanzania - Lena Lorenz, London School of Hygiene & Tropical Medicine (LSHTM), UK

The ABCDR study in Tanzania includes 3420 households in 76 villages. They have done a retrospective study of durability of Olyset as phase 1, and then for phase 2, a prospective study on three brands: Olyset, Permanet-2, and Netprotect. They will compare durability over 3 years, attrition, physical degradation, and bio-efficacy within a sub-sample. In the first phase of the study, they found 6,537 nets in households; 77% were LLINs, 96% of these were Olyset. Using the color, they can determine whether the net is from the universal coverage and under five mass campaigns or from the ANC/EPI voucher program. Calculations of attrition were made more challenging by the fact that it was difficult to differentiate nets from the two mass campaigns (a call to better identification for nets at the time of manufacture, as the labels had fallen off). WHO tests for insecticide bio-efficacy using the cone test on samples of Olyset nets showed that 76% of nets failed; however, when failing nets were tested by the tunnel test (blood feeding inhibition) only 5% of nets failed (this is typical for the permethrin treated Olyset LLIN brand). Using HPLC analysis of the permethrin residue, 23% of three year old nets showed mean concentrations of less than 15g/kg considered as too low. According to the WHO cut-off, 34% of the nets were too torn after three

years. In the second phase of the study, 10,000 nets were distributed in October-December 2013 in equal numbers of the three brands. Follow-up at ten months yields some preliminary data: roughly 15% of nets were no longer used for sleeping, primarily because nets were 'too damaged' for use. Of the nets that were lost, 84% were reported to have been discarded, thrown away or burned. Approximately 70% of the nets were in use the previous night. For physical degradation, 32% of the nets had no holes, 68% had some holes. Using the proportionate hole index, nearly 90% of the nets were considered serviceable according to WHO standards. Additional analysis and future data collection is pending. The team will look at questions such as the correlations between net loss and degradation with the environment, household, sleeping space and individual user, as well as what happens to nets that are no longer deemed useful. The behaviour of the net user and how the net is used in the household are very important factors.

Discussion

Textile testing:

- The RD score tries to predict resistance to mechanical damage, so the denominator is less important. This evidence is being gathered now to have some kind of metric that has correlation with the field.
- At a meeting in August 2014, there was concern that the abrasion test would not be valid, and perhaps should be replaced or modified for the RD score to be useful. It is not clear if any progress has been made to date on this issue.
- The different RD tests reflect different textile criteria, for example, some test denier others the knitting pattern. However, this Work Stream is not the forum for these technical issues. Rather the durability Work Stream should define the research and advocacy agenda.
- There is the question whether durability testing is a tool that manufacturers should take on as their responsibility to improve their products.

Informing procurement decisions:

- It is appropriate for this Work Stream to push for the field validation of RD score, without which it cannot serve its intended purpose. In addition, much wider monitoring of LLIN durability per WHO guidelines should take place. All programs should be doing this for every large procurement and delivery of LLIN. A large pool of data is required to inform procurement, and this Work Stream can disseminate findings with the HWG, Global Fund, PMI and others.
- Although it may be more feasible for programs to simply monitor LLIN attrition in the field, the data regarding LLIN attrition indicates that there is no difference in attrition by brand or type of net. Therefore, the simple measure of attrition cannot inform procurement decisions. It is necessary to monitor holes and physical integrity in order to find a difference across brands and support procurement decisions and justify production of a more durable net.

Future of the Work Stream:

- In general, the Work Stream is moving in the right direction for producing the evidence to inform procurement, however, the pace needs to move faster.
- Without the data that this Work Stream is producing it is very difficult for the manufacturers to move forward with any new products. Therefore, this work is critical. An improvement in

quality of nets is more realistic if there are strong testing methods with minimum entry specifications.

- This Work Stream is important and there is a need to coordinate durability with insecticide resistance; as resistance increases the physical barrier that nets provide becomes even more important.
- The Work Stream needs to support implementation in the field of current monitoring guidelines so that more data can be produced to justify a longer lasting net. Capacity building on LLIN monitoring needs to be undertaken, as does capacity building on how to use the resulting data.
 - Produce a guidance note, monitoring tools, and capacity training – these can be hosted on a website.
 - Data consolidated by the Work Stream will also inform program planning decisions.

Proposed 2015 Work Plan

1. Continue to define the research agenda for durability.
2. Continue to collect the body of evidence (through the work of the members and other groups) on durability, and in particular the RD score validation. This evidence is what may eventually justify production of a longer lasting net, so it is important.
3. Define the best practices for measuring LLIN durability.
4. Provide the tools to inform procurement decisions.
5. NMCPs want to start monitoring durability, this Work Stream can produce:
 - a. A **brief guidance note** on operationalizing durability monitoring in the field for malaria programs to monitor field performance and **plan LLIN distributions**.
 - b. **Tools** to collect and use durability data.
 - c. **Capacity building training modules**/manual on how to do monitoring, using tools.
6. Sharing information is a useful function of the Work Stream to its members, who mention that this is one the most important groups, as it is consolidating and sharing much-needed data with the Global Fund and others regarding procurement and also informing industry on what the malaria community needs. Therefore, to maintain the discussion and efforts moving, the Work Stream can encourage more regular discussion and knowledge sharing through more meetings during the year, calls or virtual meetings.
7. Establish a compilation of data: an online repository of durability data for scientific exchange.
8. Team up to write a proposal to develop prototypes of LLINs that can withstand some of the durability problems.
9. Advocate to manufacturers to make LLINs more distinguishable for retrospective studies (labels fall off).
10. Articulate the link between insecticide resistance and durability issues; these need to be looked at together, especially as resistance grows.

Next steps for the Work Stream

- Circulation of action points to the meeting participants and request feedback.
- Activities will be defined and delegated as appropriate.
- Initiate virtual meetings (phone or web) to continue sharing information and move products forward and gauge if there is interest in regular participation in this type of meetings.

6th Larval Source Management (LSM) Work Stream Meeting
13.00-15.00, Thursday 29th January 2015
Salle XI, International Labour Organization, Geneva

Chairs: Steve Lindsay and Silas Majambere

Rapporteur: Lucy Tusting

Steve Lindsay opened the meeting and informed participants that Silas Majambere has been appointed as co-leader.

Control of malaria vectors by the auto dissemination of insecticides – Silas Majambere, Ifakara Health Institute (IHI), Tanzania

Silas Majambere presented work on behalf of Dickson Lwetoijera, Samson Kiware and Gerry Killeen. More vector control tools are needed to complement long-lasting insecticidal nets (LLINs) and indoor residual spraying (IRS) to address outdoor transmission and for insecticide resistance management. A key challenge in LSM lies in targeting the most productive larval habitats to ensure cost-effectiveness. The concept behind auto dissemination is that mosquitoes are exposed to pyriproxyfen (PPF) while resting and that aquatic habitats are then contaminated during oviposition. Semi-field testing facilities at Ifakara Health Institute are ideal for this work. The first component of the study was to identify resting preferences for *Anopheles arabiensis*. Second, it was demonstrated that treatment of sites with PPF reduced the number of adult mosquitoes produced from larval habitats (Lwetoijera *et al.* 2014, *Malaria Journal*). Third, a pilot study of auto dissemination to larval habitats was carried out. Auto dissemination was associated with an 82% reduction in mosquito emergence. New modelling work predicts scenarios for successful auto dissemination of pyriproxyfen (Kiware *et al.* under review, *PLOS ONE*). The study will move to small field settings in June 2015. Funding from the Bill and Melinda Gates Foundation was acknowledged.

Discussion

Auto dissemination circumvents the argument that larval habitats should be 'few, fixed and findable'. This intervention might be combined with attractants; however, attractants tend to attract unfed mosquitoes. Future work will evaluate contamination of the hydrology system in the area. It was queried how safe it is to have PPF on the ground and whether the intervention is scalable. PPF has a long shelf life if not exposed to the sun in clay pots.

EMIRA-a LSM partnership project based on the wide-scale use of Bti against malaria vectors in Nouna, Burkina Faso – Norbert Becker, German Mosquito Control Association, Germany

EMIRA stands for Ecological Malaria Reduction for Africa. The aim is to transfer LSM technology from the Upper Rhine Valley, Germany to Nouna, Burkina Faso. In the Upper Rhine Valley, the German Mosquito Control Association carries out LSM along a 320km stretch of the river through hand and helicopter application by 300 field workers. Between 1981 and 2013, a total of 329,000 hectares were treated with 4,250 tonnes of *Bacillus thuringiensis* subsp. *israelensis* (*Bti*). In treated areas, there is consistently a >95% reduction in adult mosquito density. The program has a resistance management component and no resistance to *Bti* has been found after 34 years of application.

EMIRA is a Manfred Lautenschläger Foundation-funded study in Nouna, Burkina Faso, a 6,000km² area with an annual entomological inoculation rate of around 140 infectious bites per person per year. Foot/h hoof prints are typical larval habitats. The study has three arms receiving: (1) full treatment (42 villages), (2) guided treatment using remote sensing (42 villages) or (3) no LSM. *Bti* treatment and larval surveillance are done every ten days by 160 field workers and adult mosquito catches are done every 14 days. The intervention has been well received by the local population. Preliminary results suggest an impact on adult mosquito density and parasite prevalence. The cost is USD 1.11 per person per year (PPY) for exhaustive treatment and USD 0.84 PPY for guided treatment.

Country update: LSM in Pakistan – Muhammad Mukhtar, Directorate of Malaria Control, Pakistan

An overview of LSM in Pakistan from 2000 to 2012 was given. Malaria and dengue are the two major vector-borne diseases in the country. Dengue incidence has increased, with the total number of confirmed cases increasing from <800 during 1994-2003 to 75,798 confirmed cases during 2005-2014. The primary vectors are *An. culicifacies* and *An. stephensi* (malaria) and *Stegomyia (Aedes) aegypti* and *St. albopictus* (dengue). Interventions include larviciding, habitat modification and manipulation, supported by community participation and intersectoral collaboration. Specific case studies were described including: (1) environmental management (vegetation removal) of water holding ponds, (2) construction of water holding ponds with vertical, circular walls, (3) treatment of drinking water storage tanks in Balochistan, (4) environmental management of water tanks and fish ponds in the South Punjab and (5) dengue control in Khairpur district, which is supported by new legislation.

Discussion

It was queried how the health impact of the LSM program in Pakistan is evaluated. LSM implementation in Pakistan is clearly successful due to strong political support. It was queried whether the program will be sustainable when incidence reduces and commitment wanes. In Germany, nuisance biting is a political issue and an incentive for re-election.

Discussion – All

- *Role of the Work Stream in capacity building and providing technical assistance (TA):*
 - There is an urgent need to address the practicalities of providing TA including: (1) RBM funding for short visits and (2) regulation of TA if not provided by WHO.
 - While some countries have internal expertise, it would be useful to consult independent advisors also.
 - LSM is a strategy requiring much entomological expertise. Resources might be pooled to build capacity for both IRS and LSM. Building capacity to collect programmatic evidence would be valuable.
- *Implementing LSM:*
 - LSM is already being implemented in a number of countries and by the private sector. Therefore, the priority is no longer to establish whether it is appropriate, but to support countries. It is important to start small and evaluate before scaling-up. Unless LSM is tested in new settings, the evidence base will not be strengthened.
 - Application equipment for larviciding needs further consideration.

- Community understanding and support can be powerful. Community-led LSM may not be sustainable without payment.
- *Global policy development:*
 - LSM is hampered by the ‘few, fixed and findable’ concept. While this expression is alliterative and memorable, it may not be well thought through, especially the ‘few’ component. An alternative is ‘concentrated, immobile and accessible’.
 - Alternative application equipment may facilitate LSM in areas considered unsuitable e.g. aerial application can be used for large flood plains.
 - It was clarified that there are many rural parts of SSA where LSM can work, such as the Kenyan highlands.
- *Advocacy for LSM:*
 - LSM may have a role in (1) managing insecticide resistance, (2) malaria elimination (LSM played a role in malaria elimination in most countries that are now malaria free; interventions not solely focused on the house are critical) and (3) outdoor, residual transmission.
 - LLINs are easy to raise money for since they are simple and appealing. It may be helpful to publicise information on the cost per person protected (e.g. Worrall and Fillinger 2011, Maheu-Giroux and de Castro 2014). Demonstration of the impact of LSM in-country will also help to attract funding from donors.
- *LSM in ECOWAS:*
 - It is important that only WHOPEs approved larvicides are used by member countries. The Labiofam product should not be recommended for use by countries until it has completed evaluation by WHOPEs.
 - There is a need to insist that countries use WHOPEs-approved larvicides and carry out quality control.

9th Outdoor/Residual Malaria Transmission Work Stream Meeting

15.30-18.00, Thursday 29th January 2015

Salle II, International Labour Organization, Geneva

Chairs: Marc Coosemans and Mike Reddy

Rapporteur: Lucy Tusting

Summary of the 8th Meeting in New Orleans, November 2014 – Mike Reddy, Bill and Melinda Gates Foundation (BMGF), USA

Consensus on the core Work Stream statement was reached: *‘To develop a research and operational implementation agenda to address malaria transmission that is maintained (often at a low level) despite high coverage of long-lasting insecticidal nets (LLINs) and indoor residual spraying (IRS) and which is not related to insecticide resistance.’* It is yet to be decided whether the Work Stream should be named ‘Outdoor’ or ‘Residual’. Stakeholders agreed on the benefit of regional networks to

sustain interest and outline a research agenda for outdoor/residual transmission. Existing partnerships are already in place in each region that can be engaged with. The inclusion of Indonesia as a fifth outdoor transmission Regional Hub was discussed. It was agreed that the regional hubs should collect as much information as possible on mosquito behaviour. There was also discussion of an extension from 'outdoor' to 'residual' aims, which could be approached as follows: (1) establish regional networks in Mekong, Africa and Amazonia, (2) develop guidelines on and estimate the importance of residual transmission, (3) develop guidelines on and estimate malaria risk in specific populations exposed to outdoor transmission (soldiers, forest workers, migrants, mobile populations), (4) outline a strategic plan for the research and development of new tools and (5) establish a network of communications and mutual technical support amongst stakeholders, including an effective 'feedback system' to relay the operational impact of any new tools or evaluated to address residual transmission. A summary of the presentations at the 8th meeting was given; these included regional updates and briefs on the Innovative Vector Control Consortium (IVCC) and BMGF Grand Challenges Explorations.

Key messages from working groups on outdoor/residual transmission – Marc Coosemans, Institute of Tropical Medicine of Antwerp, Belgium

Residual malaria transmission is that which persists despite universal coverage with effective LLINs and/or IRS, due to outdoor, early evening and morning biting vectors and human behaviour. Most exposure to infectious bites occurs indoors at night. However, in many areas early evening and morning biting is also prevalent. This is true of much of South America (Killeen 2014, Malaria Journal). Two World Health Organization (WHO) working groups have been convened to address residual transmission. Key messages are that (1) universal LLIN and/or IRS coverage remain an absolute priority; all other methods are supplementary, (2) there is a need to collect local data on the proportion of transmission occurring outdoors and (3) there is a need to develop new tools to address outdoor transmission. Both Grand Challenges Explorations Round 14 and IVCC have specifically called for proposals on outdoor transmission.

Novel tools for sampling outdoor-biting mosquitoes: the Suna trap and long-lasting attractants – Alex Hiscox on behalf of Willem Takken, Wageningen University, The Netherlands

Given the ethical issues surrounding human landing catches (HLC), an alternative, standardised tool for monitoring outdoor biting mosquitoes is needed. Preliminary work to develop a fabric prototype began in early 2012 by Wageningen University and the International Centre of Insect Physiology and Ecology (ICIPE) in Kenya. The first full 'Suna' trap prototype was developed mid-2012, with a solid metal cone replacing the fabric, a plastic mesh base and the introduction of a CO₂ release pipe. Subsequently the flexible plastic mesh base was replaced with a rigid plastic mesh base and the final trap was created in early 2013, entirely made of plastic. Concurrent work has investigated long-lasting attractants that mimic human hosts, resulting in the development of the Mbita-5 odour blend which remains attractive to *Anopheles gambiae* sensu stricto after four months of field use. The Mbita-5 blend was tested also in the MM-X trap. Free flight and semi-field behavioural experiments showed comparable performances between Suna and MM-X traps. The next stage of development was to investigate trap positioning outside houses, which in the western Kenya region have mud walls and iron roofs. 30cm above ground level was found to be the ideal height. The SolarMal trial is now underway on Rusinga Island in western Kenya, to evaluate a solar-powered mosquito trapping system (SMoT). Odour-based Suna traps have been installed outside 4200 houses. Primary

epidemiological outcomes are clinical malaria incidence and parasite prevalence in addition to entomological outcomes. The next steps are to compare the Suna trap with HLC inside and outside houses, to test the traps on other continents and in different settings, to investigate the use of molasses fermentation as a source of CO₂ (Mweresa *et al.* 2014, *Malaria Journal*), to modify traps to preserve the condition of trapped mosquitoes and to investigate whether the baits can be made more long-lasting.

Some recent advances in outdoor mosquito control technologies for residual vectors – Fredros Okumu, Ifakara Health Institute, Tanzania

Malaria transmission remains high in parts of north and west Tanzania, but has declined in central districts. However, maintaining progress here is important. A close correlation between outdoor human activities and vector biting times has been observed (Moshi *et al.*, unpublished data). Complementary outdoor interventions are therefore needed to address residual transmission. After behaviourally active compounds were identified in the laboratory, experiments in semi-field systems were used to finalise a synthetic blend. In field settings, this blend was demonstrated to attract more mosquitoes than humans alone. Mosquito landing (Nancy) boxes have been developed to electrocute and kill mosquitoes; these contain an odour dispensing system and fan. Mosquito landing boxes can also be used to provide lighting for local people. Field data has shown that local residents are able to predict accurately where the greatest mosquito densities are found nearby which makes it easy to position Nancy boxes. The next step is to conduct a small before-and-after trial. The support of Grand Challenges Canada, BMGF and the Wellcome Trust was acknowledged.

Discussion

It was queried whether the Suna trap was comparable to HLC and whether the need for CO₂ is sustainable. Mass molasses fermentation or channelling of human odours from houses may be possible. The Nancy box might be scaled-up through local cottage industry or 3D printing.

Outdoor sleeping and other night-time activities in northern Ghana: implications for malaria prevention – April Monroe, Johns Hopkins University Center for Communication Programs (JHUCCP), USA

Malaria prevalence is persistently high in northern Ghana and it has been hypothesised that exposure during time spent outdoors at night is partly responsible. In-depth interviews and observations were carried out during February-March 2014 (late dry season) in two villages. At least 20% of people were observed to be outdoors (either active or asleep) at any point during the night, with the majority of the population outdoors and active in the early evening. Typical activities at different times were described. 42% of observed participants slept outdoors at some time during the night, with heat cited as the most common reason. Of the 69% of people with access to a bednet, only 17% slept under one. Among the recommendations were similar studies conducted in different seasons and research on the acceptability and feasibility of outdoor net use. Support from the President's Malaria Initiative was acknowledged. The results are in press (*Malaria Journal*).

Discussion

- Participants knew they were being observed. Although there was initially some reactivity, the observation time was sufficiently long for this to lessen.

- Encouraging outdoor LLIN use has the caveat that LLINs left outside during the day will be damaged by UV light. Making LLINs more portable may help.
- Both communities studied were specifically selected because they had received IRS yet malaria transmission remained high. This precludes comparisons of IRS and non-IRS communities, which merit future investigation. It would also be interesting to investigate yearly variation in sleeping patterns and the effect of electricity access/power failures, which encourage people to be outside.

Spatial repellents for vector-borne disease control – Nicole Achee, University of Notre Dame, USA

Spatial repellents are products designed to release volatile chemicals into the air and to prevent human-vector contact within the treated space. It is hypothesised that their deployment in enclosed/semi-enclosed spaces will reduce pathogen transmission. Mechanisms of action include: (1) movement away, (2) attraction-inhibition and (3) feeding inhibition. Spatial repellents can contribute to reducing outdoor and residual transmission by addressing day, early evening and/or outdoor biting. They may also have a role in insecticide resistance management, since they have a different mode of action. Spatial repellents could potentially be used in many different housing types and might help increase intervention coverage since they are consumer products. A randomised controlled trial of mosquito coils in China and another trial of a spatial repellent in Sumba, Indonesia give preliminary evidence for the efficacy of spatial repellents in semi-enclosed spaces. WHO *Guidelines for Evaluation of Spatial Repellent Products* are now available. Study design for proof-of-principle studies was discussed at a Vector Control Advisory Group (VCAG) review in February 2014 and will be discussed at an IVCC Expert Scientific Advisory Committee meeting in February 2015. A newly funded BMGF program led by Notre Dame will evaluate the effect of transfluthrin on malaria and dengue transmission at multiple sites in Africa, Asia and South America.

Evaluation of topical repellents in Cambodia – Marc Coosemans, Institute of Tropical Medicine of Antwerp, Belgium

An overview of the MalaResT project was given, the aim of which was to study the added value of repellents to LLINs for the control and elimination of malaria in Cambodia. 140 villages were selected in Ratanakiri province. Picaridin repellent was used, which was shown to give >95% protection against biting by malaria vectors for up to five hours (Van Roey *et al.* 2014, Plos Negl Trop Dis). Baseline malaria prevalence was similar in both the LLIN + repellent arm and the LLIN alone arm. After the implementation of the intervention, there was no difference in prevalence, serological measures and malaria incidence by passive case detection. Qualitative work suggested that despite high acceptance (>90%) and reported use (47-76%), observed daily and consistent use was low (7-15%). Contact with repellent distributors was closely associated with repellent consumption. The main conclusion is that while Picaridin is effective and can give personal protection against malaria, there was no overall effect on prevalence, possibly due to low coverage overall. This concurs with the results of a recent meta-analysis that indicate considerable heterogeneity between studies, most likely due to variable levels of compliance.

Discussion

- While the results of the MalaResT suggest that topical repellents are not recommendable as a community intervention in this setting, they can offer personal protection. The lack of observed protective efficacy may be attributable to low repellent use combined with high

LLIN coverage in a low transmission area. Since the efficacy of topical repellents is dependent on human behaviour, the results may not be generalizable elsewhere. However, achieving a high coverage (effective daily application by all members in the community) to induce a mass effect on the vector population is challenging.

- Reasons for low compliance were discussed. Picaridin was used because the smell is more acceptable and it does not dissolve plastic like DEET, but is as effective. It was queried whether protection lasted for less than five hours when potentially rubbed off by clothes/sheets. Children were less protected than adults because they were reliant on application by others.
- Diversion of biting by topical/spatial repellents is a major issue.
- There was some discussion of the definition of spatial repellents presented by Achee. It was clarified that there are six currently available volatiles labelled as repellent. To move the paradigm forward, it is necessary to work with these, even though they may not be repellents in the strictest sense. A broad definition also encompasses new active ingredients in the pipeline.

General discussion issues – All

The discussion centred largely around the possible extension from an outdoor to residual transmission focus, as outlined in the presentation by Mike Reddy. The value of smaller regional hubs to bring together entomologists, social scientists, chemists and epidemiologists was agreed upon. These would require a paid secretariat to maintain mailing lists and organise meetings. Those whose primary area of work is outdoor/residual transmission should be identified. It was also noted that residual transmission is poorly characterised and data sharing could be improved. In closing, Marc Coosemans thanked all participants and highlighted that a key strength of the Work Stream was to encourage partnership between different disciplines.

Day 3: Friday 30th January 2015

**6th Capacity Building for IRS Work Stream Meeting
8.30-11.30, Friday 30th January 2015
Salle XI, International Labour Organization, Geneva**

**Chairs: Manuel Lluberas and Dereje Dengela
Rapporteur: Lucy Tusting**

Dereje Dengela has been appointed as co-leader, succeeded Shiva Murugasampillay.

IRS in Pakistan - Muhammad Mukhtar, Directorate of Malaria Control, Pakistan

Malaria is a major public health problem in Pakistan. Indoor residual spraying (IRS) is a core vector control component of the National Malaria Control Strategy, which is based on (1) early diagnosis and prompt treatment, (2) multiple methods of prevention (indoor residual spraying (IRS), long-lasting insecticidal nets (LLINs), larval source management (LSM)), (3) epidemic preparedness and (4) behavior change and communication. The current goal is a 60% reduction of the annual parasite

incidence between 2010 and 2020. Pakistan has had well-defined guidelines for IRS since the 1960s and these were updated in 2007 and 2014. IRS is carried out before the main transmission season. Data on coverage in 2013 and 2014 was presented. Despite a 20-25% increase in whole district coverage and 100% health facility coverage, there has been no change in malaria incidence. Challenges to implementing IRS in Pakistan include poor political commitment, security issues in border areas, the use of sub-standard insecticides not approved by the WHO Pesticide Evaluation Scheme (WHOPES), poor monitoring and evaluation and a lack of funding from district governments. A key area of capacity building for IRS in Pakistan is training in quality assurance.

Discussion

- Details of the insecticide resistance management plan in Pakistan were requested. Pyrethroids have been used since 1995 and some foci of resistance were identified in 2010-2011. A national survey of insecticide resistance is currently planned for February 2015.
- It was clarified that training needs assessments are done individually for all tiers within the programme, including spray operators, managers and entomologists.
- The procurement of local or substandard insecticides has previously been problematic but it is hoped that from 2015 this will be resolved through new policies.
- Vector control is still conducted vertically. A key challenge is to combine data from different components of programs. In Pakistan, data from dengue and leishmaniasis control is combined with malaria control data.

Malaria elimination in Namibia - Richard Nchabi Kamwi, Ministry of Health, Namibia

Namibia is currently in the pre-elimination phase. In 1960, DDT-IRS was introduced in Namibia and South Africa. This remained the backbone of malaria control until Namibian independence in 1990, alongside selective LSM. By 1990, parasite prevalence was reduced to <1%. However, after independence DDT became synonymous with an intervention for the poor, leading to a boycott of DDT-IRS and a malaria epidemic in 1990. In this epidemic, there were 7000 deaths in a total population of 1.5m people, with the northern part of the country (Kunene to Zambezi) most affected. The Ministry of Health then decided to introduce an integrated approach comprising good case management, LLINs and IRS, coordinating with other southern African countries. Total confirmed malaria cases declined from 700,000 in 1990 to 400 in 2000. In 2013 there were only four malaria deaths (all imported from Angola). The E8 has now been established with the aim of eliminating malaria from eight countries in southern Africa with technical support from WHO. Botswana, Namibia, South Africa and Swaziland are now in the pre-elimination phase. IRS with DDT (or pyrethroids for modern structures), together with focused LSM, LLINs and good case management remain the backbone of the programme. *Anopheles gambiae* sensu stricto and *An. funestus* have been eliminated in Namibia. *An. arabiensis* remains, with importation from Angola.

Discussion

- It was queried how the Ministry of Finance views the economic return on malaria control in Namibia and whether this information could be packaged as a case study for other countries. Political support for malaria control is strong in Namibia, with recognition of the benefits on productivity and educational achievement and the provision of funding. The President of Namibia has received an international award for leadership in malaria control for the past two years.

- It was suggested that the Advocacy Working Group of RBM could work with the Namibian Ministry of Health to develop a case study of malaria control in Namibia.

Improving efficacy & efficiency of IRS – Allan Were, Abt Associates, USA

The President's Malaria Initiative *Africa Indoor Residual Spraying Project (PMI AIRS)* works in 15 African countries and to date has protected nearly 30 million people at risk. The programme includes (1) spray operations, (2) entomological monitoring, (3) environmental compliance, (4) monitoring and evaluation and (5) information, education and communication. Budget problems have increasingly arisen due to a shift to more expensive insecticide formulations (the price of organophosphates is approximately double that of carbamates and ten times that of pyrethroids) and dwindling budgets. The goal is now to cover as many beneficiaries as were being covered before the shift to the higher-priced insecticide.

Operational costs are related to the length of a spray campaign, with costs incurred on a per-day basis for vehicle rentals, seasonal workers and rental of warehouses and operation sites. PMI has attempted to reduce human resource costs by reducing the length of spray campaigns. This can be achieved by increasing the number of spray personnel or increasing daily output/productivity of spray operators by: (1) paying attention to spray calendars to minimize redundant time, (2) using community mobilization to reduce the time it takes to prepare homes for spraying and (3) clearly communicating and monitoring performance expectations to spray teams. In addition, structural changes have been made to reduce human resources costs not directly related to spraying, especially 'mobilization'-related costs. For example, alternative modes of conducting community mobilization were implemented, such as embedding mobilizers in spray teams, shortening the length of mobilization campaigns by mobilizing households closer to their actual day of spraying and using alternative communication channels such as radio. To reduce the number of vehicles and rental days, PMI has: (1) reduced the lengths of campaigns, (2) hired vehicles that carry more people (larger volume vehicles are normally cheaper per unit), (3) optimized daily use of vehicles by staggering the daily spray start times by team, (4) reduced the number of days vehicles were engaged during campaigns (in many cases, vehicles are not required during the final days of a campaign). Some costs increase as a result of these initiatives, including supervision, spray equipment and personal protective equipment. However, the reduction in overall cost far outweighs the cost of these new initiatives.

Benin was used as an illustrative case study. Approximately 240,000 houses were targeted for spraying. A switch in insecticide type doubled the cost of insecticide procurement, yet the total campaign budget remained static. The options were to scale back the campaign and cover fewer beneficiaries or to restructure operations to protect all targeted beneficiaries. PMI achieved the latter by improving efficiency, specifically by reducing the spray campaign time from 32 to 19 days, increasing the number of seasonal workers from about 450 to 900 and reducing the number of community mobilizers from 500 to 170. Options to increase cost efficiencies vary by country.

Building country capacity in IRS – Bradford Lucas, Abt Associates, USA

The end goal for capacity building in IRS is that district and national level malaria control programmes (NMCPs) have structures, systems and staff with the skills to plan, implement, and monitor high-quality IRS campaigns effectively and independently. The medium-term goal is that

districts and national level malaria control programmes have skilled staff to take on responsibility for specific components of IRS campaigns. The short-term goal is to use existing tools and build skills to improve the quality of IRS campaigns done by existing NMCP staff. Tools at the top level of the IRS capacity building pyramid that can be used to improve IRS quality include district micro-planning, environmental compliance (pre-spray environmental compliance operations site assessment and inspections and environmental compliance supervision checklists) and campaign quality control tools (e.g. spray performance trackers, job aids for supervisors and store managers and supervision checklists). At the bottom of the pyramid, dedicated ministry of health (MOH) staff at the district and national levels are needed, in addition to support from other stakeholders. In order to build capacity, MOH district IRS managers must be developed professionally by: (1) convincing the MOH to employ dedicated district IRS managers for 4-6 months of the year, (2) conducting competency based 'boot-camps' for MOH district IRS managers and (3) coaching district IRS managers 'on-the-job' by project district managers for the duration of planning, campaign, and close-down operations. National MOH/NMCP managers must also be developed professionally by: (1) convincing the MOH/NMCP to employ dedicated IRS management staff (e.g. environmental compliance manager), (2) conducting competency based 'boot camps' for each management position and (3) job sharing with counterpart project staff during campaign.

Discussion

- It was clarified that PMI training is customized to the level of experience, to ensure consistently good quality spraying. Good supervision is also critical; this can be achieved by supervisors' checklists and the provision of personal protective equipment so supervisors can enter homes. Partnership with suppliers of spray equipment can aid capacity building and help with training. For example, Bayer has provided training within PMI programmes.
- It was queried how human resources can be shared between districts given the heterogeneity of expertise and spray operations. Generally, districts with more spraying experience can be used to improve spray operations elsewhere. IRS training is most effective when trainees are embedded within existing programmes.

Updates from the field & discussion: AngloGold Ashanti; country representatives - Sylvester Segbaya, AngloGold Ashanti Malaria Control Ltd., Ghana

The AngloGold Ashanti programme in Ghana focuses on malaria control in high burden districts, mainly in the north. The number of malaria cases presenting to some health facilities has declined, including the Edwin Cade hospital, Obuasi (2005-2013). A summary of Global Fund support for IRS was given. The 2015-16 concept note will request USD 15.5m to spray ten districts, protecting 1.02m people. The Ghana IRS programme has achieved high community acceptance, increased work and school attendance, a total of 2.5m people covered in the most endemic communities, over 3700 short-term jobs created in IRS implementing districts (by AngloGold Ashanti & PMI) and local capacity built for IRS in 34 districts. Ongoing challenges include the reduction in targeted districts from 49 to 15 due to budget constraints and the limited range of efficacious WHOPEs-approved insecticides for IRS (which restricts insecticide rotation plans). Moving forward, it is hoped that efficacious but expensive insecticides can be subsidized to help maintain IRS in districts most in need and that there will be support for a more integrated approach to vector control.

Discussion

Private sector spray operators should be viewed as innovators, since they have considerable flexibility in adopting new equipment, procedures and information management systems. Government-run programmes can learn much from close collaboration with the private sector.

Navy Entomology Center of Excellence (NECE) - Eric Hoffman, Navy Entomology Center of Excellence, USA

Established in 1947, the mission of the Navy Entomology Center of Excellence is to leverage partnership to reduce or eliminate the spread of vector-borne disease. There are three functional arms: (1) consultation, which provides direct consultation to programmes; (2) education and training, which provides instruction and training to vector control specialists in different tools and techniques and (3) testing and evaluation of new tools for controlling vector-borne disease. The team is multi-disciplinary and includes chemists, biologists, technicians, entomologists, education specialists. This diversity of disciplines is important in developing and testing new ideas. The testing and evaluation arm has been a core component of NECE since its foundation; for example it was the first organisation to consider using giro crafts for the aerial dispersal of insecticides. Facilities for testing and evaluation include an outdoor site with multiple potential vectors, a semi-field site, larval pools, laser analysis for pesticide cloud dispersion evaluation, a wind tunnel, toxicology laboratories and access to the United States Defence Association laboratories.

Discussion

The compression sprayer was first designed many decades ago. Thus, a goal of improving the quality of the spray application is critical to complement the large amounts of funding spent on the development of new insecticides and formulations. NECE will soon become a new WHO Collaborating Centre for Insecticide Application Equipment.

Discussion – Role of the Work Stream – All

- *Structure of the Work Stream:*
 - It was queried whether a new name for the Work Stream may be needed (e.g. 'IRS Work Stream').
 - More frequent meetings would be helpful, as held by other Work Streams.
 - The Work Stream should work closely with the Insecticide Resistance Work Stream since the priorities of each overlap.
 - Merge of IRS and Housing Work Streams to develop and implement innovative and complementary concepts.
 - VCWG meeting should operate on a 'rotation basis' among the countries actively involved in mosquito control operations. This would attract local and regional public health entomologists from areas where the vector-borne disease burden remains the highest.
 - Reduce the number of research papers presented and focus primarily on practical implementation ideas beneficial to program managers. Place research papers without practical information that can be quickly implemented by vector control programs in a poster session, so that more time can be allotted to discussing innovations directly addressing challenges in the implementation of vector control plans.

- Establish a deadline for submission of papers and select a review panel to select which presentations are directly relevant and applicable to active vector control operations. Other papers can be given a poster option to make time for more discussions on innovations for addressing vector control challenges identified in program implementation.
 - Pay more attention to 'Cross-Border' issues of transmission and implementation of vector control interventions jointly. Also promote the concept of 'Joint Proposal' among the countries having similar problem in bordering areas.
 - Promote, endorse and support active environmental management as a key component of an integrated vector control scheme as outlined in WHO *Offset Publication No. 66: Manual on Environmental Management for Mosquito Control with special emphasis on malaria vectors* (1982).
 - Assign key positions/roles within the Work Stream to public sector for better ownership and continuity.
- *Supporting the development of new insecticides and application technology:*
 - Insecticide resistance is an emergency especially in West Africa and a rapid and coordinated effort by all stakeholders to expedite the development of new insecticides is needed. Manufacturers need support in getting new products to market.
 - A competitive market with multiple available insecticides is needed.
 - Direct engagement with the private sector is critical for innovation.
 - Key indicators of IRS coverage are inconsistent.
 - The quality rather than the quantity of spraying is critical; application technology needs approving.
- *Training and dissemination of information:*
 - The Work Stream can help to aggregate and disseminate information from PMI settings.
 - The NetWorks project has a 'Lessons in Brief' series for continuous LLIN distribution; this could be replicated for IRS.
 - The Pan African Mosquito Control Association can play a critical role in improving entomological expertise, collaboration and assisting with training and data sharing (e.g. annual conference PAMCA 2015 in Dar es Salaam).
 - Partnership between PAMCA, private sector, PMI and other partners can create a foundation for data sharing and capacity building.
 - Encourage the participation of various mosquito control associations like the American Mosquito Control Association (AMCA) and European Mosquito Control Association. Also encourage other regions including Asia to develop mosquito control associations.
- *IRS strategies:*
 - Countries need support to develop plans for carrying out IRS in the context of insecticide resistance and the need to move to more expensive insecticides.

- It may be helpful to assemble a package of information for countries describing the insecticide resistance problem in other countries and its likely impact on future malaria control. The Work Stream is also an ideal forum to develop a database of the interventions being used in different countries.
- Revisit the role of IRS in the context of IVM and encourage global IRS strategy update.
- Entomological monitoring remains critical.
- Promote a 'Network Approach' to capacity building

Additional comments:

1. The VCWG should take a Leadership Position by modifying the definition of integrated vector control established by the WHO Expert Committee on Vector Biology & Control in 1983 to read:

'Integrated Vector Management is a rational decision-making process to determine the most appropriate mix of interventions drawing on resources beyond health, both public and private. These include LLIN, IRS, larviciding, environmental manipulation, housing improvements, Information Education and Communication, etc. Otherwise, suboptimal use of available resources will continue and millions of people will remain vulnerable.'

**7th Optimizing Evidence for Vector Control Interventions Work Stream Meeting
9.00-12.00, Friday 30th January 2015
Salle II, International Labour Organization, Geneva**

**Chairs: Christian Lengeler and John Gimnig
Rapporteur: Lucy Tusting**

Welcome and overview – John Gimnig, Centers for Disease Control and Prevention (CDC), USA

John Gimnig opened the meeting and gave an overview of the pathway from initial development of new paradigms, funded by donors and the Innovative Vector Control Consortium (IVCC), to their review via the Vector Control Technical Expert Group (VCTEG) and Vector Control Advisory Group (VCAG), before implementation. The Optimizing Evidence Work Stream helps to facilitate this process.

LLIN-IRS interactions – an update of recent evidence - Immo Kleinschmidt, LSHTM, UK

There remains no conclusion on the added value of indoor residual spraying (IRS) to long-lasting insecticidal nets (LLINs) so it is helpful to revisit the evidence, particularly in the context of (1) pyrethroid resistance, (2) geographical variation in the impact of one intervention alone on malaria transmission and (3) the potential role of LLINs with IRS in local elimination. The evidence to date is provided by four randomised trials and 17 observational studies. The process of weighing this evidence was reviewed. Overall, well-conducted randomised trials give the best evidence. If designed as superiority trials, the null hypothesis is that combination is no better than LLIN alone. To prove that the combination is equivalent to LLIN alone, it is necessary to conduct a non-inferiority trial. In vector control trials, intervention effects might be masked by mosquito movement between villages, or by emerging or undetected insecticide resistance. The interpretation of findings is complicated by many factors differing between studies, such as primary vectors, the insecticide

used, insecticide resistance, coverage and transmission intensity. A summary of the evidence from four randomised controlled trials and two non-randomised studies was recently published (Lines and Kleinschmidt 2014 *Lancet*) (Table).

WHO guidance for countries on combining IRS and LLINs was produced by the Malaria Policy Advisory Committee (MPAC) and made available online in March 2014 (<http://www.who.int/malaria/publications/atoz/who-guidance-combining-irs-llins-mar2014.pdf>).

The main recommendations are that: (1) in settings of high and effective LLIN coverage, IRS may have limited utility in reducing malaria mortality and morbidity. However IRS may be implemented with LLINs as part of an insecticide resistance management strategy, (2) where LLINs and IRS are deployed together, a non-pyrethroid insecticide should be used for IRS, (3) the priority is to deliver either IRS or LLINs to a high standard, rather than using one to compensate for deficiencies in the others, (4) more evidence on combining IRS and LLINs is needed for different eco-epidemiological settings outside Africa and (5) countries that use both interventions should undertake an evaluation of the effectiveness of combining versus either LLINs or IRS alone.

Table. Summary of trials and selected non-randomised studies investigating combination indoor residual spraying and insecticide-treated nets for additional protection against malaria

Country	IRS insecticide	Number of clusters per arm	Main vector	Reported LLIN coverage by arm	Reported IRS coverage	Susceptibility of main vector	<i>PfPR</i> ₂₋₁₀ endemicity class ^s	Primary endpoint Effect [95% CI] ^d
Benin	B-carb	7	<i>An. gambiae</i> s.s.	Target groups only	>90%	97	High	IRR=1.32 [0.90-1.93]
Sudan	B-carb	70	<i>An. arabiensis</i>	Very high	>95%	Range 43-100	Low	IRR=0.87 [0.54-1.39]
The Gambia	DDT	35	<i>An. gambiae</i> s.s. & <i>An. arabiensis</i>	Very high	>80%	High but kdr resistance genes reported nearby	Intermediate	IRR=1.08 [0.80-1.46]
Tanzania	B-carb	25	<i>An. gambiae</i> s.s., <i>An. arabiensis</i> , <i>An. funestus</i>	Modest	~90%	Range 28-70	Intermediate	OR=0.43 [0.19-0.97]
Kenya	Pyr	Non randomised	<i>An. gambiae</i> s.s., <i>An. arabiensis</i> , <i>An. funestus</i>	Very high	74%	Not reported	High	IRR=0.38 [0.28-0.50]
Burundi	Pyr	Non randomised	<i>An. gambiae</i> s.s., <i>An. funestus</i>	High	>90%	Not reported	Intermediate	OR=0.88 [0.60-1.31] IRR=0.95 [0.57-1.57]

(Source: Lines and Kleinschmidt 2014, *Lancet*)

Sudan – Immo Kleinschmidt, LSHTM, UK

Galabat, Sudan, has a short, intense malaria transmission season and pyrethroid resistance. A recent two-armed randomised trial compared LLINs with IRS to LLINs alone. During the period June 2012 to May 2013, no difference was found between the deltamethrin IRS + LLINs arm and the LLIN alone arm. During the period June 2013 to May 2014, bendiocarb IRS was introduced instead. Preliminary results indicate a reduction in malaria incidence. This concurs with the Tanzania study in Muleba, which suggests that IRS has an impact only where vectors are susceptible to the insecticide class used.

Discussion

A priority is to carry out trials of LLINs and IRS versus LLINs alone in areas of very high transmission. It was queried whether rotations will be evaluated in the future. It is not only susceptibility that compromises the efficacy of LLINs, but also low compliance, which can be highly localised.

Defining strategies for controlling malaria transmission in areas of pyrethroid resistance using a mixture of LLIN and IRS: evidence from two trials in Tanzania – Mark Rowland, LSHTM, UK

A review of two trials in Muleba, Tanzania was given. Muleba is on the western shore of Lake Victoria. The primary malaria vectors are *An. gambiae* s.s. and *An. arabiensis* and pyrethroid resistance is high. The first trial (complete, see West *et al.* 2014, PLoS Med; Matowo *et al.* 2014, Med Vet Ent) was a two-arm cluster randomised controlled trial, with 25 clusters per arm. In the baseline year, both arms received pyrethroid IRS and LLINs. Due to pyrethroid resistance, bendiocarb was introduced in Year 2, with one arm receiving bendiocarb IRS with LLINs and one arm receiving LLINs alone. LLIN coverage was low but IRS coverage was high. CDC bottle assays indicated that the pyrethroid resistance mechanisms were MFO and kdr. Overall, a significant reduction (60%) in parasite prevalence was observed in children aged 0.5-14 years in the IRS and LLIN arm compared to LLINs alone, alongside a reduction in *An. gambiae* adult density (measured by CDC light trap catches) and the entomological inoculation rate (EIR). In conclusion, IRS with bendiocarb gave significant additional protection compared to LLINs alone and LLIN use was protective regardless of IRS status. The findings concur with other studies, i.e. that the effectiveness depends on the insecticide used and level of insecticide resistance. Strategies for deploying non-pyrethroid IRS and LLINs are needed.

The second trial of LLINs and IRS in Muleba is ongoing, supported by the UK Medical Research Council, Wellcome Trust and UK DfID. It has a four arm factorial design with 12 clusters per arm: (1) Olyset LN, (2) Olyset Plus LN (pyrethroid + PBO synergist), (3) Olyset LN + actellic CS IRS, (4) Olyset plus LN + actellic IRS. Olyset Plus was chosen since it was found to kill all moderately resistant Muleba strain *An. gambiae*. Since each intervention in the four arms has a potential operational niche, it is hoped that the trial will help define future policy in different transmission zones. Cluster mapping and the first cross-sectional survey indicate similar baseline prevalence.

Multi-center spatial repellent trial – Nicole Achee, University of Notre Dame, USA

Spatial repellents are products designed to actively or passively release volatile chemicals into the air and prevent human-vector contact within the treated space. The target product profile (TPP) is an emitter lasting for seven months. It is hypothesised that deployment of spatial repellents in enclosed/semi-enclosed spaces will reduce pathogen transmission. A broad definition of spatial repellents has been agreed upon in order that a large range of products can be tested within this new paradigm: Mechanisms of action include (1) movement away, (2) attraction-inhibition and (3) feeding inhibition. A spectrum of chemical concentrations determines whether a product will repel or kill. Spatial repellents can contribute to reducing outdoor and residual transmission by addressing

day, early evening and/or outdoor biting. They may also have a role in insecticide resistance management, since they have a different mode of action.

Existing evidence is provided by Phase I studies that have assessed the evidence for chemical actions, Phase II studies that have evaluated entry and feeding inhibition in semi-field conditions and two clinical trials: (1) a randomised controlled trial of mosquito coils in China and (2) a trial of a spatial repellent in Sumba, Indonesia, which give preliminary evidence of efficacy in semi-enclosed spaces. Entomological correlates of protection have also been investigated within the Indonesia study. WHO *Guidelines for Evaluation of Spatial Repellent Products* are now available. Additionally, study design for proof-of-principle studies was discussed at a VCAG review in February 2014 and the IVCC Expert Scientific Advisory Committee III review in February 2015. Primary issues raised by VCAG included: (1) protective coverage required, (2) geographical variation in efficacy, (3) community level versus diversion effect and (4) suitability for areas with insecticide resistance. Reflecting the VCAG comments, a newly funded BMGF program led by the University of Notre Dame will evaluate the public health impact of one spatial repellent product to reduce and prevent transmission of malaria and dengue. There are multiple sites in Peru, the Amazon region, Kenya, Tanzania and Zambia, the Mekong Delta and Indonesia. The program will use an adaptive approach, such that adequate powering of individual studies allows adaptation of study designs based on interim results (e.g. increase cohort or cluster size, product numbers per household entomological sampling strategy). The studies are all double-blind cluster randomised controlled trials with primary epidemiological and entomological outcomes of infection incidence (active case detection) and per cent reduction in adult mosquito density (human landing catch). The trials will also measure changes in incidence around the core intervention zone to measure diversion, insecticide resistance, and dengue incidence in Peru.

Discussion

It was clarified that the product being trialled is transfluthrin and this has passed through mammalian risk assessment. The dosage being used is 1000-fold lower than that considered safe. Adverse events will be monitored throughout.

Centre for sustainable malaria control at the University of Pretoria (UP CSMC), South Africa – Christiaan de Jager, University of Pretoria, South Africa

UP CSMC was founded three years ago to make a sustainable contribution towards the creation of a malaria-free Africa by (1) using sustainable and environmentally safe malaria vector control technologies, (2) establishing IVM strategies, (3) ensuring effective case management, (4) promoting health education, and (5) contributing to malaria elimination in South Africa. There are three clusters: parasite control (e.g. a new research chair to focus on parasite biology and transmission blocking), vector control (e.g. an integrated vector management initiative) and human health (e.g. a new education book for primary school children: *Sibo Fights Malaria*). The centre has also been designated as a MRC Collaborating Centre for Malaria Research. Collaborative projects include (1) cross-border (Nwanedi trans-boundary) malaria, (2) semiochemical malaria vector reduction and (3) strategies to guide transmission blocking in Limpopo Province (N.B. semiochemicals transmit messages between insects and elicit a behavioral response (e.g. pheromones for attraction or repellents)). An overview of vector control projects and interventions under evaluation was given. The African Consortium for Malaria Vaccine Research was also initiated in 2014.

Update on the Data Quality Task Force – Rajpal Yadav, World Health Organization, Switzerland

Efficacy, risk assessment and pesticide specification data are required for evaluation of new products. Given the importance of vector control, the spread of insecticide resistance and many new products in the pipeline, CropLife and WHOPEs held a joint meeting in 2014 to examine how to improve data quality. A Data Quality Task Force (DQTF) was established with members from WHO, CropLife, IVCC, CDC, Bill and Melinda Gates Foundation (BMGF) and members of the VCWG. The three areas identified as needing improvement are: (1) data quality, (2) development of new tests and application methods and (3) improved experimental design and statistical analysis. Ongoing activities include the development of standard operating procedures (SOPs), training and new guidelines for data analysis. It is hoped that the DQTF will encourage more efficient use of resources and shorten time to market. The group will begin by focusing on IRS trials intended for WHOPEs submission, the long-term objective being to establish good laboratory practice for IRS Phase I and II WHO guideline tests in selected sites, to obtain accreditation of trial sites and begin new trials. The 2014-2015 work plan was outlined. Recent meetings were held in November in New Orleans and in January in Geneva.

Discussion

It was suggested that vector control should have independent monitors as in drug trials. Guidance on responsibility and insurance for different research partners would be valuable.

VecNet portal – a demonstration – Tom Burkot, James Cook University, Australia

VecNet is a BMGF project to help preserve intervention efficacy and to guide new tool development by providing an interface to model the impacts of interventions on malaria transmission, using mathematical models and data from Swiss TPH and the Malaria Atlas Project among other data sources. A demonstration of the transmission simulator was given. OpenMalaria is in the alpha stage of development. It is envisaged that both interfaces will be launched publicly in 2015. Training courses will be run.

Discussion

The envisaged end users are malaria control program managers, policy makers and researchers. There is potential for turning it into a serious game. The potential use of the portal in university teaching was also discussed. It is intended that the program will be able to model new paradigms in addition to existing interventions.

Recent developments of IVCC plans for new paradigms in vector control – Tom McLean, IVCC, UK

A key IVCC strategic objective is to work with end users to define and validate new vector control paradigms. The IVCC portfolio for interventions to address outdoor biting was outlined. A call for expressions of interest in 2014 received 19 proposals; several overlapping proposals were invited to form consortia. Four topics were selected for development to a full proposal (attractive toxic sugar baits, mating swarms, push pull strategies, repellent clothing) and three topics were held for further inputs (ivermectin, auto dissemination of pyriproxyfen, and Fipronil cattle treatment).

Discussion and way forward – All

1. Providing technical assistance (TA) to countries

- Given that the Work Stream has no budget and that many members already advise and work with countries, it is difficult to see how technical support to countries could be improved.

- VCWG members have a high degree of influence via VCTEG, VCAG and MPAC. IRS and LLIN interactions are a good example of bringing together evidence and translating into policy. It may be helpful to make a statement that the VCWG is not a TA provider but is a convening forum for meeting TA providers.
- Technical assistance to neighbouring countries is important for cross-border control in elimination settings.
- *Possible routes for the provision of TA:*
 - Some countries have local technical assistance (e.g. DRC, Chad, Equatorial Guinea and Cameroon); others do not (e.g. Congo, Gabon and Central African Republic). Central Africa in particular needs support if it is to achieve malaria elimination.
 - Many programs would prefer that expertise is developed in-country rather than spending valuable resources on international resources. There is capacity within Africa to support other countries and this is potentially cheaper, but it is not being deployed properly. For example, Ifakara Health Institute has 18 entomology PhD students willing to provide TA. Countries need to communicate that TA is required and the VCWG could establish a database of experts willing and able to provide this.
 - Close interaction with the Roll Back Malaria Harmonization Working Group (HWG) would be worthwhile since the HWG has existing experience of providing TA. However, it only helps countries to develop GFATM concept notes, while TA needs are more extensive.
 - Provision of entomological and epidemiological surveillance expertise has been previously supported by the President's Malaria Initiative and Swiss TPH.
 - DfiD is funding a new project to map economic, social and health information to help develop national strategic malaria control plans in the context of limited resources and to strengthen GFATM concept notes.
- *Funding TA:*
 - The HWG has direct funds for TA from USAID. The lack of funding from RBM to the VCWG precludes the attendance of many NMCPs and this is a limiting factor to facilitating TA.

2. Aligning the agenda with VCWG priorities

As always, the role and value of the Work Stream was reviewed and discussed. Some of the current topics are no longer meaningfully part of the Work Stream because they are better hosted either in plenary sessions (i.e. IVCC updates, etc.), or in other more specific Work Streams (larviciding, residual transmission Work Stream for some of the relevant interventions).

Areas that will remain in the future are the combination of interventions, as for example for the LLIN-IRS combinations. This could be extended to other interventions in the future.

Another useful area for our Work Stream is the reporting from projects such as AvecNet, as well as continuing to report and discuss the data quality process initiated by WHOPES and its partners.

Finally, promising future discussion includes the risk analysis at country level, and the stratification of control activities according to detailed (in time and space) epidemiological data.

7th Entomological Monitoring and Integrated Vector Management (IVM)

Work Stream Meeting

13.00-15.30, Friday 30th January 2015

Salle II, International Labour Organization, Geneva

Chair: Raman Velayudhan and Michael Macdonald

Rapporteur: Lucy Tusting

Michael Macdonald has been appointed as co-leader, succeeded Jacob Williams.

Introduction – Raman Velayudhan, World Health Organization, Switzerland

An overview of Integrated Vector Management (IVM) was given. WHO guidance on IVM includes: the *Global Strategic Framework for Integrated Vector Management* (2004), the *Report of the WHO Consultation on Development of a Global Action Plan for IVM* (2008) and four documents published in 2012: (1) *Guidance on policy making for IVM*, (2) *Core structure for training curricula on IVM*, (3) *Handbook for IVM* and (4) *Monitoring and Evaluation indicators for IVM*. 62% endemic countries globally and 53% of countries in Africa have national IVM policies. Current areas of focus within IVM include: (1) redesigning programs in the context of insecticide resistance and climate change, (2) reorientation of programs with capacity building and career pathways, (3) encouraging intersectoral work, (4) IVM in emergency situations. There is a need to improve the definition of IVM to simplify advocacy.

Update on toolkit for IVM in sub-Saharan Africa – Steve Lindsay, Durham University, UK

Golding and Hay have developed integrated maps of the distribution of vector-borne disease worldwide, which show that 82% of the global population lives in areas at risk of more than one major vector-borne disease. Vector control is the major tool for controlling these diseases. However, IVM is poorly implemented given the current status of insecticide resistance, resource constraints, disease-specific silos, weak inter-sectoral action and poor generation and use of evidence. The definition of IVM includes (1) multiple methods used against a single disease and (2) single or multiple methods used against multiple diseases. A recent systematic review demonstrates the protective efficacy of LLINs against multiple diseases and the potential for IVM (Wilson *et al.* 2014). While more than half of all 110 WHO member states have IVM policies, there are no practical guidelines on how to do it. Thus, toolkits are being developed for sub-Saharan Africa (SSA), South America and Asia, beginning with SSA. The end goal is a paper-based manual, but a web-based interface will also be produced to ensure information is kept up-to-date. These manuals will build on the 2012 WHO Handbook for IVM, using the following framework: (1) characterisation of the disease situation, (2) selection of vector control methods, (3) needs and resources, (4) implementation and (5) monitoring and evaluation. The SSA manual has been developed by Anne Wilson and Steve Lindsay (Durham University), Willem Takken (Wageningen University) and Nick Golding (University of Oxford), with contributions from a panel of over 20 vector-borne disease and IVM experts. A final review by an independent WHO panel of experts was undertaken in Geneva, January 2015. The manual will be submitted to WHO for final editing and publication in February 2015.

IVM experience in emergencies – Richard Allan, The MENTOR Initiative, UK

The MENTOR Initiative carries out vector-borne disease control in humanitarian emergencies. MENTOR has six programme areas in South Sudan, which has a long history of conflict, with renewed population displacements and violence in 2013. Malaria is the primary public health problem, accounting for 20% deaths. Since the introduction of universal LLIN coverage in 2009, malaria incidence has increased and pyrethroid resistance has been confirmed. Visceral leishmaniasis has also increased and trachoma prevalence is high. IVM has been used in four refugee camps in Maban. While LLINs were not able to control malaria transmission, larviciding at the peak of the malaria transmission season was followed by a rapid reduction in malaria incidence and IVM (with IRS, larviciding and LLINs) was associated with a halving of malaria cases between 2013 and 2014. This demonstrates the potential of IVM within contained populations. MENTOR has also been working in North Syria since 2013, where cutaneous leishmaniasis (CL) is a major public health problem (and the largest concentration of CL in the world). MENTOR implemented large scale IVM using IRS, long-lasting insecticidal nets (LLINs with smaller mesh), long-lasting insecticidal curtains (LLIC; curtains, smaller mesh), waste removal and diagnosis and case management support. The average number of CL cases per facility in Aleppo declined throughout 2014. This provides the first evidence of CL control through IVM.

Little guidance is available on IVM in humanitarian emergencies. The *WHO Handbook for IVM* excludes emergency situations and the *WHO Guide to Malaria Control in Humanitarian Emergencies* has no mention of IVM. Therefore, MENTOR is currently developing a toolkit for IVM in humanitarian emergencies to complement the WHO handbook being developed at Durham University. Workshops on IVM in emergencies will be run in SSA (two), East Asia (one) and the Middle East (one).

Discussion

It is essential to ensure that tents, blankets and other tools already being used in humanitarian settings are impregnated during manufacturing. However, since WHOPES/Vector Control Advisory Group (VCAG) recommendations on new products are needed for United Nations agencies to be able to procure new products, this is a major obstacle. Furthermore, pyrethroids should not solely be relied upon. Apart from pyrethroid resistance, two main reasons for the failure of LLINs in emergency situations are (1) over washing (in South Sudan, where 98% coverage was achieved, nets were washed weekly) and (2) low compliance and misuse in stressed populations.

Combined vector control and disease management – Randall Kramer, Duke University, USA

An overview of the 'Implementation Science to Optimize Malaria Vector Control and Disease Management' project was given. This is underway in Mvomero District, Tanzania, coordinated by the National Institute of Medical Research of Tanzania and other partners and funded by the US National Institutes of Health. There are four arms, each receiving different combinations of early detection and treatment and larviciding. Routine parasite prevalence data are being collected in addition to entomological data. 962 households and 5385 individuals have been enrolled. Baseline malaria (5.6%) and anaemia prevalence (52.4%) were described. Preliminary results indicate that larviciding is well accepted by the population, with a high willingness to pay (Mboera *et al.* 2014, *Int J Environ Res Public Health*). Project results will be integrated into a Malaria Decision Analysis Support Tool to improve decision-making on malaria control strategies with support from WHO and the United Nations Environment Programme Division of Global Environment Facility. A new farmer-assisted microbial larviciding project is planned in Moshi, Tanzania.

Capacity building for IVM in Western Pacific Region – Rabindra Abeyasinghe, World Health Organization (WHO), Philippines

10 of 37 countries in the Western Pacific Region (WPR) are malaria endemic, with the highest burden in Papua New Guinea and artemisinin resistance in the Mekong Region a major problem. Dengue is endemic in >30 countries, lymphatic filariasis in 23 countries and Japanese encephalitis, leishmaniasis and other vector borne diseases are also prevalent. IVM capacity building activities in the region include: (1) an Integrated Vector Management Course organised by the Ministry of Health of Malaysia, (2) an Asia Pacific Dengue Control Workshop organised by the Singapore National Environmental Agency jointly with WHO, (3) Integrated Neglected Tropical Diseases Programme Management training organised by WHO and (4) planned Dengue Vector Management training by the Chinese Centers for Disease Control in March 2015.

Leveraging opportunities for multidisease approaches: malaria – LF interface– Jacob Williams, RTI International, USA

There is significant opportunity to integrate vector control for malaria and lymphatic filariasis, because in many areas either the same vectors transmit the two diseases, or the local vectors share common ecology. There are significant challenges to mass drug administration for LF control in certain settings and a growing evidence of the utility of IVM as supplementary intervention to support LF elimination. There is however a need to generate evidence to inform policy and strategy for multi-disease approaches; develop guidance and decision tools; support implementation and enhance advocacy. RTI undertook a study with funding from Bill and Melinda Gates Foundation, to (i) review and map the distribution of LF vectors and (b) identify opportunities for supplemental vector control, within the context of ongoing national MDA program. Study developed interactive maps of LF vectors distribution around the world (www.healthydays.biz/lfmap8) with display functions to the depth of districts within endemic countries. A corresponding online database was also developed (www.healthydays.biz/rti1). Co-endemicity of LF and other major vector borne disease has also been mapped, including loa loa, malaria, onchocerciasis and dengue. Examples of the impact of malaria vector control on LF were presented. To encourage the use of IVM for LF control, the following are needed: (1) guidance on vector control for LF, (2) funding for IVM, (3) further evaluation of the potential impact of malaria control on LF, (4) capacity strengthening, (5) vector control tools that target non anopheline species and (6) LF surveillance and monitoring.

Networking and experiences of PAMCA – Charles Mbogo, Kenya Medical Research Institute (KEMRI), Kenya

The Pan African Mosquito Control Association (PAMCA) is a non-profit association founded in Kenya in 2009, now with members in 27 countries and chapters in Nigeria, Cameroon, Burkina Faso and Tanzania. The aim of PAMCA aim is to provide leadership in promoting control, research and dissemination of information on mosquitoes in Africa and beyond. In 2014 the first conference was held in Nairobi with 138 scientists from 21 countries. The meeting identified the need for: (1) better capacity for entomological surveillance and IR management, (2) the proper use of data for informed decision making, (3) data on re-emerging vector-borne disease including dengue and Chikungunya, (4) training on IVM, (5) adoption of IVM by countries and (6) intersectoral collaboration. Anyone is welcome to join (www.pamca.org/join/pamca-members). The 2nd PAMCA Annual Conference will be held in October 2015 in Dar es Salaam. Registration opens on 30th March 2015.

Discussion – All

- There is a need for mosquito taxonomy expertise since entomologists are often only able to recognise a limited number of species. In China, a real-time taxonomic tool has been developed for the identification of imported vectors in ships and containers within 30 minutes. Currently, WHO is in negotiation with the Chinese government to explore adapting its use in other settings.
- It was queried whether other work streams (e.g. Larval Source Management) could expand their remit to other diseases, as well as the IVM Work Stream.
- A library of case studies on IVM would be useful for presenting to donors and this needs to be documented.
- Small investments could allow mosquito samples discarded by programmes to be used.
- An entomological surveillance document is currently under development with GMP and will be presented later.

Session 5: The way forward for 2015

Chairs: Jo Lines and Jacob Williams

Summary of the outcomes of the Work Stream meetings

Housing and Malaria – Steve Lindsay, Durham University, UK

The following topics were discussed:

- Review of the evidence on housing and malaria by Tusting and colleagues.
- The work of Habitat for Humanity International and ARCHIVE Global on housing and malaria.
- Ongoing studies on housing and malaria:
 - New RCT of housing improvements in The Gambia.
 - Portable mosquito-proof housing for itinerant rice farmers in rural Tanzania.
 - Housing modifications as a malaria control strategy in peri-urban Cameroon.
- Opportunities for controlling malaria by addressing better housing design and the peri-domestic environment.

Draft 2015 Work Plan:

1. A WHO position statement on malaria and housing is required to improve advocacy. Housing is a form of environmental management and should be considered a means to sustaining elimination after control has ended.
2. Engage with interested parties within health and other sectors, particularly with the private sector (construction, engineering, architecture, extraction and plantations) as part of Corporate Social Responsibility programmes.
3. Hold a follow-up meeting to develop a research agenda for housing and malaria and to address:
 - a. What structural changes are recommended?
 - b. How to generate demand and scale-up improvements?
 - c. How to strengthen our long term vision with a business case, market research and mapping?

4. Identification of 'good practice' for house construction and screening, starting in Africa before addressing other regions; consider developing a manual.

Discussion

It was suggested that old documents should be revisited, such as the WHO handbooks for malaria vector control by Rozendaal. Types of evidence required by different funders should be identified.

Larval Source Management – Steve Lindsay, Durham University, UK

The following topics were discussed:

- Update on LSM technologies:
 - Control of malaria vectors by the auto dissemination of insecticides.
 - Monomolecular surface films for control of anopheline larvae in rice fields.
- Ongoing LSM trial in Nouna, Burkina Faso.
- Country update: LSM in Pakistan.

Main outputs from the meeting:

1. LSM is a supplementary tool for malaria control and elimination. It can be used for outdoor control.
2. LSM is also a tool for resistance management. Diversifying the vector control toolbox to include LSM needs to be emphasised in insecticide resistance management plans and WHO guidance.
3. Providing TA for countries is critical. Many countries are conducting LSM and urgently need TA support from WHO experts, particularly with respect to quality control in ECOWAS, monitoring and evaluation and publishing case studies. There is a need for funding for this initiative, including countries budgeting for TA assistance.
4. Silas Majambere has been appointed as new co-leader. Steve Lindsay will be replaced in 2016.

Discussion

Quality control of the Labiofam *Bti* product is urgently needed. WHO confirmed that Labiofam has agreed to submit to WHOPES. There has been a six month delay in delivering the product to the WHO test site, however WHOPES will evaluate the product within 12 months. *Bti* application is also important. The use of LSM in IRM may be appropriate, but care must be taken when using insecticides also used in adult vector control such as pyriproxyfen.

Entomological Monitoring and IVM – Rabindra Abeyasinghe, World Health Organization, The Philippines

The following topics were discussed:

- The 'reorientation' of IVM, including how to define IVM for a broad audience and the use of IVM for the efficient use of resources for vector control.
- Capacity building and career pathways, including the need for ongoing training in public health entomology.
- Implementing IVM, including a new IVM Toolkit, the need for evidence to support IVM in different settings, combining lymphatic filariasis and malaria control.
- IVM in emergency situations, including the MENTOR programmes in South Sudan and Syria.
- Update from the Pan African Mosquito Control Association.

Priorities for 2015:

1. The need for the Work Stream to work across diseases, while keeping malaria a priority.
2. How to convince donors of the importance of IVM (building the evidence through research and case studies; emphasising the collateral benefits of vector control for malaria)?
3. Improving capacity for mosquito identification and taxonomy in Africa.

Discussion

There was little discussion during this year's meeting of entomological monitoring, but this remains important especially for outdoor biting.

Continuous LLIN Distribution Systems – Kojo Lokko

The following topics were discussed:

- Immediate past activities of the Work Stream, including the NetCALC tool and Assessment Guide to choose elements of a continuous distribution (CD) strategy.
- Pilot CD programmes, including school distribution in Ghana and Nigeria and community distribution in South Sudan, Nigeria and Madagascar.
- Outstanding questions, which include: (1) the ability of CD to sustain universal coverage over long time periods, (2) populations not reached by CD channels, (3) inter-household re-allocation and (4) cost considerations.

Draft 2015 Work Plan:

1. Conduct operational research to look at cost issues (compare different CD mechanisms).
2. Produce standard methodology (templates, spreadsheets) to assist countries in documenting costs.
3. Assist in incorporating strong evaluation into CD activities in countries.
4. Produce an algorithm, to compliment NetCALC that helps countries move through a decision tree to establish the best CD strategy.
5. Conduct operational research to understand which populations are being missed by existing CD strategies.
6. Explore the role of private sector in CD (create a small group to work on this).
7. Clarify/interpret technical guidance to country teams.
8. Improve TA by: (1) joining the HWG at meetings with countries, (2) training AMP and other consultants, (3) packaging CD guidance for country teams.
9. Identify an opportunity to test full-scale CD over 2-3 years.
10. Continue discussions on stratification and prioritization.
11. Inform policy.
12. Produce more case studies of LLIN distribution.

Durability of LLINs in the Field – Steve Smith, Centers for Disease Control and Prevention, USA

The following topics were discussed:

- Mosquito entry into bednets via holes.
- Laboratory evaluation of LLIN resistance to damage.
- Tanzania ABCDR study.
- Work Stream relevance and impact:
 - Significant progress in understanding LLIN physical durability since 2008.

- Physical durability will remain relevant as insecticide resistance becomes more common.
- Increasing use-life offers high potential cost-savings.
- Strong consensus that the Work Stream is needed.

Draft 2015 Work Plan:

- Promote the development of tools to inform procurement decisions.
- Provide technical input on best practices for monitoring LLIN durability in the field.
- Help to define the research agenda on durability.
- Initiate virtual meetings (telephone or web) to continue sharing information and move agenda.
- Encourage feedback and suggestions from members to co-chairs regarding Work Stream priorities and activities.

Outdoor/Residual Malaria Transmission – Michael Reddy, Bill and Melinda Gates Foundation, USA

Key outputs of the meeting were:

- Universal coverage of LLINs (or IRS) remains an absolute priority. All other methods are supplementary to reducing malaria and achieving elimination.
- There is a need to generate local evidence on the scale of outdoor/residual transmission, and to understand the contribution of both human and vector behavior.
- Industry and their partners are encouraged to develop new vector control tools to address residual transmission.
- The recommendation is not to evaluate individual products, but product classes.
- It is important to partner with stakeholders with local economic interests (e.g. extractive industries) as these companies are financially autonomous and often willing to provide support towards public health product evaluations that benefit their workforce.
- Support for R&D:
 - *BMGF Grand Challenges Explorations Round 14: New Approaches for Addressing Outdoor/Residual Malaria Transmission: 1st round: September 2014, 2nd round late 2015.*
 - *IVCC call for expressions: Responding to the challenge of Outdoor Transmission of Malaria (Sept 2014).*
- Promising technologies include: (1) spatial and topical repellents, (2) attractive sugar bait traps and (3) genetically manipulated vectors.

Draft 2015 Work Plan:

1. Establish regional networks in the Mekong, Africa and Amazonia.
2. Develop guidelines for estimating the importance of residual transmission.
3. Develop guidelines for estimating malaria risk in populations exposed to outdoor transmission (soldiers, forest workers, migrants, mobile populations).
4. Outline strategic plan for R&D of new tools.
5. Establish a network of communications and mutual technical support amongst stakeholders including an effective 'feedback system' to inform on the operational impact of any new tools being developed/evaluated to address residual transmission.

Capacity Building for IRS - Dereje Dengela, Abt Associates, USA

The following topics were discussed:

- IRS programmes in Pakistan, Ghana and Namibia.
- Improving the efficiency and capacity building in IRS (evidence from PMI).

Priorities for 2015:

1. Re-naming the Work Stream.
2. Improving communications between Work Stream members.
3. Supporting the development of new active ingredients by working with insecticide manufacturers.
4. Preparing briefs on lessons learned in capacity building for IRS.
5. Supporting capacity building in country.

Discussion

It was suggested that cost-benefit analysis and analysis of the economic impact of insecticide resistance would be a useful output.

Insecticide Resistance – Janet Hemingway, Liverpool School of Tropical Medicine, UK

The following topics were discussed:

- The threat of increased pyrethroid resistance to malaria control and the possible elevation of this to a state of emergency (it was agreed that a stepwise approach would be better).
- Help for countries on resistance management planning and GPRIM implementation – and communicating that costs will increase. VCWG should help with this but consistent messaging is needed.
- The shift from basic bioassays to intensity monitoring of resistance; this is required to establish whether specialist tools need to be deployed.
- The lack of data for some areas of central Africa and the importance of ensuring that data is meaningful for decision making (e.g. intensity monitoring). The quality of testing kits is still an issue and this needs to be tackled if countries are to sensibly generate data.
- The potential of digital technology in training tools.
- The potential of IVM in reducing selection pressure on mosquitoes – we need evidence for what is cost effective and where.

Next steps:

1. Advocacy documents for non-vector control experts on insecticide resistance to increase support for GPRIM implementation.

Optimizing Evidence for Vector Control Interventions – John Gimnig, Centers for Disease Control and Prevention, USA

The following topics were discussed:

- Update on evidence on LLIN-IRS interactions, including results from Galabat, Sudan and Muleba, Tanzania.
- Update on a new multi-centre spatial repellent trial.

- Brief on the Centre for Sustainable Malaria Control at the University of Pretoria, South Africa.
- Update on the WHO/RBM Data Quality Task Force.
- Demonstration of the VecNet Portal.
- Updates from IVCC.
- Role of the Work Stream, including provision of technical support to countries, facilitating policy and guidance development and opportunities for funding Work Stream activities.

Priorities for 2015:

1. Continue as a forum for academics, policy makers, donors and implementers to discuss potential new interventions as well as combinations of existing interventions.
2. Support monitoring and evaluation at an appropriately fine scale.
3. Epidemiological stratification at the country level to target and prioritize resources, to determine the appropriate mix of vector control interventions and to guide the implementation of other interventions.

Discussion

Prioritisation where resources are constrained is a major issue and the Work Stream could produce case studies to guide other countries (e.g. Somalia). Work Stream members are not paid for their work, thus there is a limit to the time that can be contributed. A solution may be to work more closely with the HWG.

Consensus statement on LLIN continuous distribution - Matt Lynch, Johns Hopkins University Center for Communication Programs, USA

The following consensus statement was approved by those present:

- “This statement is issued by the Roll Back Malaria Partnership working groups on Malaria in Pregnancy and Vector Control, together with the Alliance for Malaria Prevention. Our aim is to appeal for more complete implementation of the World Health Organization recommendations for achieving universal coverage with long-lasting insecticidal nets (LLINs) in malaria control (released September 2013, revised March 2014). In particular we wish to draw attention to the recommendation that: *‘Continuous distribution channels [of LLINs] should be functional before, during, and after the mass distribution campaigns to avoid any gaps in universal access to LLINs.’*”
- “Action: The RBM Working Groups therefore strongly urge national programme managers responsible for malaria control, ante-natal care and immunization services, and all health professionals concerned with these services, to heed and rapidly implement the WHO recommendations that indicate that in addition to mass campaigns, a high priority should also be given to continuous distribution of LLINs during and after mass campaigns - such as through ANC, EPI services, and mother and child health weeks/months campaigns as appropriate to the local context.”

Update on elections and budget - James Banda, Roll Back Malaria Partnership, Switzerland

Elections will be run in 2015 to replace Jo Lines as co-chair of the VCWG. Funding in 2015 for the Working Groups will be the same as in 2014, as these have already been approved and included in the RBM program of work. Two budget lines are relevant to the VCWG: (1) promoting evidence

based strategic planning and (2) supporting the production of a harmonized tool – operational aspects of planning at country level. VCWG members should think about what outputs can align with these.

VCWG priorities for 2015 – Jacob Williams, RTI International, USA / Roll Back Malaria Partnership

A draft summary of major issues was presented by Jacob Williams and comments were invited. This summary will be circulated after the VCWG meeting for additional input and then finalised.

Closing discussion – All

- *Collecting evidence for the Architecture and Governance Task Force:*
 - A template for collating evidence on work of VCWG will be circulated.
 - The irony of justifying the purpose of a self-funded VCWG was highlighted.
- *VCWG documents and budget:*
 - It was confirmed that all presentations and the meeting report will be available online. A summary of the meeting costs will be circulated for transparency.
 - It is possible that the VCWG needs a payment model to reflect the resources available to different participants.
- Inviting journalists to join the VCWG would create greater outreach.

In closing the 10th Annual Meeting, Jacob Williams thanked all present for their continued input.

List of acronyms

AI	active ingredient
AIM	African Initiative on Malaria
AIRS	Africa Indoor Residual Spraying Project
AMCA	American Mosquito Control Association
AMP	Alliance for Malaria Prevention
ANC	ante-natal clinic
ASTMH	American Society for Tropical Medicine and Hygiene
BCC	behaviour change and communication
BMGF	Bill and Melinda Gates Foundation
<i>Bti</i>	<i>Bacillus thuringiensis</i> subsp. <i>israelensis</i>
CAR	Central African Republic
CDC	Centers for Disease Control and Prevention
CD	continuous distribution
CL	cutaneous leishmaniasis
CSR	corporate social responsibility
DfID	UK Department for International Development
DQTF	Data Quality Task Force
DRC	Democratic Republic of Congo
ECOWAS	Economic Community Of West African States
EIR	entomological inoculation rates

EPI	extended programme of immunisation
GFATM	Global Fund for AIDS, Tuberculosis and Malaria
GMAP-2	2 nd Global Malaria Action Plan
GMP	Global Malaria Programme
GPIRM	Global Plan for Insecticide Resistance Management
GTS	Global Technical Strategy for Malaria 2016-2030
HFH	Habitat for Humanity International
HLC	human landing catch
HWG	Harmonization Working Group
iCCM	Integrated Community Case Management
ICIPE	International Centre of Insect Physiology and Ecology
IFRC	International Federation of the Red Cross and Red Crescent Societies
IHI	Ifakara Health Institute
IR	insecticide resistance
IRAC	Insecticide Resistance Action Committee
IRM	insecticide resistance management
IRS	indoor residual spraying
ISGlobal	Institute for Global Health
ITN	insecticide-treated net
IVCC	Innovative Vector Control Consortium
IVM	integrated vector management
I2I	Innovation to Impact
LF	lymphatic filariasis
LHW	Lady Health Workers (in Pakistan)
LLIC	long-lasting insecticidal curtains
LLIN	long-lasting insecticidal net
LSTM	Liverpool School of Tropical Medicine
LSHTM	London School of Hygiene and Tropical Medicine
LSM	Larval Source Management
MAP	Malaria Atlas Project
MAWG	Malaria Advocacy Working Group
MESA	Malaria Eradication Scientific Alliance
MDG	Millennium Development Goal
MFO	mixed-function oxidases
MOH	Ministry of Health
MPAC	Malaria Policy Advisory Committee
NECE	Navy Entomology Center of Excellence
NGO	non-governmental organisation
NMCP	National Malaria Control Programme
PAMCA	Pan African Mosquito Control Association
PMI	President's Malaria Initiative
PN-3	Permanet-3
PPF	Pyriproxyfen
PPP	public-private partnerships
PPY	per person per year

RBM	Roll Back Malaria
RCT	randomised controlled trial
RD	resistance to damage
ROI	return on investment
R4D	Research for Development
SBCC	social and behaviour change communication
SDC	Swiss Agency for Development and Cooperation
SDG	Sustainable Development Goal
SMoT	solar-powered mosquito trapping system
SOPs	standard operating procedures
SRN	sub-regional network
SSA	Sub-Saharan Africa
Swiss TPH	Swiss Tropical and Public Health Institute
TA	technical assistance
TPP	target product profile
UNDP	United Nations Development Programme
UNHCR	United Nations High Commissioner for Refugees
UNICEF	United Nations Children's Fund
UP CSMC	University of Pretoria centre for sustainable malaria control
USAID	United States Agency for International Development
USD	United States dollar
VCAG	Vector Control Advisory Group
VCTEG	Vector Control Technical Experts Group
VCWG	Vector Control Working Group
WASH	water, sanitation and hygiene
WHA	World Health Assembly
WHO	World Health Organization
WHOPES	World Health Organization Pesticide Evaluation Scheme
WPR	Western Pacific Region