



Roll Back Malaria Vector Control Working Group (RBM VCWG)
13th Annual Meeting, 7-9th February 2018
Moevenpick Hotel, Rue de Pre Bois 20, 1215 Geneva

Chair: Jacob Williams
Secretariat: Konstantina Boutsika
Rapporteur: Vanessa Chen-Hussey



Day 1: Wednesday 7th February 2018
Session 1: Introductions and Objectives
Chairperson: Jacob Williams

Welcome, introductions and meeting objectives - Jacob Williams, Tropical Public Health Practice

Jacob Williams opened the meeting and welcomed new participants to the Working Group. He reminded all participants that the overall objective of the workgroup was to respond to enduring challenges to achieve effective and sustainable malaria vector control. He commented that inter-sectoral actions are particularly necessary in today's funding environment in order to formulate a relentless, nimble and efficient response. The objectives of the 2018 meeting were:

1. To reflect on experiences and lessons of the last two years of VCWG's work, within the context of ongoing implementation of *WHO Global Technical Strategy (GTS)* and *RBM Action and Investment to Defeat Malaria (AIM)* and *RBM Advocacy Plans*.
2. To refine the priorities and work plans of the work streams and strengthen VCWG-wide strategic approaches and tactics.
3. To clarify in-house issues including the election of new co-chair.

Introducing the agenda for the meeting, Jacob indicated that each work stream will meet for 3 hours to review the status of practice and challenges in their specific technical areas and generate consensus on work plan updates for plenary discussion. The updates should advance actions began in the previous two years, further sharpen and clarify outputs and explore specific actions to promote multi-sectoral approaches. The participation of regional networks was geared towards improving knowledge sharing and collaboration.

The meeting also presented updates from the World Health Organization, regional network groups (AMCA, APMEN, E8, PAMCA, PIAM). There was a special side meeting on vector control in humanitarian emergencies. The meeting closed with a panel discussion on vector-borne diseases – focused on increasing integrated and inter-sectoral approaches.

Update from the RBM Partnership - Kesetebirhan Admasu, CEO, Roll Back Malaria Partnership

Kesetebirhan Admasu presented an update of RBM activities in 2017 and the priorities for 2018. He reminded the group of the aims of the RBM partnership – stressing that the revitalised RBM partnership will focus much more on multi-sectoral engagement and true country-led ownership and country-driven requirements to achieve a sustainable outcome. The partnership is a collaborative platform for collective action. RBM would like to deepen expertise in resource mobilisation, communication and mission critical support to countries.

The RBM Governance structure is relatively slimmed compared to previously, with a partnership board, secretariat, partners, and working groups. The board now has 15 members, which apart from those from the UN and WHO, are recruited on individual experience and expertise. There are three partner committees: advocacy and resource mobilisation, country and regional support, strategy communication. These are intended to formalise, consolidate and amplify the core partnership functions, engage and relate with regional entities, and create a collaborative environment for all partners to work together. The activities of these three partner committees are coordinated by the CEO, through the partnership coordination board group that meets every month. Governance is through two co-chairs, a steering committee and work streams. There is regular communication and engagement with general membership and monthly coordination calls for co-chairs and CEO.

Previous working groups are retained; however Terms of Reference are being revised. The most significant change being the interaction of working groups with the board. Previously working groups had direct interaction with the board, but now communication will be through the management team.

Activities in 2017 included a rebranding exercise, which was unveiled at the 2017 UN General Assembly (more detail on the website: rollbackmalaria.com). The RBM strategic plan for 2017-2020 was also developed and has gone through a robust consultation process. The RBM strategic plan objectives for 2017 -2020 are to:

1. Keep malaria high on political and developmental agendas.
One activity is to facilitate the formation of All Party Parliamentary Groups on Malaria, similar to those existing in UK and US in other potential donor countries, and priority endemic countries. These can survive changes in administration, keeping the focus on malaria. The African Union Platform will be used to spread the “Zero Malaria Starts With Me” campaign launched by Speak Up Africa and others in Senegal. This encourages engagement in malaria control efforts from the individual right up to government level. Other key meetings from 2018 have been identified including MIM, Commonwealth Heads of States Meeting, World Malaria Day, and the WHO World Health Assembly.
2. Establish a regional approach within existing political and economic platforms.
The first initiative will be a Sahel Malaria Elimination Initiative. This is not aimed to set up a separate structure, but to embed it in existing structures to raise financing and political traction.
3. Increase financing envelope for malaria.
Currently, only about a third of estimated global requirement is being funded and a greater focus is being put on domestic funding. RBM aims to support efforts to explore new ways to raise domestic financing. Country pilots in 4 African countries (Mozambique, Sudan, Zambia, DRC) aim to explore flexible and creative ways to resource malaria control. RBM is also prioritizing collaboration with China in 2018-2020. China is currently the largest partner and financier for many programmes in sub-Saharan Africa. Bilateral support is huge, but malaria outcomes are very small. RBM will facilitate further realignment and leveraging of investments to improve malaria control outcomes. A high –level malaria summit is planned for 2019 in China, with a side event to celebrate Chinese manufacturers that have WHO prequalified products.
4. Cross-cutting objective to build a high-performing secretariat.

Members were asked to visit the new website and engage in the activities planned.

Discussion

- The plans to further increase partnership with China was well received, particularly with regards to the potential to engage more with Chinese manufacturers and building sector to aid the Housing work stream’s goals.
- Wherein response to a question to clarify if support for innovation and research and development work was adequately represented in the RBM objectives, Kesetebirhan Admasu replied that this is covered by the resource mobilisation partner committee’s work. He noted that in addition, that David Reddy will coordinate this through the establishment of a forum that will look at regulatory bottle necks, and product development challenges.

Individual Work Stream Meetings

3rd LLIN Priorities Work Stream meeting

10:00-13:00, Wednesday 7th February 2018

Co-leaders: Hannah Koenker & Lena Lorenz

Introduction – Hannah Koenker, Johns Hopkins University

Hannah Koenker opened the meeting, and reviewed the work plan. One talk by Jim Sutcliffe (the importance of differentiating between LLIN durability and LLIN serviceability) was cancelled due to illness. But the presentation will be shared via webinar.

Pooled analysis of LLIN durability monitoring studies: what is the effectiveness (in controlling malaria) of a mass distributed cohort of LLINs over time and where can the greatest gains be made? – Olivier Briët, Swiss Tropical and Public Health Institute

A pooled analysis of 8 PMI durability studies was carried out to determine what factors (e.g. physical durability, insecticide retention, usage and LLIN survival) surrounding net durability were of the most importance when monitoring net durability. Data was collected from 37 sites in 8 countries between 2009 and 2015. Survival curves of 6-monthly data were presented for net attrition (due to destruction), usage, means and standard deviations of log holed area, insecticide content, and mosquito mortality from cone bioassays. A mathematical model of vectorial capacity was developed and informed using probabilities of death at each stage from experimental hut studies. The model was then used to estimate the proportion of vectorial capacity averted in different scenarios: i) indestructible nets, ii) no loss of insecticide, iii) maximum usage of nets, and iv) maximum survival of nets. These scenarios are hypothetical and have two important limitations. Firstly, nets were followed individually, so when these nets were not used, people were assumed to be not sleeping under a net, but no information was gathered on how many people were sleeping under non-study nets. In addition, the attrition is likely to be underestimated, due to the nature of this long-term study. In addition, the variables will usually interact with each other in the real world. However, the results showed that net usage looked to be the most important factor in reducing vectorial capacity, followed in order of importance by, net survival, insecticide retention, and the area of holes.

LaHoSA-Location adjusted Hole Surface Area: method for estimating the functional effectiveness of LLIN under operational conditions – Sarah Moore, Swiss Tropical and Public Health Institute

The aim of LaHoSA was to find a functionally more accurate but still operationally feasible method of looking at the functional efficacy of bed nets when doing hole-counting. The factors that were looked at were: where holes actually do occur in nets; the probability of mosquitoes entering and feeding; the interaction of the insecticide with those holes, the probability of mosquitoes dying after interaction with whole nets of suboptimum condition, and the effect of the resistance status of the mosquitoes. The Ifakara Ambient Chamber Test (I-ACT) was developed, consisting of chambers where the natural interaction of mosquitoes with a net and human host can be modelled. It allows high throughput, 100% recapture, multiple strains and randomisation. Data from I-ACTs were found to correspond well with data from WHO experimental huts. Light-weight frames for holes counting in the field compared well with the traditional methods of hole-counting: 80% of field counts agreed with lab counts; they are easy to carry out; and faster. The impact of net holing was then assessed using I-ACT, which found that hole-size, location and insecticide quantity and resistance status all influence and interact on the probability of successful blood feeding. For example, data from ABCDR

project and Mozambique shows that most holes occur at the bottom of the net, but 94% of 3,500 households said that they tucked the net under the bed. I-ACTs showed holes in the bottom of the net were less important, provided the net was tucked under the bed. Although the majority of nets recovered from Tanzania were torn, they are still biologically efficacious. So more focus should be on behaviour change to ensure torn but efficacious nets are retained.

Durability Monitoring Discussion – All

- It was asked whether the outcomes of the pooled analysis are enough to suggest that we can reduce data collection down to just the use rate and attrition rate. While most studies look at chemical content and holes, few gather good data on use. But the results of the model suggest that this would actually be a very powerful indicator of the effectiveness of a programme.
- It was asked whether there was an assumption that all nets are equal when they come out of the bag, and whether variation in quality could be added to the model. For the model, all net parameters were based on measurements at 6 monthly intervals including some performed at the start of use, so this variability is already included within the model.
- It was asked whether polyester or polyethylene is most resistant to holing. The settings of the studies seem to have much more impact on the number of holes than the material of the net. In order to answer this, a study would have to randomise different nets within the same area. The knitting pattern can also have a huge impact on the number of holes, and this may in turn interact with the material as well.
- It was asked whether maximum net use assumed net use during all of the vector biting hours or only during sleeping hours. It was assumed that 20% of the time mosquitoes would be biting when people were not under nets.
- It was asked whether the factors that impact most on vectorial capacity would vary between different settings. It was acknowledged that there were definite differences between countries and there were a small minority where for example, net integrity did have more impact.
- It was asked whether the differences between the irritancy of different pyrethroids would have an effect on how well they were able to deter mosquitoes from holes. The initial studies were done with deltamethrin to allow different doses to be applied, but a longitudinal study with three brands of net and two insecticides is planned that will collect more detailed data around this issue.

Cost and cost-effectiveness of LLIN distribution strategies in Sub-Saharan Africa – Josh Yukich, Tulane University

There has been a massive scale up of LLIN distribution in Africa but questions remain about the heterogeneity and sustainability of the coverage. Repeated campaigns result in peaks and troughs of LLIN coverage and this analysis aimed to estimate the economic and health costs of these gaps between campaigns. First, a case series of costing for continuous distribution strategies (school based in Tanzania & Ghana; ANC/EPI in Tanzania, Ghana & Mali, routine community based distribution in Zanzibar) was carried out. Then a systematic review and meta-analysis of existing data was carried out. Next the health impact was modelled using a generic African malaria scenario, with three baseline scenarios and 12 different campaigns built on top. Then the cost effectiveness frontier was plotted. The conclusions were that on average CD systems were slightly more expensive but there is huge variability and this difference was not statistically significant. Ministry of Health contributions were higher in CD systems than in campaigns (about 30-40% of programme costs).

Effectiveness of a long-lasting PBO treated insecticidal net and indoor residual spray interventions, separately and together, against malaria transmitted by pyrethroid resistant mosquitoes: a community randomised trial – Natacha Protopopoff, London School of Hygiene & Tropical Medicine

The study was carried out in Muleba, Tanzania a high altitude area bordering Lake Victoria. Prior to the study, there was annual IRS with bendiocarb since 2012 and universal coverage of LLINs in 2011. The four interventions arms were: Olyset (permethrin), Olyset Plus (with PBO & permethrin), then either net plus IRS with Actellic 300CS. Epidemiological and entomological data was collected including *Plasmodium* prevalence, *Anopheles* density, and resistance status of mosquitoes. Olyset Plus reduced malaria prevalence from 9-21 months compared to the standard Olyset net. IRS provided similar reductions but only at 9 months. Although vector density decreased in all three arms compared to the Olyset LLINs alone, the effect on EIR was actually most revealing with IRS showing high impact in Year 1, which decreased into Year 2 (spraying was not repeated). Pyrethroid and bendiocarb resistance was observed. Olyset Plus nets lost 83% of the PBO over the 2 year study period, and 42% of the permethrin (Olyset Net lost 22% of the permethrin content). In conclusion, the PBO net worked better than the standard net, and while the addition of IRS also decreased prevalence, but there was little additional reduction when used with a PBO-LLIN.

ITN distribution / NG-LLIN Discussion – All

- It was noted that the impact on the mosquito population is less important than the impact on overall malaria transmission and therefore, it was asked what other indicators might be looked at in assessing other products. The EIR is a good indicator and is especially useful in areas of high transmission. However, where transmission is low, other indicators would need to be developed.
- As there was very little PBO left in the nets after 2 years, it was questioned whether the increase in efficacy observed in the trial was due to the addition of PBO, or due to the improvement in net polymer and degradation of pyrethroid. In laboratory trials, it is clear that the addition of PBO does make a difference. Based on the high resistance observed in local mosquito populations, a small difference in pyrethroid concentration on the net is unlikely to explain that difference. Standard Olyset, when it was originally assessed entomologically and epidemiologically, showed very good effectiveness. This study has shown, this is no longer the case but the problem is with resistance not the net.
- It was asked whether the high attrition was due to nets being damaged and thrown away or whether they were given away. The longitudinal survey did follow up individual nets for one year.
- It was asked whether there really was a need for WHO to have a category of LLINs which are labelled PBO-nets. The point was made that not all PBO nets are the same and lumping them all together does not make a lot of sense.
- Josh Yukich made a clarification on his presentation to state that ANC/EPI was in places shortened to “ANC” but these all included EPI distribution also.
- Cost implication of PBO net when combined with IRS
- WHO policy currently is that it recommends the scaling up of PBO nets in areas where resistance frequency by bioassay is 20-80%. But resistance was higher in this study area, so it was asked whether the WHO should consider scaling up of PBO nets in every area including areas of very high resistance. The frequency assay might not be the best way to assess the appropriateness of a PBO net, but it is important that these nets should be targeted properly to prevent exacerbating existing resistance.

- It was asked what signs (e.g. finding blood-fed mosquitoes inside nets) programmes should be looking for when making a decision on resistance management. Blood-fed mosquitoes within nets are an easy method of data collection but also age-grading of mosquitoes can provide useful information. The use of sentinel sites to monitor mosquito data would be very helpful.
- It was asked if there is any sign of community effect with PBO nets as compared with standard nets. There was no difference between users and non-users in year one. However, there were very few non-users at this point. There might be more powerful data on this from subsequent years, when usage decreased.

PQT-VC Approach to Post-Market Activities – Dominic Schuler, World Health Organization

The regulatory life cycle starts with pre-market evaluations (conversion from WHOPES recommendation to Pre-Qualification and new applications). Products are then evaluated in a continuous cycle of post-market activities, updated guidelines and re-evaluations. New guidelines should come with an implementation plan to make it clear if new data must be generated for existing products or if they only apply going forward. At the end of their life, products may be de-listed or voluntarily withdrawn from the market. Post-market activities can be pro-active, for example variations or updates to a product (these must be re-submitted to PQ); lot-testing (results may lead to additional lot testing or additional studies); or additional studies (e.g. long-term durability and bioavailability data, either through studies or operational monitoring). Post-market activities can also be reactive, so for example triggered by a complaint. Product failure or trends seen across a product or types of products, feedback on this must be received from everyone who makes, orders, uses, or assesses a product in order for complaints to be addressed. Effective routes of communication are essential for ensuring all stakeholders (manufacturers, end users, procurers, national control programs, national regulatory authorities, WHO) are involved in feeding information back. A good resource on post-market activities has been produced by the diagnostics team and is available online (www.who.int/diagnostics_laboratory/postmarket/en/).

Discussion

- It was asked what the process is of setting up some of these systems for reactive activities. At this point it is about identifying these groups and any suggestions are welcome.
- It was asked what is in place for building capacity for regulatory authorities within countries where skills may currently be lacking. The Regulatory Systems and Strengthening group with the Regulation of Health Care Technologies department of WHO. Work is already underway to help identify these regulatory authorities and help build capacity. Countries can use evaluations from WHO, which can improve time to regulation.
- It was asked what triggers a re-evaluation of an active ingredient. Currently, the conversion process has meant that data on complaints, incident reports, and regulatory actions are being examined. A structured approach to prioritisation of those conversions should reveal whether re-evaluation is required.
- It was asked where durability study data should be submitted. Manufacturers must carry out these studies under Phase III, so these are required to be submitted. If appropriate, a complaint-type submission could be submitted. With regards to the pyrethroid-resistance issue, this is more about selection of an appropriate product, rather than the evaluation of a product.
- The durability of nets is evaluated by testing nets still existing in the field after three years. But those nets still remaining will represent the best case in terms of efficacy, and if these are a very small proportion of the original nets then this is not a good measure. Attrition

should be part of the measurement and part of the recommendation criteria, but was not under WHOPES. It was asked whether this issue was included within the new PQ system. The current guidelines are under revision, but have not yet been updated. Complaints can be based on real world data on products, or they can be about the guidelines.

Discussion & work plan development – Hannah Koenker, Johns Hopkins University and Lena Lorenz, London School of Hygiene & Tropical Medicine

Hannah Koenker asked the work stream to consider what role they might play in assisting in the post-market surveillance activities that PQ is trying to do. She also asked what existing items should be closed down and also what other new activities might be added to the work plan. Members were invited to contact the co-chairs by email on these suggestions and a vote will be held to reduce the work plan to three or four items.

- It was asked how the data generated within the work stream can be translated to the programme level, for example ensuring the average durability of nets is included in planning of distribution campaigns.
- It was asked how the work stream can address a growing lack of faith in nets, due to a loss in efficacy, whether through resistance or attrition. The best approach might be to identify the types of data that might be required, what data indicate a loss of efficacy of LLINs, and also to approach VCAG with the question of how to re-evaluate product performance.
- It was suggested that the health and economic implications of LLINs combined with IRS could be looked at.
- A comment was made that NMCP do not have spare money at the moment and most are looking at ways to scale back coverage. So discussions of combinations or scaling up are academic in the current funding environment. It was commented that looking at ways to help NMCPs by determining the best strategies for targeting limited resources would be useful.

The co-chairs also asked whether the communication from the work stream has been sufficient. There have been emails as well as focused topic calls. Further consultation will be done over email on this topic. It was asked if minutes can be provided following the calls, as although people might not be available, they still will be able to make comments and contribute to subsequent e-discussion.

8th Larval Source Management Work Stream meeting

10:00-13:00, Wednesday 7th February 2018

Co-leaders: Ulrike Fillinger and Silas Majambere

Welcome, review of work plan and challenges to LSM uptake in Africa – Silas Majambere, Innovative Vector Control Consortium

Ulrike Fillinger was absent due to work commitments in the field. Silas Majambere opened the meeting and gave a brief reminder of aims of the LSM work stream: i) to update the evidence base and protocols; ii) to assess and help develop local capacity; and iii) to help national programmes identify where and how to implement LSM. The progress on the work plan from last year was briefly reviewed. Apologies were given for the absence of Mbarack Diop from the African Development Bank (ADB) who was due to give a talk about the ADB's safeguards for health impact assessments.

Larviciding to control malaria – systematic review and meta-analysis – Anne Wilson, Durham University

A systematic review of larviciding to control malaria was carried out following an update of the guidelines. After screening, only 5 studies could be included, with only 4 included in the meta-analysis. This was because most studies only looked at entomological outcomes, or had flawed study designs. Three of the studies were in sub-Saharan Africa (Kenya, Tanzania and Gambia), and the final study was in Sri Lanka. Larvicides used were Bti (applied by hand in Africa), and pyriproxyfen (SL). In terms of risk of bias, only one study was an RCT, and there was also risk of baseline imbalance, and attrition bias. A sub-group analysis based on the extent of aquatic habitats was used. For small (<1km) habitats, evidence for effect showed moderate decrease in malaria incidence and prevalence. For large habitats, evidence showed no effect. The lack of studies was a concern, and recent guidelines from VCAG on the design of vector control efficacy trials were highlighted (apps.who.int/iris/bitstream/10665/259688/1/WHO-HTM-NTD-VEM-2017.03-eng.pdf).

Discussion

- It was asked what the impact would be if entomological outcomes were included. Although more studies might have been included, time pressures meant this was not done.
- It was asked why historical examples were not used. Although historical evidence will be included in the introduction to give background, these cannot be included in meta-analysis due to the type of data collected at the time.
- It was asked whether there was a way to link epidemiological and entomological outcomes. It is not known if entomological outcomes could be used as a basic predictor of epidemiological ones.
- It was asked how the work stream can change the vision of “few, fixed and findable”. This is the aim of the new position statement to be discussed.
- A question was raised on whether there should be more focus on the impact of larviciding on other vector borne diseases. There are lots of *Aedes* larval control studies, but this would be a subject of a different study.
- A comment was made that designing studies for large habitats is very hard, and randomisation in particular would be a challenge.
- A comment was made that evidence of larvicide efficacy may be available from a WHO larval control group in Thailand in the 1970s.

Consensus statement as RBM VCWG work stream with the aim to change WHO position on LSM – Jacob Williams, Tropical Public Health Practice

The draft statement was provided to the work stream, containing 13 updated recommendations. The original statement included the concept of “few, fixed and findable”. New technologies are now emerging changing the definition of what larval habitats are accessible to control programmes. There also seems to be reluctance on the part of funders to support larval source management, and the new position statement aims to give countries better guidance on where LSM is appropriate. The draft statement was discussed and the consensus was that this was very much still needed, but in its current form does not address these needs.

- A comment was made that the global vector control response (GVCR) includes elimination of breeding sites, so these recommendations are already part of the broader response within the GVCR.
- The number of recommendation was thought to be too many, and a suggestion made to limit it to five at the maximum.
- Situations outside of Africa where LSM would work should be included.
- The current language was thought to be too vague to help with decision making. For example, the use of words like ‘may’ means that LSM is still optional, whereas it should be a part of the toolkit.
- The WHOPES reference should be updated for the PQ process
- The limitations of LSM should be acknowledged.
- The ability of LSM to target outdoor biting mosquitoes in a way that IRS and ITNs do not should be highlighted.
- It was recommended that terminology was tightened up, so references to “LSM” in preference to “larviciding”. It was also suggested that an economist might be able to help define “small” and “highly populated”
- A comment was made that the draft statement currently falls halfway between a policy statement and operational advice. Updates that would be more suitable for the LSM Operational Manual should be separated out.
- Many felt that the lack of support for LSM amongst funders was due to the lack of RCT evidence showing clear epidemiological benefits of LSM. It was argued that there is a huge amount of existing evidence and perhaps this is not being communicated effectively. In addition, if large scale LSM is not being funded then there is no possibility of collecting new data, even from monitoring and evaluation. An example was given of LSM in Sudan, where a comprehensive vector control needs assessment identified LSM to be the main tool in urban settings. This unlocked government funding suggested that if donors see local government support for LSM, then funding may be more forthcoming.

Spatial intelligence systems – targeting LSM – Chris Thomas, Aberystwyth University

A talk was given about two areas of technical development that are making larval sites more accessible to larval control; mapping using drones, radar and space remote sensing, and spatial modelling. Drones can vary from very low cost, up to very high cost options, allowing the collection of detailed terrain data. Currently, legislation is the major limitation for the use of drones. However, change is in progress in many countries. A case study was presented for Zanzibar, where larval spraying is used in the elimination programme. Clinical cases will be used to identify hot spots, which will then be mapped using low-cost drones. The data will then be uploaded into the iSoper app, which will be used by spraying teams to target waterbodies to be sprayed. In total, the mapping and image process take around 3 hours (with manual delineation of water bodies the most time

consuming step), and spraying could be carried out the next day. New radar sensors operational this year can provide freely available 20-30m resolution data every 6 days, regardless of daylight and cloud cover. Simple hypothesis generating models have shown a 0.8 correlation for prediction of larval hotspots. New technology can increase mapping precision and area.

Science driven solutions to the challenges of LSM: New developments in spraying technology - Peter DeChant, Valent BioSciences LLC

Examples of effective larviciding were given from across the world (Tanzania, Singapore, Brazil, Italy, Germany and USA). But it was made clear that the methods vary from country to country depending on setting, and this enabled difficult habitats (those that are not few, fixed or findable) to be managed. Wide area larvicide spray (WALS) was used in mangrove forest in Singapore to successfully control larvae in small cryptic sites. The point was also made that the problems and methods of LSM and IRS are not transferable, so for example while both might use spraying, a modified nozzle will ensure more effective treatment of larval habitats. The work stream was reminded that although resources might not be present in malaria control programmes, they might be present elsewhere. For example aerial spraying is used in Africa in tsetse control, and this might be adapted for LSM for malaria control.

Discussion

- It was asked if case studies might be made available to quantify the cost of mapping with the aim of helping resource mobilisation.
- It was asked if there were any problems with ethics and legislation with regards the use of drones. At the moment the risk assessment is left to the Civil Aviation Authorities who provide permits to fly. This transfer of responsibility was accepted by research ethic committees so far. Drones are increasingly being utilised and accepted, and permits may be much easier in the future.
- It was asked whether radar mapping could give data on water table. By linking in hydrological models, the water table can be included in the models

Larval Source Management in Africa: a lost opportunity to strengthen the evidence-base on cost effective African malaria control - Ruth DuPlessis, Liverpool School of Tropical Medicine

A policy analysis on LSM in Africa was presented, which included Anglophone countries only. Data was available from 6 countries (Eritrea, Ghana, Nigeria, South Sudan, Uganda and Zanzibar). Policy drivers were malaria elimination, IRM and residual transmission. Only one country (Eritrea) was in the implementation phase of IVM with a country-wide approach across multiple disease targets. Others targeted high risk locations or seasons. LSM had been suspended in Ghana due to difficulty in generating evidence of impact and lack of funding. Importantly it was observed that when LSM was funded, there was no monitoring of outcomes in performance reports and there were no performance measures for LSM in GF fund grant performance reports. Barriers to implementation were determined to be dependence on external funding, a lack of evidence, problems with coordination, and feasibility. In conclusion, there was a lack of joined up policy making, and little consideration of IVM, with funding only for single disease programmes. Countries do want to adopt LSM, but funding is difficult, and where it is implemented monitoring and evaluation is poor, representing a missed opportunity for generating additional much needed data.

Work plan

1. **Project 1: Draft a consensus statement as RBM VCWG work stream with the aim to change WHO position on LSM.**

The current WHO position statement is confusing and may be slowing down or preventing funding and implementation of LSM. The aim for this meeting was to agree on the draft and then move on to how to approach the WHO to adopt the new statement. However, no consensus was reached and Manuel Lluberas and Anne Wilson volunteered to redraft and circulate a new version.

2. Project 2: Advocating for environmental management including habitat modification and manipulation and inter-sectoral collaboration as priority interventions in LSM.

This is a cross-cutting topic that will also appear in IVM work stream. So there was discussion around whether to keep this project or to move it over to the IVM work stream. It was determined that the danger of removing this from the LSM work stream is that LSM will get lost amongst other interventions. So the project will be kept, but with greater collaboration with the IVM work stream.

3. Project 3: Update and expand spreadsheet of WHOPES approved larvicides as source of information, and compile SOPs on testing larvicide efficacy and testing for resistance.

This project is in progress, I2I is helping to move laboratories to GLP status in line with PQ requirements. SOPs have been collected and collated for facilities as well as for test methods, and are currently with work stream panel for reconciliation. At present there is good documentation for IRS and LLINs, but very limited information for larvicides and space sprays, and consultants have been engaged to create these from scratch, which may take 6 months. SOPs will be hosted by WHOPES alongside current guidelines. Industry wishing to input on the SOPs were asked to contact John Lucas at Sumitomo. However, at the moment there are no GLP certified labs for larvicide testing.

4. Project 4: Review of state of the art technology for LSM.

Chris Thomas and Peter DeChant presented some updates for this project in their talks. Capacity building should include all vector control tools available, including those currently in use in the African agricultural industry. These opportunities might be exploited for larviciding, and linking up larval and adult control programmes. This is a spur to make contact with the agriculture and water industries. There are also plenty of smaller and cheaper spraying options (gyrocopters, drone sprayers), so spraying programmes can be scaled to wider areas depending on budget. Limitation can come from WHOPES recommendations, most space sprays are approved for fogging only. It was also clear that *Aedes* borne disease should be included in programmes.

5. Project 5: Reviewing operational LSM in national malaria control programmes – evidence of impact, training and support needs.

Ruth du Plessis presented an update for this project. Less progress has been made trying to establish a list of LSM experts willing to provide support for programmes. A recent PAMCA survey may help. The WHO may help set up a clear channel to increase visibility of LSM work streams and experts for programmes or other interested parties to seek advice and support. It is clear that needs assessments are not performed due to a lack of expertise. Training needs will be identified at the end of the project.

The reasons for the suspension of LSM in Ghana were clarified. Although LSM was government funded, there was not enough expertise on the team carrying out LSM, and monitoring and evaluation was not done. There is a need to help countries to design their own LSM programmes so that they do work well and resources are not wasted in situations where LSM is inappropriate. There is a mechanism within WHO for technical support from national malaria control offices which could be used for experts from outside WHO.

6. Project 6: Develop guidelines for LSM in emergency situations.

This is also a cross-work stream topic and it was discussed whether to keep within the LSM work stream.

Open discussion: How do we make the LSM work stream useful for mosquito control programs?

- The debate over evidence is held every year: there cannot be implementation without evaluation but large-scale trials are hard to do. Therefore surveillance data is what is needed looking forwards.
- It was noted that no representatives of the major funding bodies were present at the meeting.
- LSM should be a supplementary tool to nets and spraying, particularly when moving to elimination
- With the focus on malaria control, the rest of vector control is ignored, LSM may be key to changing this mind set.
- Focus should also be given to malaria control outside Africa, as control tools do not necessarily work in all areas equally.

3rd IRS IRM Priorities Work Stream meeting

14:00-17:00, Wednesday 7th February 2018

Co-leaders: Mark Hoppé & Dereje Dengela

Welcome and introduction – Dereje Dengela, ABT Associates & Mark Hoppé, Syngenta Crop Protection AG

Mark Hoppé opened the meeting and welcomed the speakers and work stream members.

MalariaGEN, Anopheles 1000 genome project, key findings - Alistair Miles, University of Oxford & Wellcome Trust Sanger Institute

The *Anopheles* 1000 genome project was established in 2014 and aimed to sequence mosquitoes collected from natural populations across Africa. The project was planned in three phases. The first two phases are completed and all data are curated and freely available on the MalariaGEN website. The final phase is underway and will involve 3,000 *An. gambiae* mosquitoes from 18 countries. The main aspects of the 1000 genome project that are relevant to insecticide resistance management are i) the identification of the genes and molecular mechanisms of insecticide resistance, ii) the discovery of specific mutations that cause insecticide resistance, and iii) the geographic distribution and spread of insecticide resistance. Strong selection pressure is evident on genes that are involved in insecticide resistance such as the voltage-gated sodium channel gene. Evidence of genetic mutations shows a complex picture of adaptation on the population level to insecticide resistance. The costs of sequencing and data analysis are currently prohibitive but new operational tools are always in development. Future work will look at these *An. gambiae* populations over time particularly around selection events such as insecticide control interventions, *An. arabiensis*, *An. funestus* and Southeast Asian *Anopheles*.

Evolution of insecticide resistance under sequences, mixtures and rotations. Narrowing the gap between models and data - Ian Hastings & Andy South, Liverpool School of Tropical Medicine

The last modelling around the use of insecticide sequences and mixtures was done by Chris Curtis in 1985. Modern analysis tools, such as sensitivity analyses are much more powerful, and this topic has been revisited. The model can help address key operational research questions, and input on parameters was requested from the work stream. The model suggested that when one insecticide is more effective it takes longer for resistance to evolve to two insecticides when they are used in a mixture than when they are used in a sequence. But if both insecticides are equivalent and resistance considered, then the opposite is true. If resistance is costly then the genes for resistance will decline in the absence of that insecticide, for example in sequences or rotations, or if there are refugia of no treatment. There is no simple answer as to whether sequences or rotations are better; it will depend on the effectiveness of the insecticides and other parameters of each situation. Models are available online.

Practical application of GPIRM recommendations in IRS programs: insecticide rotations – Allan Were, ABT Associates

Three 3rd generation IRS insecticides may be available by the end of this year (currently Actellic 300CS and SumiShield® 50WG pre-qualified). However, countries are likely to differ on how they interpret the GPIRM guidelines in implementing these tools. It is important that rotations are implemented before there is any sign of resistance. Countries may vary their rotation programmes due to cost or residual effect concerns. This can lead to market instability, leading in turn to difficulties in consistent supply. The IRS insecticide should be different to that used on LLINs, adding

another layer of complication. Another consideration is whether NMCP managers will view SumiShield and Fludora Fusion as separate products for IRM purposes, as both contain clothianidin.

Work stream discussion and feedback: practical application of IRM recommendations and modelling - All

- A comment was made that one really useful application of the 1000 genome project could be to advise on best practise with regards to insecticide resistance selection in mosquito colonies, as different resistance mechanism are often lost at different rates when colonies go through bottle necks.
- A question was asked whether historical data can be put into the model to test some of the assumptions. This is one of the next steps planned.
- It was asked what was meant by a fully effective insecticide, and whether this meant different approaches to insecticide deployment in the past might have avoided the current insecticide resistance problem. A more effective insecticide is one that kills more mosquitoes but in doing so, it exerts a higher selective pressure and resistance can then emerge more quickly. However, really high levels of insecticide can still kill “resistant” phenotypes.
- Data from the 1000 genome project shows that resistance is not usually a single locus mutation but the modelling is based on a single locus assumption. Therefore, it was asked how the model might behave if multiple locus resistance were included. Metabolic resistance for example is likely to be under the control of a number of different genes and therefore a different modelling approach is required. This is on the agenda but has not been completed yet.
- An example was given of blackfly control where three different larvicides (Bti, OP and pyrethroid) were used in a seasonal rotation which resulted in the complete control of insecticide resistance. The model suggests that continuing this indefinitely would still eventually result in resistance.
- A question was asked whether the same genes for resistance were found in separate species exposed to the same insecticide. There is evidence of gene flow between *An. gambiae* and *An. coluzzii*, however the project has not yet looked at *An. arabiensis* yet so the extent of gene flow here is as yet unknown.
- It was asked how the different applications of insecticide (at the larval stage, in bed nets affecting only adult females, and walls affecting adult females and some males) might result in different modelling outcomes. This could be looked at by changing the parameters of the model, however the model is at an early stage and further refinement work would be needed before introducing these kind of questions.
- It was asked whether the new models have shone any light on whether mixtures might reduce or exacerbate resistance. Mixtures will always be more effective at killing mosquitoes. However, the model is concerned not with driving down the mosquito population but with the emergence and spread of resistant genes.
- Bed nets work not just by simply killing mosquitoes, they also prevent blood feeding, and it was therefore asked whether this exposure could be included within the model.
- The early models were vulnerable in their assumptions of the limited fates of mosquitoes, and it was asked whether the new models could capture this more sensitively. The variation is captured only as an average. However, it is something that is included.
- PCR has given a lot of information about *kdr* resistance. However, it has been less useful for other resistance genes. Sequencing can answer these questions and more but the laboratories that have the capacity to carry this out are limited. An interim tool might be

amplicon sequencing panels which can be designed in a similar way to PCR to target a specific gene.

The WIN Initiative: A Global Network to Combat Insecticide Resistance in Arbovirus Vectors - Claire Durot, IRD

WIN supports the third pillar of the GVCR by putting insecticide resistance on the vector control agenda. WIN activities focus on networking, research, expertise, and education and training. Research has been produced on the global distribution of insecticide resistance (Moyes *et al.* 2017); insecticide resistance management (Chandre *et al.* submitted), integrated *Aedes* management (Roiz *et al.* submitted) and alternative tools for *Aedes* vector control (Achee *et al.* submitted). WIN has coordinated inter-lab validation of discriminatory concentrations, investigated new synergists and provided cost estimates of national IRM activities. The next WIN international conference is planned for Singapore in September/October 2018. The WIN is welcoming new partnerships and financial support.

NgenIRS – update on activities and progress - David McGuire, NgenIRS IVCC

Costs of insecticides are reduced through a system of co-payments which means an additional 1 million units of Actellic were procured last year which would be able to protect 8 million people. Prices are reducing in line with forecasts, particularly with volume guarantee, and the IRS market is improving since its low in 2015. However, the introduction of another product for 2018, and the prospect of a third soon mean this is much more challenging going forwards. Support for the project from industry was acknowledged. Entomological data from an ongoing RCT in Mozambique suggests the use of IRS is associated with a 50% reduction in mosquitoes with epidemiological data to come. In Mali, there is evidence of a 36% reduction in malaria cases as a result of IRS addition to LLINs. Reductions were also observed in Ghana, Zambia. Pre-emptive sub-national rotation is necessary not just to attempt to control resistance but also to protect a stable and growing market of IRS insecticides. It is expected that prices will continue to decrease with co-payments phased out by end of the year. A transition plan is being developed now to ensure the end of the project in 2019 does not result in difficulties with the market.

Update on work stream activities: IRM MOOC and Vector Learning Exchange – Mark Hoppé, Syngenta & Laura McCarty, ABT Associates

An update was given on the planned MOOC. This will be a multimedia course with talks, presentations, games, and an interactive online forum. Languages are proposed to be English, French and possibly Spanish. It will be available to anyone but the core target group will be people involved in planning, funding, procurement, logistics, and monitoring of vector control. The course outline is completed and some speakers are confirmed. Further contributors and funding will be sought this year.

The Vector Learning Exchange, an online knowledge sharing platform, has been set up. This will be a collaborative site for dialogue and knowledge sharing. The first official discussion is on 6th of March and will be on "Safe working environments and opportunities for women." Material is currently being sought to populate the site, as well as ideas for events and discussions, and ideas for improvement. Work stream members were encouraged to join the community through the website: vectorlearningxchange.com.

Discussion

Questions for speakers and proposals for work stream activities were welcomed, in person and also by email after the session.

- A clarification was given on the impact of IRS in Mali. Both IRS and LLINs had been in place. However, when IRS was removed, this resulted in an increase in malaria of around 70%.
- A proposal for additional work stream activities was made regarding the management of targeted IRS for Aedes control.
- A clarification was given on the volume of Actellic 300CS in a bottle (833ml).
- A reminder was given that PATH are running a taskforce on the standardisation of IRS measurement, which meets monthly via voice calls. Anyone interested was asked to contact Molly Robertson at PATH.

5th Housing and Malaria Work Stream meeting

14:00-17:00, Wednesday 7th February 2018

Co-leaders: Steve Lindsay & Lucy Tusting

Welcome & review of work plan – Lucy Tusting, University of Oxford

Steve Lindsay reported that the name change agreed last year to “Vector Control in the Built Environment” will happen but not until next year. Lucy Tusting opened the meeting and welcomed all participants. The structure of the meeting was outlined, with the audience asked to think particularly about the subject of outreach, both to industry, outside of Africa and to use the experience within the work stream. Lucy Tusting reminded the participants of the role of the work stream to bring together housing and malaria communities in line with Habitat III and MDG 11, and also to identify the best approaches for house improvements. There were four projects last year:

1. Support development of housing and VBD recommendations.
House improvements were included as an “effective vector control approach” in “keeping the vector out” a policy brief highlighting the links between housing and VBDs.
2. Strengthen links with housing sector
3. Encourage basic and applied research on VBD & the built environment
4. Information Exchange

The last three are addressed by the BOVA network, for which an update was given by Anne Wilson.

BOVA Network update (Building Out Vector-Borne Disease in Africa) – Anne Wilson, Durham University

The BOVA Network is an inter-disciplinary network of researchers encouraging basic and applied research, information exchange and news updates through web and twitter (@BovaNetwork). The BOVA Network is led by Steve Lindsay and Mike Davies (architect at UCL) and supported by an interdisciplinary board. The four pillars of action are information exchange, research, capacity building, advocacy and sustainability. Activities are: pump prime funding (with 52 expressions of interest, and 17 currently preparing full applications), global advocacy, yearly open network meetings for information exchange, and grant writing workshops. Research gaps of interest are: basic biology of mosquito entry, keeping houses cool, preventing other VBD, risk factors within African cities, and mobilising communities. The next open network meeting will be held on 28th March in London. Travel bursaries are available and work stream members were asked to sign up at www.bovanetwork.org.

The potential of the BOVA network to fund work within the work stream was discussed.

Research in Progress – Steve Lindsay, Durham University

Updates were given on on-going projects with discussion and questions in turn:

1. WHO policy on housing
GVCR means a major change and house improvements are there as an established tool for vector control. A new policy brief “Keeping the vector out” has also been published by the WHO recognises the importance of housing improvements for vector control.
2. Research on risk
New publication from Rek *et al.* in Lancet Planetary Health (Rapid improvements to rural Ugandan housing and their association with malaria from intense to reduced transmission: a cohort study).

Rapid improvements in house design were observed in a cohort of households in rural eastern Uganda from 2013-2016. Modern housing was associated with an additional reduction in mosquito density and parasite prevalence following an IRS campaign.

3. New house design

Keeping houses cool improves use of nets. Southeast Asian style houses (raised, with open sides for ventilation) were built in Tanzania. Houses were cooler and had reductions in malaria vectors. Largest reductions were seen in double storey buildings.

4. Relative attractiveness of houses

80-100% of malaria transmission in SSA occurs indoors. Experimental houses were built on the village edge, the same standard size of single room houses in the Gambia, with sleepers inside under LLINs. Data loggers recorded indoor climate. House design (roofing material, closed or open eaves) was rotated around each position. Results showed closing eaves and doors reduced mosquitoes. But metal roofs with closed eaves and open doors attracted many more mosquitoes than thatched equivalent. Ventilated houses reduce vector entry. Temperature and carbon dioxide build up under different materials may explain some of the difference in attractiveness.

5. Development of interventions

Ventilated doors such as louvered doors already exist and can be made mosquito proof by adding netting. However, there is a challenge in keeping the netting in good condition. New screen door are being tested; concertinaed door, ventilated through 2mm holes, self-closing, with blinds and windows. Preliminary data on nuisance mosquitoes indicates a reduction in mosquitoes indoors by two thirds.

6. Eave tubes

These will be covered in subsequent talks, but are a powerful tool that turns the house into a lethal trap.

Discussion

- It was clarified that mosquitoes were trapped using light traps in the door study.
- The comparison between metal and thatched roofs was discussed. Although in the study, metal roofing was associated with higher indoor vector densities. The consequences of metal roofs are likely to be different in the Gambia where it is very hot, compared to say Uganda where it may much cooler. Understanding the basic science here can help innovation.
- These results indicate that targeting improved roofs only is not the way to go, but a more holistic approach should be made, to ensure the odour profile of a house is thought about when carrying out improvements. It was suggested that the odour plume through a screen door would attract mosquitoes which would then enter when the doors were opened. There are some really basic questions that need answers (does gap size around doors matter, does window size matter, door opening and closing with time of night).
- It was asked whether reflective paint might reduce the heating problem of metal roofs. This is currently being investigated, but the data are not yet analysed.
- It was asked whether outdoor toilets were a factor in doors opening and closing at night. The data loggers suggested that front doors are opening at night rather than back doors leading to the toilets.
- Alternatives to metal roofs that might be as acceptable to communities were discussed such as the Southeast Asian style houses, which are now being copied in the village where they were trialled.

Eave tubes update – Marit Farenhorst, In2Care BV

Eave tubes are tubes through walls that allow odour bait out, but are blocked with insecticide treated mesh. VCAG have categorised it as a Lethal House Lure. A RCT is currently underway in 3,000 houses in Cote D'Ivoire, where eave tubes are being installed, alongside window screening and gap blocking in open eaves and walls. Insecticide particles are loaded onto the mesh via a long-lasting static charge, resulting in high dose transfer allowing killing of resistant mosquitoes. Ethovision is being used to track mosquito contact (transfer time and interaction with resistance status) with eave tubes. This can then feedback into quality assurance assessments. Benefits of the technology are that it is transferable to any particle (insecticides, fungal spores), mixtures can be used without interaction, mosaics can be used at house level, minimises residents' contact with insecticide; and minimises insecticide doses required per house. Implementation developments include pre-cast bricks with holes for new houses, or eave bricks.

Discussion

- The suitability of eave tubes for different house types was discussed. Eave tubes were developed in Tanzanian brick houses. Implementation was difficult in houses with multiple gaps in walls.
- The challenges of screening windows and doors were discussed. Specialised window screening tools were developed for the Cote D'Ivoire trial. Despite the use of local materials and skills, window screening seems to be the most costly part of the intervention. Hut trials are currently being conducted to compare non-window screen implementations alongside the full eave tube and screening approach. Although eave tubes target *Anopheles*, screening might better target *Culex* so may be best not to lose this aspect of the intervention.
- It was asked whether there are any data on dosage and exposure time for efficacy against resistant mosquitoes. Very resistant strains are being tested at the moment, but results are not yet available.
- The potential for eave tubes to help implement mosaic treatment was discussed. Although WHO does currently recommend this approach it is not often implemented often due to budget constraints. The reduced treatment area with eave tubes reduces costs, and it may be possible to put combinations on the same piece of netting.

Discussion: Increasing outreach to housing sector - All

- Previous experience with obesity in the US showed that small grants, such as those offered by BOVA were a good way to engage with housing sector. In US, making contact with the sector relatively easily done through existing networks. These may be replicated in other countries, but working on a global scale, identifying these groups would represent a huge task.
- Tourism and education departments were suggested as routes to gain funding and community engagement.
- It was suggested that rebuilding activities, whether following natural disasters or slum clearances would be a good point at which to get these lessons into practice.
- The potential for regional bodies such as PAMCA to be route to regulatory bodies was suggested.
- The NGOs, Habitat for Life, Engineers without Borders and UN-HABITAT, were suggested as a route to incorporating vector control in routine building activities.
- A suggestion was made for creating competitions to solve vector control problems within specialised architecture training institutions.

- Advocacy funding for in-country meetings is available from BOVA. Prosper Chaki and Nick Brown volunteered to organise a model meeting in Tanzania, which would bring together all target groups.
- Local entrepreneurs were suggested as another route to getting these ideas into reality. Alexa Bednarz will suggest some contacts from the India TIE network and global innovation exchange.
- Houses built by the government (e.g. teacher's houses) were suggested as a target for modelling vector control innovations. Ministries for planning were also suggested as a key target
- A comment was made that the level of development will affect whether houses are locally built, or whether this is a specialised skill, and the approach should be adapted to each setting.
- The potential of architects from China was mentioned and it was asked how these ideas might be presented.
- It was suggested that these ideas were brought to NMCP meetings.
- A label or certification for mosquito-proof houses was suggested, based on measurable factors e.g. percentage of gap screening.
- An attractive alternative to metal roofs were discussed and bamboo was suggested.

Discussion: Increasing outreach to South East Asia and Latin America - All

- It was suggested that by removing the malaria focus of the work stream, it would be easier to reach out to vector control elsewhere, and the Southern Cone Initiative against Chagas was given as an example. The name change for the work stream is coming next year.
- Similarly, in urban Malaysia it is dengue that is the main concern, not malaria. An integrated approach involving the Ministry of Health, Planning, and building contractors is already in place aiming to minimise the creation of breeding sites around homes. In rural areas where malaria is an issue, outdoor biting is the main challenge, so housing is not the whole answer and human behaviour must also be taken into account.
- Livestock producers were suggested as a target, for example tsetse fly control programmes in Africa, and domestic chicken rearing practices in South America.

Discussion: Increasing the role of individual work stream members - All

Steve Lindsay asked members to make contact with any further ideas.

Informal side meeting: Vector Control in Humanitarian Emergencies

17:00-18:00, Wednesday 7th February 2018

Co-leaders: Josiane Etang and Michael Macdonald

Introduction – Michael Macdonald, Consultant

Michael Macdonald opened the meeting and introduced the discussion. The mission statement of the group is to a) improve service delivery, uptake, integration and evaluation of existing vector surveillance and control tools; and b) facilitate the development of an evidence base and uptake of supplementary and emerging tools. The aim of this meeting was to lay out the framework of the initiative and facilitate introductions, meetings and discussions for collaboration among different partners, funders and researchers to address the two objectives of improved service delivery and introduction of new tools.

Review of the outcomes of Basel Meeting and integration of services - Valentina Buj, Unicef

The first meeting of the steering group was held on 14-15 September 2017 in Basel, which resulted in a mission statement (official report available on RBM website). Emergency situations present a range of challenges from insecurity, lack of access, insufficient human resources and supply chains to inadequate funding. However, this group identified a number of opportunities to solve these problems rather than simply implementing solutions. There is a need for clear definition of roles and responsibilities among implementing agencies and among “clusters” such as Health, Shelter and WASH, to prevent issues being offloaded as someone else’s problem. Flexible funding will allow rapid deployment of technical assistance and commodity procurement. Every emergency is unique. In-country solutions are vital, and as part of this, all plans must be tailored to the local situations, how to deliver services to these communities.

Improved service delivery with existing tools - Richard Allan, The Mentor Initiative

Delivering services and making a difference in humanitarian emergencies requires a different approach. Whilst malaria is amongst the top 5 causes of mortality, it is not enough to target this disease in isolation, an integrated solution is essential. Products are provided by the commercial sector, but they must be informed by people on the ground, and usually an adaptation is required from standard use in non-emergency situations. A number of discussion points for work stream members were suggested from scale up of new chemistries, evidence-gathering for larval source management and regulatory challenges. The challenge to industry for this sector is the unpredictability of demand, including the costs of stockpiling in order to rapidly deliver. These situations provide a unique opportunity to gather field data, but there is a real need for increased standardised data collection and publication. The group is looking for targets to build a work plan for 2018, focused on generating evidence and facilitating roll out. Participants were asked to contact Michael Macdonald with any contributions.

Discussion

- Manufacturers involved in product development were urged to contact WHO early in their assessment process, there is now a streamlined approach through VCAG who will advise on the evidence that will be required. This advice will take into account the difficulties of RCTs in humanitarian emergencies, but will also ensure data is of the highest possible quality.
- The costs of stockpiling were discussed, as well as the potential waste of products that are not used before expiry. In addition, industry will need to finance national registration costs and additional regulatory requirements that may come from funding agencies. It was asked whether funding agencies might be able to help with some of these costs.

Opportunities for new product development - Peter Maes, Médecins Sans Frontières

Traditional tools cannot work in these challenging contexts and new tools are required. For example, in Masisis DRC, populations are constantly moving and staying in small make-shift structures so IRS and LLINs are not working well. Impregnated blankets are a potential solution. However, current products may not have the right target product profile, including potential issues with pyrethroid effectiveness in areas of high resistance. In nomadic populations in Turkana, Kenya, nets without holes are preferred. However, again only pyrethroids are available. Spatial repellents have a lot of potential for night watchmen or forest workers in Southeast Asia.

Discussion

- Impregnated blankets were discussed. They were first used in Afghanistan as a very thin sheet barrier. When standard thick blankets are impregnated, then the host signals are masked and vector contact with insecticide is reduced. But the Shelter/Non-food Item Cluster's standard product profile is a thick blanket that will keep people warm
- A comment was made that packaging is important in terms of package size to enable mass transport. Improving deployment of existing tools is a main aim of the group, for example preventing the creation of larval habitats by the Shelter sector digging brick pits for housing construction or the WASH sector putting in pumps without adequate drainage aprons.
- The level of evidence required for vector control in general is going up, which is a good thing, but in humanitarian crises this is a real challenge. VCAG can demand cluster randomised trials, but realistically no funding body will fund these trials in the timescale required. Safety data is of course required, but once this is obtained roll-out needs to happen; monitoring and evaluation should be used to gather evidence base afterwards.
- Endectocides were suggested as many additional pests would be addressed (lice, scabies, helminths). It can be rolled out easily with small packages and safety data is already available.
- A comment was made that the WASH and SHELTER clusters need to be represented in this group so that products developed for vector control do not run afoul of their product specifications.
- It was suggested that eave tubes could be adapted for ventilation flaps on tents.
- Data collection should be realistic and based on usage of the tools. Scale-up of nets and IRS has not met the challenges in these countries. In fact, death rates have been rising. Therefore, standardised collection of feasible and useful data is required.

The meeting closed with general call for ideas and a pledge to bring donors to the next meeting to help fund these ideas.

Day 2: Thursday 8th February 2018

3rd New Challenges, New Tools in Vector Control Work Stream meeting

09:00-12:00, Thursday 8th February 2018

Co-leaders: Michael Reddy & Fredros Okumu

Michael Reddy welcomed participants to the meeting, and opened the meeting with a reminder of the work stream objectives. Fredros Okumu gave an update on the work stream activities, accomplished or pending as of December 2017.

Updates on the recent discussions around the concept of “Residual Malaria Transmission” – Mariam Otmani Del Barrio (on behalf of Florence Fouque), World Health Organization / TDR

Ongoing and completed projects to produce evidence on residual malaria transmission in a range of settings were presented. In the Greater Mekong Sub-region, the main malaria drivers were high exophagy, high biting outside of sleeping hours, non-net use, use of damaged nets, high population movement, and predominance of *vivax* malaria. The next steps will be to implement personal protection tools and modelling of transmission sites. In Peru and Brazil malaria hotspots are being quantified. In Cameroon, Kenya and Ethiopia, it was found that outdoor biting has increased and continues throughout the night. In Papua New Guinea, an ongoing project is looking at vector biting behaviour in areas of low LLIN use. In Tanzania and Burkina Faso, it was found that ITNs and IRS remain effective but are increasingly compromised due to insecticide resistance, outdoor biting and human activity. The overall conclusion was that current tools are not fully effective to achieve malaria elimination; and there is a need, first to better define residual transmission and second, to develop complementary new tools that address the identified gaps.

Discussion

- The problem of outdoor biting was discussed. It was asked whether it could have been caused by extensive insecticide use, targeting indoor biting populations. Indoor insecticidal interventions often have differential effects on different mosquito species, such as *Anopheles gambiae* s.s (indoor-biting, indoor-resting and anthropophagic) versus *An. arabiensis* (opportunistic species which will readily bite outdoors, feed on cattle and rest outdoors when challenged with LLINs and IRS). Untargeted species will then become more significant in entomological trapping, despite not necessarily increasing in numbers.
- It was asked what personal protection solutions apart from repellents could suit Southeast Asian forestry workers who often will not carry a net because it is too cumbersome.

Towards better morphological and molecular identification of malaria vectors - Seth Irish, CDC & Neil Lobo, University of Notre Dame & University of California San Francisco

It is important to know exactly which species are present and the behaviour of each species. As different interventions target different behaviours, knowing which species are present is key to adapting interventions to the situation. Mosquitoes are hard to identify. Molecular identification tools are available and are particularly helpful in differentiating cryptic species. Molecular data can support and correct morphological data and has identified novel species. However, they require some morphological identification first in order to ensure the correct tests are being applied. Morphology relies on small features which may not be present in old or damaged specimens and this work requires trained entomologists. It was acknowledged that there is a need to improve

morphological identification skills. In cases where PCR assays are used to distinguish morphologically similar species (e.g. members of *An. gambiae* complex, and members of *An. funestus* group), it is important to ensure the basic morphological identification of these complexes or groups is done accurately before the samples are subjected to PCR, otherwise the incorrectly identified specimen will return with non-amplified DNA. At present, funding is being sought for training, and keys are being updated.

Discussion

- It was asked whether the observed changes in mosquito behaviour are caused by unseen changes in mosquito species that are present. It was agreed that this might be the case, although it may be site dependent.
- It was remarked that there is no established system for training, and the possibility of a quality assurance laboratory where specimens could be sent was discussed. At present funding is being sought for this type of project.
- Near Infra-red species identification was mentioned as an option; but it was stated that data on this approach is currently unsatisfactory, thus more research is needed.
- A comment was made that laboratory studies show significant behavioural plasticity within species, and intervention strategies should plan for these types of changes.

Unmanned Aerial Vehicles (UAVs) for Vector Control - Joe Eyerman, RTI International

RTI started integrating aircraft into their research in 2013, mostly using low-cost off-the-shelf hardware and flight management systems. The areas that required niche problem solving were coding, analysis, field staff training and ethics. A feasibility study was carried out in Guatemala, and field staff reported drones were faster in mapping, however hand coding larval sites was slow and there was no direct observation on larvae in containers identified. Validation was done through ovitrap placement near to identified sites but without larval sampling of these sites. A project is currently ongoing in North Carolina to improve coding procedures and results are still pending. However, it is clear that sites not detected by visual survey, such as debris on roof tops are being identified by drones. In the future, drones could also be used for spraying, although there will be technical and regulatory hurdles to overcome.

Discussion

- A clarification was made that the primary aim of the first study in Guatemala was to see if drones could be integrated into existing activities, and whether the drones could effectively identify potential breeding habitats, regardless of whether the habitats had water or not. The aim of the second study was to validate the data collected.

Self-limiting mosquitoes as a tool for vector control - Jennina Taylor-Wells, Oxitec Ltd

Self-limiting *Aedes aegypti* have been approved for commercial release in Brazil. The technique relies on a lethal gene that kills in the late larval stage. The gene expression is suppressed by tetracycline to allow mass rearing, but does not persist in wild populations. Males only are released, with mosquitoes sorted at pupal stage (target for release of <0.2% females). New innovations using this type of technology are to have a male-selecting gene which is lethal only to female offspring. This would reduce wastage in mass rearing and could persist for longer in the population, increasing time between each release. There is also potential for synergy with existing vector control tools. The release of susceptible males introduces susceptible genes back into populations. Oxitec are currently working with *Ae. aegypti* and *Ae. albopictus*, however there has been successful transformation of *An. stephensi*, and this may be a route for research in the future; with potential applications in malaria vector control.

Discussion

- It was asked whether there was concern that suppression of *Ae. aegypti* could lead to selection for *Ae. albopictus*. Monitoring in the short term showed no indication of replacement, but it is a concern and work is ongoing for this reason
- An *Anopheles* product was discussed. This is planned, and proof of concept is already published. Work is likely to take a few years, and there are regulatory hurdles. However, this is significantly faster than a new insecticide. Costs are likely to be similar to the current *Aedes* programme
- It was asked if the technology was propagated by gene drive. The self-limiting gene is not associated with any drive mechanism; mosquitoes are released with gene, and it does not persist in environment. This is seen as an advantage in general, but does mean releases have to be maintained. Eradication might be possible on islands, but an urban environment is more challenging.
- The impact of tetracycline on the environment was discussed. The levels in rearing water are low, and both gut bacteria and tetracycline is lost from the insect on eclosion, so none is released along with the mosquitoes. In terms of pollution, the only water bodies found with high enough tetracycline levels to potential rescue these mosquitoes were fast flowing water associated with agricultural systems, which would be unlikely larval sites.

A planning tool for entomological surveillance - Allison Tatarsky, University of California San Francisco

The Entomological Surveillance Working Group convened in December 2016 with the aim of re-introducing problem solving into vector control decision making and creating operational guidance for entomological surveillance. The Entomological Surveillance Planning Tool is currently a handbook containing guidance on site selection, minimum essential indicators, sampling methods (for entomology and human behaviour), operational guidance through use of decision trees to help countries decide on action to take on baseline surveys, routine sentinel surveys, focus investigations, other key programmatic questions. Therefore it can be used in planning and protocol development, capacity gap analysis, training framework, transmission investigations, data collections, integrated data analysis and intervention evaluations. The document is currently being discussed and improved by way of expert groups. The next steps will be pilot implementation in Panama, Namibia, Mozambique and Lao PDR.

Updates on eave tubes for malaria control - Matt Thomas, Penn State University

A large RCT is currently underway (8 months in 2 year trial) in Cote D'Ivoire, testing full house screening with insecticide treated eave tubes, an intervention described by VCAG as "lethal house lure". LLINs were distributed to 40 villages, and the screening and tube intervention placed in 20 of these. Average coverage within each village is 70%, and varies from 30-100%. Data were collected on epidemiological, entomological, physical environment, social science and economic outcomes. Preliminary entomological data show vector density seems to be reduced in treatment arms. Data loggers show very little difference to indoor microclimate. Additional experimental hut studies showed no deflection to untreated houses, and also that eave tubes reduced vectors even if windows were open. Despite full screening, mosquitoes were still caught indoors, and data loggers showed a large proportion of doors open throughout the night. A possible next step will be an RCT with multiple arms to test the impact of each intervention individually.

Discussion

- It was asked whether eave tubes could work as exit tubes. This has been tested in experimental hut trials, and a significant increase in mortality was observed.
- It was asked whether it was odd that a fairly large proportion of mosquitoes did not enter experimental huts. The trial was extended to multiple nights, but this did not affect the outcomes. The next set will be to look at the effect of opening doors.
- A comment was made that research into netting eaves also showed windows might not be important. However an open window will decrease the attractiveness of the odour airstream from the eave tube. Recruitment of mosquitoes through doors is currently being investigated, and it is not clear yet whether self-closing doors would be acceptable to local communities.
- Overall, it was observed that there is already a remarkable progress, as observed via the entomology indicators, for which the 8-month data was presented.

Potential of auto-dissemination for malaria vector control - Mike Banfield, SpringStar Inc.

Auto-dissemination is the spread of insecticide via an insect to other insects, and resting or breeding sites. The method was developed in 2003 for *Aedes*, and the concept demonstrated against *Anopheles* in 2014. A commercial *Aedes* formulation is planned for 2019. Current active ingredients include pyriproxyfen, methoprene and novaluron, but this is a flexible tool and can be adapted provided safety profile is correct. Delivery systems can also be very flexible (clay pots, eave tubes) and can and should be adapted to local conditions. An outline of possible new trials was provided, with a focus on developing a scalable format for making the auto dissemination approach practical in endemic communities.

Updates on potential of spatial repellents for vector control - Neil Lobo

Spatial repellents are potentially a powerful tool alongside traditional methods of vector control, as they can target early evening and outdoor biting, and their light weight means they are smaller and easier to distribute for example during epidemics. Two previous studies have shown reductions in mosquitoes (77% in China, and 32% in Indonesia) and disease (52% reduction in Indonesia) as a result of spatial repellents. VCAG wants more data on the coverage required, efficacy variation, whether there is community protection or diversion, and the effect with resistant populations. A planned study to look at these had to be scaled back, so efficacy variation, diversion and insecticide resistance are not currently being investigated. The component of this study previously running in Africa had been stopped. The studies in Indonesia and Peru are ongoing and blinded, so no results are available until after March 2018.

General discussion and plans for the next steps - Mike Reddy, Bill & Melinda Gates Foundation & Fredros Okumu, Ifakara Health Institute

- The community acceptance of spatial repellents was discussed. In general it is very good, more so in Southeast Asia where there is historical use of repellents.
- A comment was made that spatial repellents should target multiple mosquito borne diseases. However, as they do not always overlap and control programmes tend to be separate, so implementation will need good coordination.
- It was asked whether there was a distinction in the data collection between the repellency and the knockdown effect of transfluthrin. This was looked at in semi-field trials, although the data is not published. The current trials are simply collecting landing rates along with a transect from the spatial repellent.

- A clarification was given that the eave tubes trial is not attempting to change behaviour in terms of closing doors, as the trial is already ongoing. Any behaviour change associated with the intervention is being monitored.
- Michael Reddy is stepping down as co-chair this year and Fredros Okumu will be following within 1-2 more years. Therefore volunteers for new co-chair position were invited to put themselves forward.

3rd IVM, Evidence and Capacity Work Stream meeting

14:00-17:00, Thursday 8th February 2018

Co-leaders: Josiane Etang and Michael Macdonald

Work stream introduction - Josiane Etang, Organisation de Coordination pour la lutte contre les Endémies en Afrique Centrale & Michael Macdonald, Consultant

Josiane Etang and Michael Macdonald opened the meeting and introduced the agenda and work stream priorities.

Tools for mapping training opportunities and vector control needs assessments - Konstantina Boutsika, Swiss Tropical and Public Health Institute/Roll Back Malaria

Two new tools have been developed by Swiss TPH designated in 2017 as the WHO collaborating centre for modelling, monitoring and training for malaria control and elimination. The first activity was to map malaria related courses worldwide (Tool 1, data collection ongoing); the second activity was to assess malaria related training needs at national and sub-national level (Tool 2, due to start in February 2018). The expected outcome is to have an online website and repository of all malaria related courses. Courses in English, French, Spanish and Portuguese are included. However, information is limited, with few courses available in Southeast Asia. Pilot work is ongoing for Tool 2 with 21 malaria experts attending WHO meetings.

Discussion

- A question was asked about the availability of metrics to determine the quality of the training. The first item of discussion in March 2018 will be how to evaluate the quality of courses.

Building capacity to manage Insecticide Resistance in the African Region – Josiane Etang

Malaria control in the African region revolved around LLINs, IRS, LSM and community mobilisation. The rollout of LLINs from 2000-2015 revealed coverage rise from 10% to 90%, and the reduction in malaria burden was evident up to 2015. However, insecticide resistance is a major threat and resistance to all 4 classes of insecticides is widespread in Africa. Capacity-building work for managing resistance has involved staff training (10 countries); supporting the development of national management plans (24 countries), and monitoring tools (42 countries). The challenges are human resources, limited knowledge, system/infrastructure weaknesses, competing priorities, long-term commitment in terms of political will, and finance. Future work will involve continued training of NMCP staff and young researchers, technical support for resistance management activities, financial support for countries in terms of kits and training, and support with the development of management plans.

Discussion

- A comment was made that at the moment there is no threshold of resistance at which control programmes should swap strategies. WHO has recently added test guidelines to help assess the intensity of resistance. The support in writing the insecticide resistance management plan covers this subject and countries are encouraged to take pre-emptive action.
- It was suggested that capacity could be sourced from private sector manufacturers of these products as well as traditional institutions. But it was noted that the private sector partners need advance notice when the trainings will occur so they can be budgeted in their annual plans.

Integrated Vector Management in Ethiopia - Delenasaw Yewhalaw, Tropical and Infectious Diseases Research Center, Ethiopia

Vector control in Ethiopia requires answering a complex series of challenges (including climate change, habitat modification, vector behaviour, and insecticide resistance). Malaria is targeted for elimination by 2030. There is a long history of DDT use and LLINs have been distributed since 1997. Resistance mapping has shown a high frequency of *kdr* and other resistant mutations. A sentinel sites for resistance monitoring have been set up. At present only combination use of vector control tools is practiced, but no other core principles of IVM are considered. There is a need for an insecticide resistant monitoring and management strategy, and a recommendation was made for a finalised national policy and IVM plan.

Integrated Vector Management in Sudan - Hmooda Toto Kafy, Federal Ministry of Health, Sudan

Vector control in Sudan also required an integrated approach to controlling VBD including endemic malaria and outbreaks of Yellow Fever. In Sudan IVM was incorporated into Ministries of Health policies, and huge efforts of capacity building were funded by the Sudan government. Interventions include LLINs (96% coverage); IRS (32 localities); LSM (main intervention in urban areas). Vector surveillance systems were set up with 106 sentinel sites collecting mosquitoes, sandflies, snails and ticks, and 73 sites are also used for insecticide resistance monitoring. Eleven insectaries have been established, including provision of equipment and training (MSc and short courses). One of the main challenges has been turnover of trained staff, one third have left following training. Other challenges are sustainability, low usage of LLINs in Sudan, and a lack of facilities for dealing with chemical waste.

Discussion

- It was asked whether *Ae. aegypti* has always been in Sudan or might it be a new invasion. Hmooda Toto Kafy gave his opinion that it was likely to have been present in the past, but may have spread further more recently.

Decentralized Entomological Surveillance: Community-based Approach - Chadwick Sikaala, Elimination 8

Entomological surveillance is traditionally carried out by highly skilled, centrally based experts, which means it can data collection can be very limited in resource poor settings. A community-based approach was piloted to attempt to fill some of these gaps. A monthly sampling scheme was devised with community health workers trained to operate CDC light traps and Ifakara tent traps, and to carry out basic sorting of the catches into culicine and anopheline mosquitoes, with the anophelines packaged for further analysis. Data entry was simplified and a central team carried out validation and quality assurance. The data collected was of a similar quality, but costs in the community-based approach were around 10 times lower in terms of collections per person night. The major challenge was in the training and re-training of community health workers. However, community engagement and ownership was high. This is a practical and cost effective method giving increased frequency and greater resolution of data.

Discussion

- It was asked what proportion of community health workers were women. No women in the teams as they were selected through an existing hierarchy structure.

Vector Control in Humanitarian Emergencies - Valentina Buj, UNICEF & Richard Allan, The Mentor Initiative

Last year 65 million people were refugees, meaning this issue is more urgent than ever. Most of the work done in these situations is done by international and local NGOs. A joint assessment of needs designing a feasible response is required. There are opportunities to collaborate to generate data, and develop tools including IRS, innovative equipment, non-mesh nets, close mesh nets, PBO or new active ingredient nets, larval source management and spatial repellents. Challenges in this area include regulatory blocks, stockpiles, siloed actors and situational analyses not being joint or shared.

2018 work plan: capacity building - Josiane Etang

Josiane Etang referred the meeting to the work plan and opened the floor to questions.

- A comment was made that it is important to identify benefits to both sides when asking for support in capacity building from industry, who have in the past provided targeted training, or built insectaries and laboratories.
- The need for an increase in training and facilities for molecular assays was highlighted by work ongoing by PMI. Some of these gaps can be filled with minimal funding.
- A comment was made on the need to liaise early with the private sector. Projects need to be prioritised, so that money is made available within annual budget plans.
- A suggestion was made that in emergency situations, a needs assessment should be carried out so that the appropriate interventions are sent, but the team that will carry this out needs to be identified.
- The availability and quality of insecticide resistance test kits was discussed. This is a large and common problem, and it was suggested that a new test kit could be supported. It was also commented that the current kits are very expensive for what they are.
- It was suggested that planning for capacity building should be country based, and span all vector borne diseases not just malaria.
- It was suggested that NMCPs should determine their training requirements and approach research institutes within country. This was carried out Sudan in 2014, and now over 200 staff have been trained in mosquito identification.

2018 work plan: entomological monitoring - Chadwick Sikaala

- *Aedes* monitoring was discussed. The expertise within AMCA on surveillance, identification and information management was highlighted. If AMCA were to receive more detail on training needs, this could be discussed. In Africa there may be existing infrastructure (staff, insectaries and laboratories) from *Anopheles* monitoring, but specialist *Aedes* skills (identification and surveillance) are missing, despite the emergence of dengue, Yellow Fever and other *Aedes*-borne viruses. There was an offer from Pakistan to share their experience and model of a surveillance programme built in response to a series of dengue outbreaks. It was also suggested that *Aedes* collected during other surveillance might be sent to other laboratories who are monitoring this data.
- The PMI Best practices in entomological monitoring were suggested as a good place to start in putting together a country monitoring programme.
- It was asked whether there was scope for a literature review and meta-analysis to bring together insecticide resistance work and gene flow without having to do new monitoring.
- It was suggested that there should be a gender component in this work stream to identify and track the engagement of women.

2018 work plan: humanitarian emergencies – Richard Allen

- A comment was made that discussions with industry can be carried out under confidentiality agreements where necessary for the development of new tools.
- A working meeting is planned for early this year, aimed at finding better ways to get products on the ground. If needed, discussions of a particular product can be held separately.
- These situations are irregular, so there is a need for novel ideas, or tweaking of old ideas e.g. innovation to increase dispersal or application, resistance management by mosaic spraying, new actives.
- Regulatory issues were discussed. Provided the product has approval somewhere, for example with the US EPA, getting a product into an emergency situation is not usually a problem.
- The use of a new active ingredient, pirimiphos-methyl, in South Sudan was given as an example of a situation where a real difference was seen. ITNs were ineffective due to resistance and to inappropriate care, but spraying with the new chemical in the camp and surrounding village houses prior to the malaria season reduced cases.
- It was reiterated that camps do provide an opportunity to test, and MSF have full time entomologists and epidemiologists to collect data on the ground. This data is usually published, and academic partners can be included. MSF can also help with the protocol, ethics and evaluation.

Day 3: Friday 10th February 2018

Session 2: Updates and Feedbacks

Chairperson: Jacob Williams

WHO's recent and ongoing work on malaria entomology and vector control – Jan Kolaczinski, World Health Organization

It should be noted that much of recent work has been conducted across partners (PQ, NTD, TDR). Members were asked to register for the newsletter and “malarianews listserv”.

1. Global Vector Control Response (GVCR).

The GVCR was adopted without amendment by the WHA, and a number of advocacy documents and a website have now been created. The Framework for National Vector Control Needs Assessment has also been created as a live document that will be improved on, as it is implemented. Translations are planned following finalisation. Other resources that have been developed are an insecticide resistance monitoring and management framework, and a malaria risk map (including IR, molecular and drug efficacy data).

Future work will focus on supporting regions in the development of regional action plans, implementation on the country level. A priority will be the development of a consolidated evidence base to inform interventions, identify evidence gaps and inform the research agenda. A contract has been signed with Tropical Health LLP to look at issues around WHO test kits.

2. Malaria Vector Surveillance.

The Global Malaria Programme has created surveillance guidance in one manual, with a chapter on entomological surveillance and research. This is undergoing revisions, with the final due in the next two months. Future work will involve the Phase 2 development of threat maps, including a mobile app. DHIS2 will develop a module, in collaboration with a number of other partners. The final global status report on IR will be a publication in May 2018. This will be followed by a comprehensive revision to the manual on practical entomology in malaria (1975), hopefully to be completed in 2019.

3. Evaluation of Vector Control Tools.

VCAG will play a significant role on evaluation of new technologies, and PQ is now co-sponsors of VCAG. A manual for the design of phase III trials was published in December 2017. New data was evaluated on pyrethroid PBO nets and revised recommendations were published in September 2017 (with a clarification in December 2017). Future focus will be on the evaluation process, and whether this should change in terms of the evidence demanded. Other VCAG activities in 2018 include a recruitment of a new manager to start work in March 2018, and the seeking of new experts on gene drive, regulations, product development. The update of documentation has not started, but resources are being identified.

4. Implementation Guidance.

AMP, VCWG and ALMA are looking at old guidance on universal coverage and treatment of malaria, with the aim of producing revised guidance and restructured documents.

5. Advocacy.

In 2017, World Malaria Day and the World Malaria Report provided advocacy opportunities. There is now an app for content of world malaria report. A technical consultation is planned to look at universal access in February 2018.

Overview of the prequalification of vector control products – Marion Law, World Health Organization

Vector control is a new stream in prequalification, with a mandate to increase access to safe, high quality efficacious vector control products. A new component of this for vector control products will be the inspection of quality, from manufacture throughout product lifecycle. The first assessor meeting was in November 2017, and a number of SOPs were developed with the next meeting in May 2018. Collaboration with stakeholders is very important, to build a useful service. The regulatory framework is built on science and policy, which dictates what you do with the evidence, and how the evidence is assessed. The priorities of PQ team are the conversion of pre-approved products, review of study protocols and focused communication with stakeholders. So far 32 products have been converted to PQ listing, with 83 applications for conversion, and 1 new product has gone through full PQ listing. Regulatory systems need to be appropriate for products, so need to be dynamic and adapt to changing needs of populations. Old and new products should be evaluated through a modern regulatory lens.

Discussion

- It was asked if products will be re-evaluated at periodic intervals as in the EU. That is not the plan; conversion was simply to ensure evidence aligned with WHOPES guidelines and possibly to re-advise on labels. Where necessary, post-market approach might be utilised to look at chemistries.
- WHOPES has a long history and there is still some confusion in the marketplace due to unfamiliarity with PQ. A one pager to connect the two was suggested, and this is being drafted.
- The grouping of product for example PBO nets was discussed. PBO nets are many different products with varying doses, but all lumped together in one group. This was an issue that was problematic under WHOPES, and it was asked how PQ will handle these products. There are lots of evidence gaps around these nets, and as the transition progresses, more issues are becoming clear. The new process is for new tools to go down VCAG path which requires 2 epidemiological studies. Products coming after would not be asked to produce the same level of data.
- It was pledged that the meeting next year will have a longer section on PQ.

Feedback from Networks: AMCA, APMEN, E8, PAMCA, PIAM

AMCA - Wayne Gale, Director of American Mosquito Control Association

AMCA is a non-profit professional association founded in 1935, with the aim of promoting sound science in mosquito control. The Association supports legislative and regulatory advocacy. It also produces two publications; JAMCA, which is becoming open access online from next month, and Wing Beats, a trade magazine. Stories and experiences related to control issues were welcomed for Wing Beats. AMCA also provides education and has produced training materials and webinars available to members. In partnership with the CDC it has established certified training programs for mosquito surveillance and control. This is a comprehensive web-based training course with 4 e-learning modules, interactive video presentations and a final assessment. A recently updated Best

Management Practices Manual is available to download from www.mosquito.org along with many other resources and information.

APMEN – Christina Rundi, Ministry of Health Malaysia & Jeffrey Hii, Malaria Consortium

APMEN is now comprised of 18 countries and its main objectives are to contribute to improved evidence, to facilitate work and action, and to develop human resource capacity within the member countries. The network is currently supported by Sumitomo and UCSF through BMGF. APLMA is an affiliation of heads of governments, who endorsed a roadmap and dashboard for elimination of malaria by 2030. ALPMA and APMEN together help transfer policy into action. Within APMEN, vector control forms one of three groups working towards elimination. Current activities aim to strengthen network-to-network information sharing between APMEN and networks in Africa, and to address the concerns from APMEN member countries on methods and challenges on monitoring activities. Some of the recommendations have been advocacy for political commitment and investment in vector control, a sustained IVM approach, to enhance civilian and military cooperation (through AFRIMS), addressing regulatory bottlenecks and harmonisation of national regulatory processes. Priorities for APMEN are dengue and residual malaria transmission.

Elimination 8 – Chadwick Sikaala, Elimination 8

In 2009, leaders of 8 southern African countries committed to eliminate malaria. Initially targets were set to eliminate malaria in the first 4 countries (Namibia, Botswana, Swaziland, and South Africa) by 2020, and the remaining 4 by 2030. Governance is through a joint council, E8 ministerial subcommittee, and a secretariat board which liaises with the technical committees. Vector control is one of 5 working groups which meet annually to set activities and priorities. E8 aims to facilitate regional co-operation in assessing regional capacity (completed 2017), develop entomological surveillance capacity, harmonize vector control surveillance indicators, and build capacity. Lessons learnt are the need for best practice in laboratory and insectary procedures. Timely implementation of activities requires coordinated cross border activities, collaboration and data sharing.

PAMCA – Prosper Chaki, Ifakara Health Institute

PAMCA is a work in progress, 6 countries are formally registered and further growth is planned. The first newsletter is now available on the website (www.pamca.org). Strategic partnerships have been set up with AMCA, APMEN, NEPAD and regional bodies involved in vector control. Last year's meeting was the most successful so far, with 250 participants, incorporating workshops on gene drive and grant writing. The first activity has been an assessment of entomological and vector control capacities in Africa; 108 institutions have been identified as being involved in vector control activities; 91 experts/institutions (from 35 countries) responded to the questionnaire. A desk review showed that amongst medical entomologists in Africa there were 215 PhD, 243 MSc, 173 BSc, and 468 students. 44% were working in universities, 26% at research institution, and only 17% were working in vector control programmes.

PIAM – Ahmad Raeisi, Tehran University of Medical Sciences

PIAM is the Pakistan, Iran & Afghanistan Malaria Network. Malaria transmission is highest in the border area of the three countries. In Pakistan, almost half of the population is at risk of malaria. A dedicated budget for malaria control has been set up for the first time by government. Major challenges are from the deteriorating security situation and mass movement of people in the border areas, and low political commitment to malaria control activities. In Afghanistan 75% of population are at risk. LLIN distribution is supported by the central government. Challenges again include insecurity and inadequate funding. In Iran, by contrast, political commitment to malaria elimination

is very high. Last year there were only 68 local cases with confirmation of all cases. As in the two countries, challenges again include insecurity in bordering areas, underdeveloped areas with high population movement.

Discussion

- A direct twinning programme between US and African districts was suggested. This can be brought to the AMCA board meeting next month.
- A comment was made that there has been a sharp increase in malaria cases in southern Africa. An acceleration plan is in process to fill gaps in vector control and surveillance, but whether it can cope with the challenge, is unknown.
- It is clear that capacity in Africa does exist, but the problem is that it is not in the right place and not fully mobilized for vector control. The VCWG should support to address this issue.

Overview from LLIN Priorities Work Stream - Co-Chairs: Hannah Koenker & Lena Lorenz

The presentations were summarised, and Jim Sutcliffe's talk (the importance of differentiating between LLIN durability and LLIN serviceability) will be set up on webinar. The take home messages were:

- Improving net use is the lowest hanging fruit to increase effectiveness.
- The location of holes and the insecticide concentration impact the effectiveness of older nets.
- There is no significant difference in cost between continuous distribution and mass distribution campaigns.
- PBO-LLINs have greater efficacy, compared to standard nets after 1 and 2 years. IRS with Actellic gave additional protection to standard nets, but not PBO nets.
- In PQT-VC all stakeholders will play important role in post marketing activities.

The work plan for the work stream will be finalized over email. Key findings from the meeting included the need to restore faith in nets; to use the right nets, getting nets to the right places at the right time.

Overview from Larval Source Management Work Stream - Chair: Silas Majambere

The progress on the work plan projects was reviewed.

1. LSM consensus statement.
This will be revised, with clear idea to distinguish between policy and guidelines. The statement will advocate for strengths of LSM and highlight limitations as well.
2. Advocating for environmental management.
Public Health engineers are being sought. Unfortunately the planned presentation from the African Development Bank did not go ahead this year.
3. Update resources on WHOPES/PQ approved larvicides and testing SOPs.
There are no adequate SOPs for larvicides under GLP and these are currently being created.
4. Review of new technologies.
This is a very fast moving field, with recent work presented on the use of drones and data advanced management. These developments are changing the definition of "few, fixed and findable" and would make those criteria less applicable in time – as larval sites can be mapped over larger areas, and at smaller scale/high resolution. New spray equipment and

techniques can make spraying much more efficient, meaning better utilisation in resource poor settings.

5. Review of operational LSM in vector control programmes.

A desktop review found M&E was very poorly done, if at all, IVM is not cross-referenced, and in general represents a lost opportunity to gather good data on LSM effectiveness.

6. Developing guidelines for LSM in emergencies.

LSM needs to be adapted for any local conditions, including emergencies, and LSM experts are ready to support the effort.

Overview from IRS IRM Priorities Work Stream - Co-Chairs: Mark Hoppé & Dereje Dengela

The presentations were summarised, and the take home messages were:

- Insecticides are eliciting strong selection pressure on the *Anopheles* genome. Further work will monitor the impact of vector control programmes in time and location.
- Models show that rotations and sequences give similar times in terms of managing insecticide resistance. Modelling can promote discussion, but is not yet sufficiently robust to inform operational decision making.
- There is an opportunity to implement IRM with the imminent introduction of new products. Planning pre-emptive rotations will minimise market instability chaos. Clear advice to IRM programmes is required to main susceptibility for as long as possible.
- The decline in the IRS market seems to be reversing, as increased affordability of 3GIRS through co-payments is increasing coverage.

Progress on the work plan was also summarised, with the IRM MOOC going forward, and a new online learning resource the vector learning exchange started.

Overview from Housing and Malaria Work Stream - Co-chairs: Steve Lindsay & Lucy Tusting

The work stream will change name next year and be known as vector borne diseases and the built environment. Progress on the work plan was summarised:

1. Two policy documents were produced, the Global Vector Control Response, and a policy brief, "Keeping the Vector Out", which both refer to housing as a vector control response.
2. The BOVA Network is a new project set up to bring together multidisciplinary researchers to address malaria risks in built environments. The project includes pump-priming funds for 8 research projects. The first meeting will be held in London on 28th March 2018, but subsequent meetings will be in Africa (limited travel bursaries are available).

Research presented showed evidence for the protective effect of modern housing, and innovative house designs to improve indoor microclimates and reduce mosquitoes. Fundamental studies are being carried out on mosquito entry to houses and the relative attractiveness of housing types. There was also discussion on outreach to the housing sector. Planned work for next year will be to strengthen link to housing sector through BOVA Network, as well as exploring opportunities to reach out to Southeast Asia and Latin America. A number of small projects are expected to be funded through BOVA this year. Finally the work stream will produce a biannual newsletter to maintain communication on progress.

Panel discussion about vector-borne diseases and their control/elimination –

Moderator: Ikupa Akim, Swiss Tropical and Public Health Institute

The discussion was opened by Ikupa Akim. The six panel members introduced themselves and gave short summaries of their perspectives on the current major issues in the control and elimination of vector borne diseases.

Marion Law, World Health Organization

Vector control products have played vital role in fighting vector borne diseases. A regulatory system should contribute to timely access to these products, and to do this a modern lifecycle approach appropriate to vector control should be in place. This involves efficacy data review, safety evaluation, and inspection of manufacturing, as well as post-market processes to review the real life use of products.

John Lucas, Sumitomo Chemical

The vector control market represents only 2% of the pesticide market, and return on investment is much lower. Manufacturers in this market want to act responsibly, but also make a profit. The battle against malaria is stalling, and resistance may be the culprit. Re-investing of profits into research and development helps innovation. However the role of industry is only to sell product, countries should decide on why, where and when to use that product.

Horace Cox, Ministry of Public Health Guyana

In Guyana, there are geographical patterns in the prevalence on malaria and lymphatic filariasis. Control strategies include mass LLIN distribution, mass drug administration and community-based management in mining camps. Some of the research opportunities surround links between mining and malaria.

Chadwick Sikaala, Elimination 8

Vector control capacity does exist in Africa, but is often not found where it needs to be. Career paths are not established for entomologists within malaria control programmes, and trained staff is lost. A system of training and certification should be considered.

Muhammad Mukhtar, Directorate of Malaria Control Pakistan

Challenges to the control of vector borne diseases in Asia include accelerating population growth, rapid and uncontrolled urbanisation, and environmental change. Dengue was first reported in Pakistan in 1994, and spread to 134 districts within 10 years. Control was hampered because of a lack of appropriate legislation, fragile surveillance, lack of research culture and donor dependence. The solution was to broaden the scope of control programmes and to enhance domestic resources.

Raman Velayudhan, World Health Organization

Neglected tropical diseases, particularly *Aedes* borne diseases (dengue, Zika and chikungunya) are the focus of WHO vector control activities. Control, surveillance and even elimination are possible with some diseases (lymphatic filariasis, leishmaniasis, human African trypanosomiasis, Chagas), but tools must be in place and the pace of progress must be hastened.

Discussion - All

- Training and capacity building were discussed. There are a significant number of PhDs in Africa, but there is a lack of connection between these people and control programmes. Operational teams are making decisions on vector control without this training. Mentorship schemes are a short term solution and some have been set up. However, in the long term, career progression is required. Consultation is required to know how to make existing

capacity most useful to control programmes, and what skills are needed. A point was made that capacity data needs to be kept up to date. Best practices already exist (for example Sri Lanka); what is required is to package the experiences and share with other countries.

- The PQ system was discussed. Although vector control is a small part of the industry, its activities affect a large number of people. There were requests for a quicker process can be in place to register product with existing registrations, and regulatory bodies, including VCAG to look at existing data rather than asking for the generation of new data sets. Regulators need to ensure tools are high quality, safe and effective. But processes can be made flexible when the aim is to improve products.
- Insecticide resistance management was discussed. A member wondered if the rotation of insecticides was replicating the effect of ACT cocktail in malaria case management - which might increase the risk of resistance.
- Supplementary tools, in particular larval source management, were discussed. The utility of LSM in malaria control has been demonstrated in many parts of the world. There is a manual for LSM, and also most countries have LSM in their strategic plans. However, external funding goes to core activities (ITN, IRS) only, so funding for LSM tends to come from within country sources, which severely limits implementation. RCT evidence is not available and new trials will not be funded. Often there is inadequate monitoring and evaluation, which makes it difficult to demonstrate efficacy of some ongoing LSM activities. It was stated that LSM is included in malaria and filariasis guidelines, it is not a matter of evidence; it is a matter of scaling up and funding.
- A comment was made that despite huge resources going to countries, there was very little coordination of partners. The NMCPs need to manage this role more effectively. The availability of national strategic plans should be used to ensure partner actions are concerted and contributing to harmonized national targets.
- A comment was made that despite the known attrition rate of nets, which points to a need for replacement after 2 years, replacement campaigns continue to assume a longer time for replacement. This undermines gains in reducing cases.
- A comment was made that malaria policy is still driven by clinical opinion, although the disease is an ecological phenomenon. Public health entomologists need to make their voices heard.
- It was asked whether the division of vector control within WHO into disease focused teams (particularly as this is replicated within countries) has hampered elimination targets. WHO leadership is also thinking along these lines, although the survival of vector control staff within WHO is concerning.
- A comment was made that there was very little presentation at the meeting from NMCPs. We need to know what their challenges are beyond capacity and funding, and collaboration.
- It was stated that the priorities of programmes and research are not aligned, and these need to be brought together to move towards elimination.
- It was stated that the present climate for industry is difficult and not business-friendly, and although new products are anticipated, a more fragmented market means financial challenges.
- The link between research and implementation needs to be shared with NCMP. Policy is needed to ensure synchronisation and cooperation.

The way forward for 2018 and beyond

Chairs: Jacob Williams & Konstantina Boutsika

Summary and Next Steps

Facilitating joint programmes is one of the fastest ways to break down barriers. Significant progress has been made by all work streams, with sharper work plans and specific action items identified. There has been improved knowledge about the work of regional vector control partners, and additional areas of potential collaboration have been identified. The take home messages from this meeting are; that there exists significant technical expertise in Africa, but it is not effectively utilised for vector control; effective supplementary tools are required if malaria elimination is to be achieved. Hence, there is a need to proactively evaluate and integrate new tools and technologies that expand the paradigm of vector control – particularly to address residual and outdoor transmission. There is a need for increased focus on vector control in emergencies as ever increasing populations sizes are getting trapped in emergency situations.

Any Other Business

The update of VCWG Terms of Reference is currently underway. Two new co-chairs will be elected this year, as soon as the RBM Board approves the new TORs. Members will be apprised as soon as is received and then the processes for nomination and election of the co-chairs will be communicated. The criteria for designation “member in good standing” are going to be looked at. A VCWG newsletter will be sent out twice per year, including updates from the work streams. Presentations and the report from the annual meeting will be uploaded on the RBM website. All participants were asked to complete the evaluation form.

The meeting relayed its thanks to Konstantina Boutsika, Laura Vavassori, Nadja Wipf and Vanessa Chen-Hussey. The co-chairs were thanked for their hard work during 2017. Jacob Williams thanked all members for their attendance and contributions and for their support over his four years as a chair for the group. Message of thanks from Gerhard Hesse, was also communicated to the meeting.

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List of acronyms

ACT	Artemisinin Combination Therapy
AIM	Action and Investment to Defeat Malaria
3GIRS	3 rd Generation IRS
ADB	African Development Bank
AFRIMS	Armed Forced Research Institute of Medical Sciences
AI	Active ingredient
ALMA	African Leaders Malaria Alliance
ANC	Ante-natal clinic
AMCA	American Mosquito Control Association
AMP	Alliance for Malaria Prevention
APMEN	Asia Pacific Malaria Elimination Network
APLMA	Asia Pacific Leaders Malaria Alliance
BBSRC	Biotechnology and Biomedical Sciences Research Council
BMGF	Bill and Melinda Gates Foundation
BOVA	Building Out Vector-borne disease in Africa
Bti	<i>Bacillus thuringiensis</i> subsp. <i>israelensis</i>
CD	Continuous Distribution
CDC	Centers for Disease Control
E8	Elimination 8 Regional Initiative
EIR	Entomological Inoculation Rate
EPI	Extended programme of immunisation
ERG	Evidence Review Group
GLP	Good Laboratory Practice
GMP	Global Malaria Programme
GPIRM	Global Plan for Insecticide Resistance Management
GTS	Global Technical Strategy
GVCR	Global Vector Control Response
I2I	Innovation to Impact
I-ACT	Ifakara Ambient Chamber Test
IR	Insecticide resistance
IRD	Institut de Recherche pour le Développement
IRM	Insecticide resistance management
IRS	Indoor residual spraying
ITN	Insecticide-treated net
IVCC	Innovative Vector Control Consortium
IVM	Integrated vector management
JAMCA	Journal of the American Mosquito Control Association
LLIN	Long-lasting insecticidal net
LSM	Larval source management
M&E	Monitoring and Evaluation
MDG	Millennium Development Goal
MOOC	Massive On-line Open Course
NEPAD	New Partnerships for Africa's Development
NGO	Non-governmental organisation
NMCP	National Malaria Control Programme
OP	Organophosphate
PAMCA	Pan African Mosquito Control Association
PBO	Piperonyl butoxide
PCR	Polymerase Chain Reaction
PIAM	Pakistan Iran and Afghanistan Malaria Network

PMI	President's Malaria Initiative
PQ	Pre-Qualification
RBM	Roll Back Malaria
RCT	Randomised Controlled Trial
SDC	Swiss Agency for Development and Cooperation
SOP	Standard Operating Protocol
SSA	Sub-Saharan Africa
TDR	WHO Special Programme for Research and Training in Tropical Diseases
UCL	University College London
UCSF	University of California at San Francisco
UN	United Nations
UNHCR	UN Refugee Agency
USAID	United States Agency for International Development
VBD	Vector borne disease
VCAG	Vector Control Advisory Group
VCWG	Vector Control Working Group
WASH	UNHCR Water Sanitation and Hygiene
WALS	Wide area larvicide spraying
WHA	World Health Assembly
WHO	World Health Organization
WHOPES	World Health Organization Pesticide Evaluation Scheme
WIN	Worldwide Insecticide Resistance Network