

**Roll Back Malaria Vector Control Working Group (RBM VCWG)
8th Annual Meeting, 28th-30th January 2013
International Federation of the Red Cross and Red Crescent Societies (IFRC)
17 Chemin des Crêts, Petit-Saconnex, Geneva, Switzerland**

**Co-chairs: Michael Macdonald and Jo Lines
Secretariat: Konstantina Boutsika
Rapporteur: Lucy Tusting**

Day 1: Monday 28th January 2013

Session 1: Introductions and Objectives

IFRC Auditorium

Chair: Michael Macdonald

Michael Macdonald opened the meeting and welcomed participants. The annual VCWG meeting has now expanded to 160 participants and is the largest of the RBM working groups. While the Work Streams deal with specific technical areas and have diverse expertise, we all work towards a common vision.

Jo Lines outlined the overall objectives of the VCWG, which are to facilitate alignment of partners on strategy and practice, to rapidly scale-up malaria vector control interventions (particularly Long Lasting Insecticidal Nets (LLINs) and Indoor Residual Spraying (IRS)) in order to meet targets for malaria control, to develop consensus on strategic issues, to identify emerging research issues and to promote public-private partnerships. One of the overarching issues for the VCWG this year is to address how well the system is working, including Work Stream and overall group leadership; funding constraints for the Work Streams; and overlap and gaps between Work Streams.

Jan Van Erps welcomed participants on behalf of the RBM secretariat and commented on the expansion of the VCWG as the largest of the RBM working groups. Elections for the chair of the VCWG will be held this year. As with the recent RBM Harmonization Working Group elections a list of core institutions participating in the VCWG will be drawn up and from this list, one person from each institution will vote. Voting will be conducted electronically and in strict confidence. A call for nominations and procedures for voting will be circulated to the membership soon.

Update from the Global Malaria Programme (GMP) - Robert Newman, Director, World Health Organization (WHO) GMP, Switzerland

Robert Newman presented an overview of GMP and the way in which the VCWG fits into this. His presentation covered: (1) the 2012 World Malaria Report; (2) the new WHO advisory

committees VGAC and VCTEG; and (3) recent updates from Malaria Policy Advisory Committee (MPAC).

World Malaria Report 2012:

Funding: While domestic government funding for malaria control has increased between 2005 and 2011, to US\$625 million in 2011, international funding has now leveled at US\$2 billion annually. Overall, US\$5 billion is required annually, leaving a shortfall of US\$ 3billion.

LLINs & IRS: Coverage has greatly increased over the past decade, however universal coverage has yet to be achieved. In sub-Saharan Africa, the total number of households owning at least one bednet has leveled at 53%. LLIN deliveries decreased from 145m in 2010 to 66m in 2012. IRS coverage has greatly increased however may have declined (or at least plateaued) during 2010-2011. The proportion of the population protected by LLINs or IRS varies greatly between countries and is greater than 50% in relatively few countries. The average LLIN delivered now costs \$7.88 of which 70-80% is the cost of the net. LLIN costs have decreased by 29% between 2007 and 2012 (8% per year). It is estimated that using 5-year nets instead of 3-year nets would reduce the total number required by 500m and save US\$3.83 billion between 2011 and 2020. The median cost per person protected per year by IRS is US\$2.62 in large programmes (more than 150,000 structures sprayed) and US\$5.52 in small programmes.

Case management: The total number of patients tested by microscopy increased to 171 million in 2011 and the number of RDTs supplied by manufacturers increased from 88m in 2010 to 155m in 2011. The proportion of suspected cases receiving a diagnostic test in the public sector increased from 20% in 2005 to 47% in 2011 in the African region and from 68% to 77% globally. Deliveries of ACTs to both public and private sectors increased from 11m in 2005 to 278m in 2011. In 2011-2012, deliveries to the public sector decreased, with an increase in deliveries overall; 58 of 99 endemic countries collect reliable data, however these countries account for only 15% cases globally.

Impact: Since 2000, an estimated 274m cases and 1.1m deaths have been averted due to control efforts. The main challenge now is to sustain funding.

VCAG and VCTEG:

Two new committees have been formed; the Standing Technical Expert Group on Malaria Vector Control (VCTEG) and the Vector Control Advisory Group (VCAG). VCAG will review and evaluate the public health value of new tools and paradigms in vector control, providing a fast-track pathway for new interventions to gain an initial WHO recommendation. VCAG is not malaria-specific but includes other vector-borne diseases such as dengue, filariasis, chagas and leishmaniasis. Funding was secured for the group in August, which is now being assembled. VCTEG has more of a strategic focus, rather than the VCAG tool-development focus. They will make recommendations on the role and appropriateness of malaria vector control interventions and strategies to the MPAC.

MPAC update:

The second MPAC meeting was held during 11th-13th September 2012. The main outputs were updated policies on IPTp and primaquine for *P. falciparum* and seasonal malaria chemoprophylaxis in West Africa, in addition to a global plan for *P. vivax* control. There has been a call for GMP to lead the development of a Global Technical Strategy for malaria control and elimination, 2016-2025. Other outputs include case studies on elimination and an updated toolkit for Malaria Programme Reviews (MPR), to be released this year.

Discussion

An update on the Global Fund for Aids, TB and Malaria (GFATM) was given. Over the last year GFATM has been redesigned and a new funding model will be rolled out in some countries later this year. It will be conducted less on a “round basis” and funding is likely to be allocated according to malaria burden and funding levels.

VCWG budget – Konstantina Boutsika, VCWG secretariat and Swiss TPH, Switzerland

In 2012 the co-chairs requested US\$624,780 of which US\$95,000 was approved. In the 2013 approved budget, executive committee strategy sub-committee (ECSC) members ranked RBM WG activities according to priority, establishing a cut-off line for funding. The Durability of LLINs in the Field Work Stream will receive US\$20,000.

Discussion

Jan Van Erps clarified that any extra funding will be allocated to the activities initially considered below the cut off. There may be carryover of funding from previous years. In addition, RBM should not be expected to fund all Work Stream activities. The priority for RBM is to coordinate partners in efforts to achieve the GMAP objectives.

VCWG website – Konstantina Boutsika, VCWG secretariat and Swiss TPH, Switzerland

Visits to the VCWG website have increased from 7753 visits during March-December 2011 to 10,898 during visits January-December 2012. Europe (38%) and the Americas (32%) account for the most visitors.

Discussion

It was suggested that Jed Stone, IVCC communications officer, and Charles Mbogo, founder of the Pan Africa Mosquito Control Association, could help improve VCWG communications.

Lessons learnt and charting the way forward - Michael Macdonald, WHO, Switzerland

Michael Macdonald discussed three areas: (1) fragile gains in control efforts, (2) program advances, and (3) ongoing challenges.

Fragile gains: Although there have been great achievements in malaria vector control since 2000, there has been a plateauing of LLIN delivery and the costs of IRS have increased as resistance necessitates the use of alternatives to pyrethroids. However, as transmission has been reduced,

so has immunity; it is imperative that despite the challenges of insecticide resistance and constrained finances we maintain coverage. There are examples from the past, such as Sudan, Madagascar and Liberia, where control programs have faltered, with ensuing upsurges and adult illness and deaths.

Program advances: Recent programmatic advances include T3 (test, treat, track); manuals on 'Disease Surveillance for Control' and 'Disease Surveillance for Elimination' that will help in targeting vector control operations; new thinking on Integrated Community Case Management (ICCM) and closer engagement with community structures; and new vector control guides (Handbook on IVM, Manual on Practical Entomology in Malaria, Malaria Control in Complex Emergencies, Global Plan for Insecticide Resistance Management (GPIRM), Guidelines for Monitoring the Durability of LLINs under Operational Conditions, Continuous LLIN distribution Guide to Concept and planning, new IRS and LSM manuals and the Interim Position Statement on Larviciding).

Ongoing challenges: New challenges to malaria vector control include:

- Insecticide resistance (documented in 64 countries to date).
- Maintaining coverage in constrained financial times.
- Outdoor transmission.
- Developing entomology capacity.

Discussion

It was suggested that in order to maintain coverage in era of financial constraints, analyses of the cost per person per year protected can help make substantial savings. Emphasis on the financial return on successful malaria control efforts (e.g. Zanzibar, AngloGold Ashanti operations in Ghana) can help with advocacy for funding. There is also a need to communicate properly with the media in order to convey a positive story.

It was queried how new products can be perceived by procurers to have an added value, such as new LLINs that can be used to manage insecticide resistance. VCAG needs to make strong recommendations to ensure that procurers understand the benefits of alternative LLINs and their associated costs. WHO should also make recommendations on existing tools and their associated costs and benefits in specific settings.

Technical training is important, but much entomological training has been too technically focused and not sufficiently programmatic and public health oriented. Improved analysis and interpretation by program managers is required. New training programs tailored to programmatic entomology, rather than to research, may help.

It was suggested that in Pakistan, malaria is focused in rural areas; therefore the WHO Position Statement on larviciding should be flexible. It was clarified that the statement pertains only to Africa and there are certainly different contexts and vector ecologies in the other regions.

Session 2: Progress on Work Plan

Chairs: Jo Lines and Jacob Williams

Alliance for Malaria Prevention (AMP) – Jason Peat, IFRC, Switzerland

Jason Peat began by describing structural changes to AMP, which is no longer a working group under the Harmonization Working Group (HWG). AMP will maintain its focus on implementing technical guidance at the country level and sharing lessons learnt. AMP is currently working to clarify how AMP and VCWG can work more closely together.

The core activities of AMP are:

1. Partner coordination and advocacy related to mass and continuous LLIN distribution.
2. Responding to country and partner requests for operational support.
3. Sharing operations guidelines, documenting best practice and keeping track of LLIN deliveries.

In 2012, AMP directly contributed to the distribution of over 33m nets in ten countries and continuous distribution was incorporated into the AMP mandate. The Emerging Issues Working Group was expanded and the Country Support Working Group was refocused. The AMP toolkit 2.0 was distributed in French and English. Continued support is being provided to HWG on LLIN issues (e.g. quantification and tracking).

The 2013 work plan proposes three areas of expanded collaboration with the VCWG:

1. Country support. There was a reduction in support missions between 2010 and 2011 with ten countries receiving support overall.
2. Closer collaboration between LLIN-focused working groups (Continuous Distribution and Durability Work Streams).
3. Some issues addressed by the AMP Emerging Issues Working Group may be better covered by the VCWG. Emerging issues for 2013 include guidance on accounting for existing nets, LLIN packaging, LLIN end of life issues and 2013-14 funding gaps for LLINs.

Priority issues for 2013 for AMP include:

- How can we improve support for implementing or scaling up continuous distribution approaches when planning for mass distribution?
- What role will mass distributions play going forward in countries with either well-functioning or on the other hand, weak or non functioning continuous distribution mechanisms?
- Methods for ascertaining trigger points for top-up campaigns.

- How do we account for existing LLINs?
- How do we assure the cost-benefit and quality of data through household surveys?
- Are there data-driven models for extending the life span of nets?
- How can data management be improved?

AMP continues to hold weekly calls at 15.00 GMT. All are welcome to join these calls (USA toll free 1-888-808-6929; international 1-213-787-0529; access code 3904916).

Vector Control Innovation Process Engineering – Tom McLean, Innovative Vector Control Consortium (IVCC), UK

In the 1990s and early 2000s there was a delay in the scale-up of LLINs once consensus on their effectiveness had been agreed. To identify bottlenecks for future interventions and how to deal with them, a joint collaboration between the Gates Foundation Malaria Forum, IVCC and WHO has been established. A workshop was held in March 2012 in Paris and a proposal for VCAG put together. The main conclusion was that introducing a new VC paradigm involves work in five areas and that there are six major areas that delay innovation:

1. Cheaper and shorter process.
2. Process to introduce breakthrough innovation.
3. Market incentives.
4. Product quality assurance.
5. Assessment and recognition of public health value of innovation.
6. Protection of investments and competition.

A working team has been assembled comprising major stakeholders (WHO, industry, funders, academia, country NMCPs, IVCC) and various projects are now underway to address each of the six 'bottlenecks'. For example, for the protection of investments and competition, IVCC has sponsored an independent review of the legal options.

Discussion

The era of universal coverage with universal interventions is over. Interventions must now be tailored locally, with three implications: (1) smaller markets; (2) expertise required on the ground and (3) toolkits required for collecting evidence. There is also a greater need to identify cross-cutting points at which one can intervene for more than one disease.

The minimum size of the market is defined by the parasite and the vector; it is not currently large enough to justify investments. There are large long-term and high-risk investments to be made and therefore the situation cannot be left solely to natural market forces.

Thinking solely in terms of cost minimization is counterproductive; we must consider the long-term economic impact and not just what it costs today. The guidelines on pesticide procurement

recommend that products should be chosen on the basis of programmatic value for money. It is also important to take into account impact on insecticide resistance management.

Optimizing Evidence for Vector Control Interventions - Christian Lengeler, Swiss TPH, Switzerland

The main areas of work being covered by the Work Stream are:

1. Developing testing guidelines for new VC paradigms:
 - The Work Stream is working closely with (External Scientific Advisory Committee) ESAC3 of IVCC and WHO on issues related to the development of new vector control interventions, including draft testing guidelines.
 - The Work Stream aims to develop with IVCC a similar working relationship to that between the Continuous Distribution Work Stream and the NetWorks Project.
 - New paradigms include: (1) spatial and individual repellents, (2) indoor spatial repellents in Indonesia and (3) attractive toxic sugar baits.

2. Interactions between multiple VC interventions:
 - LLIN-IRS interactions have been investigated in Bioko, Sudan and Tanzania (London School of Hygiene and Tropical Medicine (LSHTM) and The Gambia (Medical Research Center (MRC) and LSHTM).
 - Other interactions need consideration.
 - A stronger link with modeling is required.

3. Updating and networking on new technologies, including:
 - Plastic sheeting.
 - Durable wall linings.

Discussion

The agricultural sector has decades of experience in new innovation and could provide guidance for the development of new public health interventions. Public sector needs to provide significant investment in innovation as the commercial market alone may not realize the immediate return for investment that may accrue in the long run.

Insecticide Resistance – Maureen Coetzee, University of the Witwatersrand, South Africa

Updates were given on the following:

1. *Global Plan for Insecticide Resistance Management (GPIRM)*: GPIRM was released in May 2012. A WHO-AFRO/African Network on Vector Resistance (ANVR) meeting was held in Cotonou Benin on 17-18th January 2013 with 14 participating countries to accelerate implementation of GPIRM in their countries and to source funding to support this. Several countries are already implementing the GPIRM, including South Africa which has developed a plan for insecticide resistance management and

training courses. Bioko and Zambia are also developing plans for insecticide resistance management.

2. *ANVR Atlas on Vector Resistance*: Data from 2004-2010 has been updated with the new criteria for resistance (98-100% mortality green, 90-97% orange, <90% mortality red). These criteria have also been adopted for the draft Guidelines on Resistance Testing. The atlas is available online.
3. *Diagnostic dose for pirimiphos-methyl*: Tests have been conducted by AvecNet at three institutions in Europe and Africa to validate the proposed diagnostic dose.
4. *Cochrane Review of the effect of insecticide resistance on malaria*: The review is currently with the editorial team and should be published within the next three months.
5. *The Pan-Africa Mosquito Control Association has been established and is being led by Charles Mbogo from KEMRI.*

Discussion

Better data is needed from multiple sites to develop diagnostic doses for pirimiphos-methyl. Funding is being made available through WHO GMP. The implications of patchy and mediocre coverage with IRS for control were discussed. The WHO Tube bioassay for resistance monitoring has been updated and will be published shortly. This test will remain the standard, while the CDC Bottle Assay will be a useful and complementary test.

Outdoor Malaria Transmission – Marc Coosemans, Institute Tropical Medicine Antwerp, Belgium

The importance of outdoor transmission was outlined and progress in 2012 described:

1. 4th Outdoor Malaria Transmission Work Stream meeting was held for Mekong countries in Bangkok, 12-13th March 2012.
2. Literature review on outdoor transmission.
3. Development of guidelines on spatial repellents (WHOPES) 'Guidelines for efficacy testing of spatial repellents'.
4. Research project topical repellents as an added intervention in Cambodia: MalaResT.

The next meeting will be held in March 2013 at Mahidol University in Bangkok.

Discussion

Outdoor transmission has always occurred. While it complicates elimination, indoor control remains the most important intervention and should not be neglected. Outdoor transmission does not indicate LLIN failure but is a reflection of success of control programs with LLINs and IRS for having reduced or eliminated vectors responsible for indoor transmission. Nomads are an important affected by outdoor transmission (e.g. in the Sahel, in East Africa) and must be protected by measures in addition to LLINs and IRS.

Larval Source Management (LSM) may help reduce outdoor biting in some specific settings. There was also some discussion of the role of space spraying in controlling outdoor malaria transmission noting that it is sometime used in the control of Aedes-borne dengue and chikungunya. WHO guidelines state that space spraying does not have a role in malaria control. Even under optimal conditions there is a maximum of 20-30 minutes when insecticide will be airborne and efficacious and often flying vectors are not active during this period. There are serious limitations to this approach and it does not have a role as a routine malaria control intervention.

There are difficulties in measuring the entomological parameters of outdoor transmission. Human landing catch at present is the only robust measure, but research ethics committees are sometimes reluctant to approve its use, especially where there are circulating arboviruses. WHOPEs guidelines for efficacy testing of spatial repellents will be published in February 2013 and subject for review subsequently.

Continuous LLIN Distribution Systems– Jayne Webster, London School of Hygiene & Tropical Medicine (LSHTM), UK

The context for LLIN distribution has changed from an era of great scale-up and improvements in LLIN coverage (2010-11), in which complementary approaches between campaigns and routine systems to ensure continuous delivery were the focus, to the current era of declining donor funding, in which funding advocacy, new funding models and increased efficiency are needed to sustain gains.

Review of products from 2010-2011:

- Consensus statement on continuous distribution.
- Options for delivery strategies (helping countries to decide which products were appropriate, alongside NetCALC.
- Best practices in delivery through routine systems.
- Country experiences: 'Lessons in Brief'.
- Lessons on successes of similar strategies in different contexts.

These products have been disseminated through three RBM regional network meetings in 2012: Central Africa Roll Back Malaria Network (CARN) (Yaoundé, Cameroon), West Africa Roll Back Malaria Network (WARN) (Praia, Cape Verde) and East Africa Roll Back Malaria Network (EARN) (Arusha, Tanzania). Ten countries have received direct assistance at this time, and nine countries are in line for assistance this year. Lessons learnt through this process are that direct assistance produces better impact and that hard copies of technical documents are needed by National Malaria Control Programmes (NMCPs).

The following work is ongoing:

1. *'Fragile gains'*: to document the 'fragile gains' in LLIN coverage to date in relation to the current funding gap and draw attention to the consequences of decreased resources and potential strategies to sustain gains. The objectives of this work are to review the gains already made and their impact to collate funding commitments until 2015, determine potential coverage and consequences for mortality and to recommend how to mitigate predicted gaps in funding and coverage.
2. *ITN Strategic Framework*: the Framework was developed nearly a decade ago, before the present scale-up (2004-05) and could be updated. The main issues include: domestic funding, who to target, how to stimulate commercial growth and increasing efficiency (maximum health impact per coverage, maximum coverage per LLIN delivered, lowest delivery costs per LLIN distributed and minimum overlap between delivery systems).

Budget:

The total budget for 2011 was US\$106,000 and US\$40,000 in 2012, provided by USAID and the Swiss Agency for Development and Cooperation (SDC).

An ad hoc meeting was held at the American Society for Tropical Medicine & Hygiene annual meeting (ASTMH) in Atlanta, November 2012.

Discussion:

It was highlighted that universal coverage rather than targeting is still important for a mass effect. There was some discussion of how best to achieve this with limited funding. Some countries already need to make decisions on targeting nets when resources do not allow for universal coverage. WHO may need to develop consensus on this. The focus must not solely be on distribution but also on compliance and use.

Durability of LLINs in the Field – Albert Kilian, TropHealth, Spain

The 2012 Work Plan included the following objectives:

- To hold a follow-up textile meeting.
- To improve field methods for specifying the cause of holes in nets.
- To explore the potential of Behavior Change Communication (BCC) interventions.
- To encourage studies investigating the level at which the number of holes with given concentrations of insecticide protection fails.

No funding was received from RBM. In 2012 there were six publications contributing to existing knowledge on LN durability; four on attrition and integrity, one on the efficacy of holed ITNs and one on the cost savings of nets with a longer life.

Future plans and issues include the publication of the WHOPES 'Guidelines for Monitoring the Durability of LLINs under operational conditions', together with the development of guidance on how to use attrition, integrity and insecticide functional data to calculate 'net life'.

Discussion

Making generalizations about nets having a three- or five-year life span may not be sensible since the way nets are treated varies dramatically. Every program should measure durability within their own contexts. There was some discussion of the ethics of conducting prospective studies; study participants will need to be informed that study staff will return, hence it is not possible to get reliable attrition data. The concepts of cohort service time (e.g. how much time will elapse before x% nets are no longer effective) and half-life are important. The environment in which the net is used should be considered when deciding which type of net is most appropriate (e.g. type of mattress or mat, proximity to fires).

Capacity Building for IRS – Shiva Murugadampillay, WHO, Switzerland

Eighty countries currently recommend IRS for vector control and it is used with LLINs in 58 countries. While there are some problems with data completeness, the data suggests that there has been a plateauing of coverage.

The 2012-13 Work Plan included:

- IRS case studies.
- Systematic review of published IRS studies.
- A draft tool for IRS program performance reviews.
- Supporting of country and regional IRS annual reporting.
- Providing guidance on the scaling-up and -down IRS.

Strategic issues for the working group include:

- Scaling-up IRS in high transmission countries.
- Targeted and scaled-down IRS in low transmission settings.
- IRS with LLINs vs LLINs alone.
- IRS with LSM.

Operational issues for the Work Stream include:

- Annual reporting on IRS.
- Program capacity strengthening.
- Private sector support consistent with expanding CSR and CSI.

Larval Source Management – Lucy Tusting, LSHTM, UK

A summary of the main conclusions from the previous meeting was given along with an update on the Cochrane Review of LSM. The Cochrane Review has been peer reviewed and the search updated. The analysis is being revisited with support from the Cochrane Infectious Diseases Group in Liverpool, and it is hoped that the review will be accepted for publication later this year.

Status of 2012 products:

1. Operational Manual on LSM.

- The manual is to be a joint WHO-RBM publication.
 - First draft completed in April 2012.
 - Draft submitted to WHO in December 2012.
2. LSM country case studies
 - Four case studies on Khartoum, Mauritius, Dar es Salaam and India are complete.
 - Available on the RBM website.
 3. Decision-making tool
 - First draft complete.
 - To be finalised alongside Operational Manual.

Discussion

The LSM Operational Manual has been sent by WHO to three independent reviewers. Monitoring and evaluation systems for LSM are important. There is much that can be learnt from LSM outside Africa (e.g. elimination of *An. gambiae* from Brazil). We need to work on assessing the cost efficiency of LSM and how best to allocate resources.

Entomological monitoring and Integrated Vector Management (IVM) - Raman Velayudhan, WHO, Switzerland

Approximately 62% of countries have a national IVM policy and one of the objectives of the Work Stream is to develop M&E indicators for IVM to guide countries. Recent relevant publications include:

- Provisional Strategy for Interrupting Lymphatic Filariasis Transmission in Loiasis-Endemic Countries. WHO, 2012.
- Van den Berg, H., et al. 2013. Malaria and lymphatic filariasis: the case for integrated vector management. *Lancet Infectious Diseases*, **12**: 89-94.

Plans for 2013 include:

- Capacity building.
- Fine-tuning entomological surveillance methods.
- Further case studies.
- Advocacy for IVM.

Discussion

Dengue is a problem in sub-Saharan Africa and IVM should be used to control both dengue and malaria. This will be discussed at an upcoming meeting on dengue in Accra, 6-9th February. The overwhelming current theme is reduced funding for malaria control. A basic package for multiple disease control, to which additional tools could be added as required, would be more attractive for donors and secure more support at the Ministry of Health level. It is also not cost-effective to have technicians working solely on malaria; field entomologists are required to tackle all diseases. The Mentor Initiative has piloted a new five day course in sub-Saharan Africa

on integrating disease control for different vector borne diseases. Malaria interventions such as IRS are often perceived to be failing due to nuisance biting by culicines, therefore targeting culicines also will increase support for programs. IVM should be incorporated into development projects in sub-Saharan Africa which often create larval habitats. The issue of stratification is key, since it is not possible to make recommendations for all vectors and all contexts. However, there is a finite number of decisions required and clear guidance can be given on these.

Summing up the 1st day – Jo Lines and Michael Macdonald

Key issues for the VCWG were summarised as follows:

1. How the VCWG works with WHO.
2. How the VCWG can work with AMP to provide country support.
3. Whether a pooled budget is needed to ameliorate the risk of bias of certain groups over others in the VCWG.
4. The evidence required for new interventions: (1) proof of principle and (2) generalising trial data.
5. Recommendations for prioritizing coverage where there is insufficient funding for universal coverage.

Discussion

GMP discussions with Habitat for Humanity were referred to, in the context of improving housing to reduce house entry by mosquitoes and ensuring that borrow pits created for plating and brick-making do not produce vectors. A colloquium may be held in 2013 on housing and vectors. The VCWG should work more closely with agricultural experts including CropLife and Insecticide Resistance Action Committee (IRAC). A public health page on the CropLife website is in progress. There was some discussion of whether the VCWG should have a slimmer portfolio and focus on doing less, but well. Though vector control is expensive, it is relatively cost-effective. Therefore the VCWG needs to share a common vision that the funding needed for malaria vector is essential and has an excellent long-term return.

Day 2: Tuesday 29th January 2013

**5th Optimizing Evidence for Vector Control Interventions Work Stream Meeting
(Joint meeting with ESAC3)
9.00-12.00, Tuesday 29th January 2013
Auditorium, IFRC, Geneva**

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

Spatial and individual repellents – Sarah Moore, LSHTM, UK

Spatial repellents are a new paradigm but not a new technology. Repellents might complement LLINs and IRS, which do not protect from all potential exposure to infectious bites. New evidence has been collated with a view to presenting to VCAG, including a meta-analysis using Cochrane methods that shows that spatial repellents had a protective effect against exposure to infectious bites in six studies (OR=0.66, 95% CI 0.44-1.00).

To assess the protective effect of spatial repellents and to gather sufficient evidence for a policy recommendation, repellents will need to be assessed through Phase I, II and III trials. Phase III trials are currently being considered for repellents to examine the community effect (vector survival and abundance) and man-vector contact, however this decision is pending further data from a tropical repellent study by Coosemans and colleagues in Cambodia. Achee and colleagues have also worked on standardised protocols for measuring vector endpoints in a Phase III spatial repellent trial, which must demonstrate an individual and community level reduction in incidence. These correlates must be tested in a range of transmission settings. This work will feed back into endpoints for a Phase II trial (i.e. mode of action, optimum dose of molecule needed, distance that protection extends and where should the molecule be placed). New guidelines from WHOPES have been developed to harmonise testing procedures: 'Guidelines for Efficacy Testing of Spatial Repellents'.

There is an economic benefit to encourage investment in the development of spatial repellents: 45-50 billion mosquito coils are used annually by approximately 2 billion people. A cost comparison of different interventions indicates that costs may be comparable to ITNs, IRS and emanators.

Discussion

- The WHO guidelines on efficacy testing will be a starting point for measuring a reduction in man-vector contact as an outcome. WHOPES is keen to be informed of new developments so it can proactively prepare for the immediate evaluation of new products.

- Antibodies to mosquito saliva could be used as an outcome as a proxy for exposure to bites.
- It will be increasingly necessary to build a suite of outcomes including parity (for measuring vector survival) for testing such interventions, which will provide evidence for an entomological mode of action.

Indoor spatial repellents in Indonesia – Din Syafruddin, Eijkman Institute for Molecular Biology, Indonesia

Methods: A cluster randomised, double-blind, placebo-controlled trial of indoor spatial repellents was conducted in Indonesia to investigate whether spatial repellents can reduce clinical attack rates and entomological outcomes. The primary endpoint was incidence of clinical malaria and the secondary outcome was the human biting rate. The study site is characterised by simple, mud-walled and thatched-roofed housing. Four clusters with a population of 400 people were selected in two villages. Forty five men per sample were administered DHA/pp+PQ to clear infection, followed up and then excluded following re-infection. Two identical coils were placed inside each house. Weekly entomological monitoring of five sentinel houses was conducted per cluster by human landing catch.

Results: 231 participants were screened and 180 enrolled, of which 170 completed radical cure leaving approximately 40 participants per cluster. There was insufficient power to draw conclusions about village level effects. A 61.1% protective efficacy was observed against new parasite infections. There was a significant reduction in the human biting rate in homes with spatial repellents. The primary vector was found to be *An. sudaicus*.

Discussion

Publication of all data (Phase II and III) would allow correlation between different outcomes to be assessed. It would also be valuable to record ARI.

LLIN-IRS interactions: an update on new evidence

Sudan – Hmooda Kafy, National Malaria Control Programme, Sudan

Methods: A trial was conducted in an area of low transmission to assess the additive protective effect of IRS with LLINs. 140 clusters in 4 study areas were randomised to receive either LLINs alone or LLINs with IRS. The size of clusters ranged from 5200 to 7600 with a total of 28000 children aged <10yrs enrolled across all clusters. The primary outcome was incidence of clinical malaria measured by passive and active case detection by community health workers.

Results: Preliminary data suggests no added protective benefit of IRS with high LLIN coverage. The incidence of clinical malaria across all clusters is 38 per 1000 per annum, with no significant difference in the rate between arms (RR 1.09, 95% CI 0.63-1.89).

Bioko –Immo Kleinshmidt, LSHTM, UK

Methods: The added personal protection from nets in the context of short residual IRS and year round transmission was assessed. It was also assessed whether a reduction in mosquito mortality due to a loss of insecticide effect leads to an increased risk of malaria.

Results: It was found that prevalence increases with time since last spray (OR 1.7, 95% CI 1.2-2.5) and sleeping under a net reduces the risk of malaria infection (OR 0.7, 95% CI 0.6-0.9). Mosquito mortality declines with time since last spray. The data suggests that IRS is compromised since residual effects do not last all transmission season and this may explain the benefit of using nets (i.e. there is a greater proportional benefit of LLINs in areas of higher IRS coverage).

The overall conclusion from Bioko and Sudan is that LLINs plus IRS combined have a greater protective effect than one intervention alone if one of the two is compromised, for example where there is inadequate use of nets or where IRS has a short residual effect.

Tanzania – Natasha Protopopoff, LSHTM, UK

Methods: A cluster-randomised controlled trial was conducted in Muleba district, Kagera region, Tanzania, an area of moderate transmission with two transmission seasons. Baseline parasite prevalence was 8.5% in 2011-2012 according to the 2011-2012 Malaria Indicator Survey. The objective was to assess whether IRS with bendiocarb plus LLINs provide added protection against clinical malaria in children aged 6m to 14 yrs compared to LLINs alone. 50 clusters per arm were selected with 80 households per cluster. In the baseline year all arms received IRS and LLINs and in the intervention year, one arm received LLINs alone. The primary clinical outcome was prevalence measured by microscopy and Rapid Diagnostic Test (RDT) and the entomological outcomes were Entomological Inoculation Rate (EIR) and density of adult anophelines, measured by light trap collections. A household questionnaire was also conducted.

Results: LLIN coverage (the proportion of households with at least one net) was 90.8% (95% CI 89-92.3%) post-distribution at baseline in both arms and comparable between control and intervention clusters. In the intervention year, there was little difference between arms in parasite prevalence (OR 0.48, 95%CI 0.18-1.24) however anopheles density was significantly reduced in the intervention arm (OR 0.26, 95%CI 0.15-0.34). The results suggest there may be some additive protective effect of IRS with LLINs, compared with LLINs alone, in areas of moderate net use and high pyrethroid resistance.

SANTE trial, The Gambia – Christian Lengeler Swiss TPH, Switzerland on behalf of Steve Lindsay

Methods: A two-year cluster-randomised controlled trial was conducted in the Upper River Region of The Gambia. 93 villages in 70 clusters were randomly allocated to receive either LLINs alone or LLINs plus DDT IRS (35 clusters per arm). The total study population was 36,611 with a cohort of 7858 children aged 6m-14yrs. The primary outcome was incidence of clinical malaria in children aged 6m-14yrs measured by passive case detection.

Results: Survival analysis indicates no difference in protection against clinical malaria, malaria infection or anaemia between the two arms. WHO bioassays conducted in 2011 indicated 89% mortality to DDT, suggesting low levels of resistance. However a mortality rate of 46% in two villages on the south bank indicated higher levels of resistance in some locations. In conclusion, IRS did not add protective effect under these circumstances.

Discussion

- The findings of the four studies above indicate that high coverage with IRS with a longer residual efficacy (and an effective insecticide) could limit the need for adding LLINs. Similarly, high LLIN coverage would limit the impact of adding IRS. Studies that have shown added value of implementing both LLINs and IRS may have done in areas with lower coverage of one or both interventions and the apparent added value may have been due to one intervention compensating for the low coverage of the other.
- The implications of the results for resistance management and GPIRM were discussed. Does adding the second intervention reduce selective pressure? Is there value of IRS as an initial step to knock down transmission and then using LLINs to maintain transmission at a low level? No clear answers are currently available to these questions.
- The application of IRS is often sub-optimal, therefore this needs to be considered in these evaluations and data is required on this. Until recently it was difficult to ascertain the quality of spraying in the field, but IVCC has developed field tests to assess this. In some ways therefore these trials reflect real-world application rather than perfect implementation (i.e. effectiveness not efficacy).
- It would be valuable to conduct a cost-analysis of the combinations and to consider the operational implication of results, i.e. the incremental benefits of additional interventions combined with a cost-effectiveness analysis.

Update on developments in plastic sheeting and durable wall lining – Richard Allan, MENTOR Initiative, UK

Insecticide treated plastic sheeting (ITPS) is a dual purpose tool providing both shelter and pest control, to reduce dependency on specialized vector control teams and to improve longevity and compliance. There is a considerable literature on this intervention (18 publications), of which two are WHO recommendations relating to the Horn of Africa and to the Indian Ocean tsunami region. A double-blind phase III trial using ITPS was conducted in two refugee camps in Sierra Leone (Largo and Tobanda). This indicated a 62% protective efficacy of ITPS against malaria infection with full protection (inner wall and ceiling). ITPS is highly effective in emergencies and has protected 500,000 people in emergencies to date. A general recommendation from WHO for use by agencies in emergency situations is awaited.

Durable wall lining is another dual purpose tool designed to provide an aesthetic home improvement that screens gaps and windows, kills resting mosquitoes and has a long residual efficacy. Messenger et al conducted a recent meta-analysis in which the bioefficacy of durable linings showed little decline over 12-15 months whereas IRS declined by 6 months with 100% loss by 12 months. Durable linings are highly acceptable to users. In Angola, the first Phase III trial of durable linings has been conducted in six villages in three pairs (Brosseau et al., 2012) and two further large studies are planned this year in Tanzania (of a first generation durable lining) and Liberia (of a second generation durable lining).

Discussion

Membership of VCAG is being finalised. VCAG will soon request data from interventions such as ITPS, to be submitted for proof-of-principle. WHOPES will then establish product standards for efficacy and safety.

Toxic sugar baits – Gunter Mueller, The Hebrew University of Jerusalem, Israel

Methods for detecting sugar in mosquitoes and for assessing the attractiveness of sugar compared to humans and chickens were described. Work is ongoing in Mali to assess the relative preference of *An. gambiae* to different sugar sources. Recently published studies have assessed how early *An. gambiae* is feeding on sugar in the field, whether sugar feeding influenced by the environment, whether there is a difference in sugar feeding between indoor and outdoor feeding mosquitoes and the rate of detectibly and digestion of sugar meals over time. Preliminary results indicate that the importance of sugar feeding for *An. gambiae* has been underestimated. Attractive Toxic Sugar Baits (ATSB) use baits prepared from fermented fruit with added stabilisers and oral toxin. A study was conducted in northern Mali in a small village surrounded by 80 ASB stations (50% with sugar bait, 50% with control). The ASB attracted 7.82 times more females than the control.

Discussion

- There is no growth of bacteria or fungi in the ATSB due to preservative, nor does palatability change over time.
- Concern over non-target insects (such as bees) was voiced, however analysis of a range of insect species caught through human landing catch and spray catch indicates that very few were poisoned by the ATSB. Ant protection can be added using grease and large insects can be screened out with netting.

Draft testing procedures for combination nets – Hilary Ranson, LSTM, UK

An additional set of standards is required to evaluate combination nets. Combination nets are those that contain pyrethroids plus a second active ingredient. Only two are currently on the market (Sumitomo Olyset Plus®; Vestergaard Permanet 3.0®). Methods for testing claims of superiority are required. For example, how can it be established that one LLIN is more effective against pyrethroid resistance mosquitoes and reducing selection for resistance in the population than another?

To assess whether a LLIN is more effective against pyrethroid resistance mosquitoes, standard methodology would be appropriate for Phase I trials, although the resistant strain to be tested needs careful definition. Phase II (experimental hut) trials would need to be conducted in areas known to be resistant to the specific pyrethroid used in the net (i.e. the study should proceed only if a cone bioassay indicates resistance is compromising conventional LLINs). The effects of synergists and secondary insecticides must also be determined prior to the trial. A Phase III trial would need to demonstrate that the combination net significantly reduces the number of blood fed mosquitoes collected resting in and exiting houses, compared to a conventional LLIN, and that this effect is sustained for the lifespan of the net.

To assess the effect of a LLIN in reducing selection for resistance in the population, studies must determine LC50 before and after net use. Such studies could be conducted in a biosphere, but ultimately large-scale community trials would be needed.

Discussion

- There was some discussion of how to define the threshold level of where a conventional net is compromised. It is necessary to know the strength of resistance within a population and to find an operationally significant cut-off.
- Careful definitions are required, for example synergists should not be classified as an active ingredient. A definition of resistance management is also needed; does management entail reducing resistance, slowing it or maintaining at a given level?
- Comparison products for the trials described above must ideally have the same type of pyrethroid. If such a product does not exist there is no operational benefit in creating an artificial product comparison, therefore it is necessary to be pragmatic and to use a similar product as a comparison.
- Guidelines for new testing methods are important because it is difficult to compare data from individual studies when different methodologies are required.

Initiative for new vector control interventions from the Bill and Melinda Gates Foundation (BMGF) – Kate Aultman, BMGF, USA

There are three objectives in the BMGF portfolio:

1. To extend and maintain the life of LNs and IRS through resistance management and new active ingredients.
2. To develop transformational new tools to enable malaria eradication.
3. To support the creation of an enabling environment for innovation.

The critical path for the development of new tools includes: (1) early lab studies to define the overall concept, (2) small-scale proof-of principle studies, (3) final prototype design, (4) confirmation and quantification of efficacy (multi-site; single, common core protocol), (5) product reach and essential characteristics. BMGF would also like to consider the engineering approach to evaluation (i.e. making trials as slim as possible whilst remaining robust). VECNet is a new online tool with various resources including maps of different vectors and their suitability for different interventions due to exo- and endophily.

Discussion – All

The discussion focused on (1) how the VCWG and WHO can productively work together and (2) overlap between the Work Streams. It will be difficult to eliminate all overlap however it is the responsibility of Work Stream leaders to communicate and reduce this as far as possible.

It was discussed how the VCWG can interact with the WHO new committees. WHO appreciates the interaction between the VCWG, VCAG and VCTEG. WHOPES also welcomes the drafting of guidelines by academia.

- The role of VCAG is to assess new tools and paradigms in all vector-borne disease. It will not address implementation issues at the country level. The VCWG should support the generation of new evidence, which will then be assessed by VCAG.
- Where proof of principle has been established, it is the role of VCTEG to examine implementation issues and related policy recommendations. The VCWG should identify gaps and make recommendations to VCTEG. Potential overlap between VCWG and VCTEG will require careful consideration and the VCWG should avoid the policy and normative functions of WHO, however overall the VCWG likely to speed up the process of approving new interventions for malaria control that will be considered by the VCAG and VCTEG.
- The overall remit of the VCWG is advocacy, communication and resource mobilisation. The VCWG can provide a forum for new ideas and can help widely communicate discussions being held at VCAG and VCTEG. It should also support the development and evaluation of new interventions. The strong links between the VCWG and ministries of health can help countries with implementation.

Work Plan 2013 – Christian Lengeler, Swiss TPH, Switzerland

1. Reinforce communication with Work Stream members.
2. Hold a meeting on combined LLINs and IRS.
3. Circulate draft documentation on LLINs and IRS for input.

4th Capacity Building for IRS Work Stream Meeting
9.00-15.00, Tuesday 29th January 2013
Salle V, IFRC, Geneva

Chairs: Manuel Lluberá and Shiva Murugasampillay
Rapporteurs: Elizabeth Streat and Michelle Helinski

Objective

To discuss current and emerging issues on scaling up and sustaining IRS for malaria control and elimination

- 2012 Progress.
- 2013 Plans.

The meeting had the style of short plenary presentations by countries and partners on progress in 2012 which set the stage for discussions and group work on 2013-14 plans for advocacy, capacity building and scaling up IRS.

Key areas discussed in plenary sessions were:

- IRS as part of elimination strategies.
- Country IRS programs scaling up and scaling down.
- IRS for cross border malaria control and elimination programs.
- Public and private partnership in IRS and malaria control and elimination.
- IRS capacity building and training.
- New tools and materials for more effective IRS.

Two groups were formed to work on the 2013-2014 priorities and plans for 2013

- IRS advocacy and training.
- IRS training and capacity building.

1. *Scaling up IRS in 2012*

1.1. *Introduction*

This session aimed to discuss the IRS work plan for 2013-2014, key issues and group work, showcase what countries and partners are doing, and to introduce new tools and technology under development.

The main sub-groups to date include:

- IRS advocacy and financing-Richard Tren/Devanand Moonasar.
- IRS evidence and reporting-Rajendra Maharaj/ Immo Kleinshmidt.
- IRS supervision, reviews, evaluation-John Govere/John Bosco Rwakimari.
- IRS procurement and supply management-Rabindra Abeyasinghe/Gerhard Hesse.
- IRS training and country capacity building-Manuel Lluberas.

The two most active sub-groups are the advocacy and financing and the training and capacity building. To keep the Work Stream and groups functioning by teleconference and email network has been challenging as many are not involved in IRS on a full-time basis.

The strategic issues for IRS include:

- IRS scaling up in high transmission countries for impact.
- IRS combined with LLIN for impact.
- IRS being targeted and scaled-down in low transmission to malaria foci for malaria elimination.
- IRS being combined with LSM.

The operational issues for IRS include:

- Country IRS data base and annual reporting.
- Country IRS program capacity strengthening.
- Limited WHO capacity in entomology and vector control.

- Private sector cooperation for IRS and malaria control consistent with expanding Corporate Social Responsibility (CSR) and Corporate Social Investment (CSI) (AngloGoldAshanti, Ilovo Sugar, Rio-Tinto, Verdanta, Exxon Mobil, etc).
- PMI/ USAID contractors, e.g. RTI and Abt Associates, Chemonics working with national programs need to support country capacity building, together with other partners.
- Private malaria commodity providers are uncertain of the IRS chemical and sprayer (pumps) market (e.g. Arysta Life Science, Syngenta, Bayer, Tagros, H. D. Hudson Manufacturing Company, HIL, Goizper, etc).

IRS is a high impact malaria control intervention as demonstrated by its continued use in many countries as a malaria vector control tool. African countries on track for a >75% decrease in incidence of clinical malaria (2000-2015) include Algeria, Botswana, Cape Verde, Namibia, Rwanda, Sao Tome and Principe, South Africa, Swaziland and Eritrea. Countries on track for a 50-75% decrease are Madagascar and Zambia (World Malaria Report 2012). Similar trends have also been observed in countries in North Africa, Middle East and Eastern Europe, which have moved to or are moving towards malaria elimination over the last five years. A recent meta-analysis of IRS by Dr Kim and colleagues at North Carolina University provides further evidence of the importance and impact of IRS (poster available).

Africa Fighting Malaria (AFM) has been the leading advocacy and lobby group for IRS and continues to provide a monthly bulletin on the subject. Regrettably, Richard Tren, who founded the group and was co-chair of the IRS Work Stream, has left the field and AFM has now moved back to Durban, South Africa under the leadership of Jason Urbach (posters and presentation available).

The DDT expert working group met in December 2012 to revise the 2011 WHO position statement on DDT. DDT is still needed for malaria vector control as part of resistance management. This class of insecticide should be made available and used in rotation schedules where appropriate. IRS is also key for resistance management strategies.

The priority areas for the IRS Work Stream in 2013-2014 include:

- Recruitment of new Work Stream members and expanding the network.
- Advocacy for RBM and ALMA support for IRS with domestic and international financing.
- Reviewing countries' IRS annual programs and reporting procedures.
- Assessing and supporting countries' IRS technical capacity and training programs.
- Supporting IRS in malaria emergencies.
- Supporting IRS and other mosquito control interventions in the prevention and control of *P. vivax*.

1.2. IRS for malaria elimination - Birkinesh Amenshewa, WHO-AFRO, Zimbabwe

As malaria control moves from control to elimination, there is a need to reorient IRS from universal coverage to targeted IRS. A number of countries in Africa are moving towards

elimination. In Southern Africa, these include South Africa, Swaziland, Namibia and Botswana. National Programmes have reoriented towards elimination strategies and border issues. When incidence drops below 1 per 1000 of the at-risk population, programs reorient towards elimination strategies, i.e. from universal to targeted implementation. The aim is to achieve the maximum possible coverage in transmission foci. IRS in elimination helps to reduce malaria prevalence from low baseline to zero transmission and to completely interrupt transmission in targeted foci.

The objectives of IRS in elimination include:

- Reducing the number of active transmission foci to zero.
- Reducing receptivity and vulnerability in recent foci.
- Preventing introduced and indigenous cases from producing secondary infections.
- Preventing the re-establishment of local transmission.

IRS delivery for malaria elimination must be:

- Linked to case-based surveillance and investigations.
- Delivered in an epidemic preparedness and response manner.
- The frequency and timing of applications determined by the type of foci the program is dealing with.

1.3. Scaling up IRS in Tanzania - Renata Mandike, NMCP Tanzania

IRS scale-up in Tanzania started in the lake zone during 2006-7 to 2011-12, as part of the second national malaria strategic plan. This is an area of around 100,000km² (~1/4 of the country) and 6.5million people (~1/6 of the total population). This project was piloted in Kagera district in 2007 and then expanded gradually, with the population protected increasing from 167,871 people in 2007 to over 6.5 million in 2011-12. Initially, all households were sprayed with Lambda-cyhalothrin (*ICON™*) and again in 2011-12, when targeted IRS was introduced. In Muleba district, in response to detection of resistance, there was a shift from the use of pyrethroids to carbamates as part of a resistance mitigation plan.

IRS is conducted in collaboration with local authorities, communities, Research Triangle Institute (RTI) International, and *President's Malaria Initiative* (PMI). In 2011-12 RQK was introduced to supplement routine supervision and monitoring of the quality of spraying with bendiocarb. Between March and April 2012, a total of 1347 samples were collected from 251 randomly selected houses. 83% of the samples had optimal concentration of insecticide, 13% semi optimal and 4% had no insecticide. The results were used to improve the quality of spraying. In the lake region, following IRS from 2007 to 2012, IRS operations are now shifting from blanket to targeted coverage.

Three types of IRS operation are conducted, based on under five malaria admissions in catchment area district hospitals: (1) knock down, (2) keep down, (3) target. Stratification of IRS is challenging due to misdiagnosis (lack of confirmed diagnosis), but the introduction of RDTs is

helping to manage this. Muleba district is being used as a model to support the scale-down of IRS.

There are long-term plans to expand IRS to new areas in Tanzania based on the following factors:

- Need to identify where IRS can make a difference (stratification).
- Tool to knock down malaria in high transmission.
- Tool to progress to elimination in moderate - low transmission.
- Outbreak prevention/response.
- Combination with LLINs.

The main challenges for IRS include:

- Insecticide resistance and limited insecticide options.
- Capacity building.
- Combining LLIN and IRS.
- Monitoring quality of spraying.
- Funding and sustainability.

The next malaria strategic plan will focus IRS in the lake and southern zones. The way forward is stratification to target interventions, combining IRS with other vector control methods and intensifying resistance mitigation monitoring.

1.4. IRS Human capacity building in Tanzania - Joshua Mutagahywa, RTI and NMCP Tanzania

1.4.1. Need for training.

High quality IRS depends on well trained, disciplined and dedicated staff. Initially in Tanzania, as IRS was introduced, training was conducted by a few vector control officers. The demand for human resources and training kept growing with the scaling up of IRS. There was then a need to ensure additional staff was adequately trained by making the training process and materials more formal.

The different human resource categories for training were identified as: NMCP, Regional and districts teams, environmental compliance officer, Monitoring and Evaluation team, Information, Education, and Communication (IEC) team, spray supervisors and spray operators.

1.4.2. Training of IRS human resource 2007 - 2010

Initially, IRS training was conducted by a few trained vector control officers available in Tanzania. As the program expanded, district malaria focal officers were trained to support the expanding demand for training. This training was semi-formal since it was not based on a formal curricula, trainers guide or teaching methodology. Some of the staff categories were not covered (NMCP, regional and district supervisors).

1.4.3. Development of formal training modules for IRS in Tanzania

Since 2011, RTI-Tanzania, in collaboration with NMCP/ZMCP, started the development of IRS training guides. The developed guides were intended to bridge the gaps in training materials. Training materials were based on existing experience, both local and international, and cover IRS planners, supervisors and direct implementers.

In 2011, 12 training modules were developed by RTI. These include:

- M1: for managers and planners, targeting national regional district managers, how to set up IRS program.
- M2: for district technical team: best practices for logistic and supervision level at district level.
- M3: for site managers and team leaders.
- M4: guiding principles for spray teams (perform IRS).
- M5: IRS team, basic knowledge of malaria, for everyone.
- M6: environmental monitoring and human safety.
- M7: for clinicians, pesticide exposure and adverse reaction.
- M8: advocacy and community mobilization (IEC staff).
- M9: MandE for IRS, MandE officers.
- M10: best practices for logistics.
- M11: best practices for spray pump maintenance and repair.
- M12: entomological monitoring for VCOs.
- Modules A, B, C: trainers guide, curriculum and teaching methodologies.

1.4.4. IRS training used the case case approach

- Core facilitators.
- Training of trainers.
- Master trainers.
- Spray teams.

1.5. East African regional IRS training and support hub for scaling up malaria vector control - Evan Mathenge, Kenya Medical Research Institute (KEMRI), Kenya

IRS is a high impact intervention but scale matters. The cost per person protected depends on scale (costs in large and small programmes range from US\$2.62-5.52 per person protected per year). Many countries are expanding IRS to increase or sustain impact. High quality and timely IRS delivery to achieve greater than 80% coverage is needed. Countries are faced with the challenge of inadequate capacity for effective and efficient operational planning and management of IRS programs. There is need to increase regional capacity to plan, implement, monitor and evaluate IRS activities in an environmentally sound manner. Countries using IRS in East Africa include: Eritrea, Ethiopia, Kenya, Rwanda, Uganda, Tanzania, Somalia and South Sudan.

1.5.1. A regional IRS training and support hub is needed to:

- Harmonise IRS training to standardise operations.
- Establish a critical mass of high quality skill-oriented and field based IRS trainers of trainers (TOTs).
- Provide technical and operational support to countries.
- Provide a platform for sharing innovations and best practices.
- Provide prompt field support (pooled experts-IST) and pooling of capacity building resources.
- Allow for comparability of programs (meta-analysis).
- Provide continuity beyond the contractor.

1.5.1.1. The objectives of a regional training centre are:

- To establish a skills-based master field training and support centre for IRS in the East African region.
- To train and support national and provincial IRS coordinators for malaria control and elimination programs.
- To develop and conduct a skills-oriented and field-based IRS TOT training course.
- To develop and update IRS training curricula and training materials based on the WHO IRS operational manuals (regional harmonization and adaptation).
- To establish a network of IRS trainers and experts to provide training and follow up mentorship and field-based support for country IRS delivery.
- To strengthen public and private partnerships for scaling up IRS.

1.5.1.2. Expected outcomes

- Development of a skills-oriented and field-based IRS TOT training course.
- Development and updating of IRS training curricula and training materials, based on WHO IRS operational manuals (regional harmonization and adaptation).
- Established network of IRS trainers and experts to provide training and follow up mentorship and field based support for country IRS delivery.
- Strengthened public and private partnerships for scaling-up IRS.

1.5.3. Kenya's training potential

Kenya is expanding its IRS activities for disease burden reduction especially in the western part of the country. IRS has been conducted since 2002. KEMRI has field training facilities for IRS, such as the KEMRI centre for Global Health Research in Kisumu.

1.5.4. Moving forward

Discussions were held and identified the need for the following:

- Training, duration, methods, curriculum.
- Budget and source of funds.

Suggestions regarding trainees and facilitators included:

- National, provincial and district IRS coordinators/focal points (25?).
- Facilitators from (possibly) Kenya NMCP, KEMRI, Uganda, Tanzania, Ethiopia, WHO.
- Facilitators from NGOs (RTI, Mentor Initiative, Abt Associates).
- Facilitators from private sector (3).
- Training coordinator and secretary/administrator (1).

1.6. IRS for cross border malaria control and elimination - D. Moonasar, NMCP-RSA; J. Mberikunashi, NMCP-Zimbabwe; G. Matsihhe, NMCP- Mozambique; S. Kunene, NMCP-Swaziland and R. Maharaj, MRC- RSA

1.6.1. Why IRS for cross border control and elimination?

- Has been conducted in Southern Africa since the 1940s.
- Vast technical skills and technical experience exists.
- High level of political support.
- Common vectors (e.g. *An.arabiensis*).
- Community acceptance and support for IRS is relatively high.
- Proven impact on reduction of malaria morbidity and mortality.

1.6.2. Where do cross border malaria initiatives exist and who are the key stakeholders?

- TLMI: Trans Limpopo Malaria Initiative, South Africa and Zimbabwe.
- MOZIZA: Moziza- Mozambique, Zimbabwe and South Africa.
- LSDI: Lubombo Spatial Development Initiative, South Africa, Mozambique and Swaziland.
- TZMI: Trans-Zambesi Malaria Initiative, Angola, Botswana, Namibia, Zimbabwe and Zambia.
- TCMI: Trans Cunene Malaria Initiative, Angola and Namibia.

1.6.3. Measuring the impact of IRS spraying programmes

- Malaria morbidity.
- Malaria mortality.
- Vector density.
- Vector species elimination.

1.6.4. LSDI case study on cross-border IRS

The Lubombo Spatial Development Initiative (LSDI) is a programme conducted jointly by the governments of Mozambique, Swaziland and South Africa to develop the Lubombo region into a globally competitive economic zone. The aim was to create sustainable employment and equity in access to economic opportunity in the region, the rationale being that malaria is an impediment to economic development. The LSDI malaria initiative was set up by President Mbeki, President Chissano and King Mswati III in July 1999.

1.6.5. LSDI interventions include:

- Assessment of malaria control in Mozambique.
- IRS for rapid impact.
- Insecticide resistant profile assessment.
- Introduction of RDTs in 2000.
- Introduction of ACTs in 2006.

1.6.6. Progress, achievements and impact

Malaria incidence has declined in South Africa (KwaZulu-Natal and Mpumalanga Provinces) and Swaziland (Lubombo region) by 99% (2000-2009). Prevalence has disease has decreased by 92% in southern Mozambique (2000-2009). This model has proven to be successful in malaria control and has been copied for other initiatives.

1.6.7. What are the consequences of not sustaining IRS programmes?

Since 2011 the project has not been sustained. A reduction in IRS coverage has been associated with an increase in malaria incidence observed in Southern Mozambique.

1.6.8. The challenges for sustaining cross border malaria IRS programmes include:

- Sustaining funding.
- Lack of leadership- who drives the collaboration?
- Lack of technical skills.
- Bureaucracy.
- Lack of understanding.
- Competing interests from partners and stakeholders.

1.6.9. Strategies for sustaining Cross Border IRS programmes include:

- Secure funding beyond donor support (local government funding is ideal).
- Building capacity (skills and staff numbers).
- Strong M&E mechanisms.
- Co-ordination.
- Articulation of the case for IRS.
- Harmonisation.
- Synchronisation.
- Optimisation.
- Collaboration.

1.7. Scale-up of IRS operations in sub-Saharan PMI countries - Richard Reithinger, RTI, USA

RTI funded the start-up of the US-PMI support for scaling up IRS1 (2006-2009). Since then, IRS2 has been introduced with support from other US partners Abt Associates and Chemonics. The key stakeholders are host governments, including Ministries of Health (MoH) and National Malaria Control Programs (NMCPs). The other country stakeholders include academic institutions and local communities.

1.7.1. Procurement and supply chain

The procurement and supply chain supports timely and efficient procurement; specific commodities need to be available at the right time and in the right quantities to provide coverage for the entire targeted area and for spray rounds to be launched and completed at the optimal time. It is necessary to balance international versus local procurements. The total number of sachets procured was 788,022 in 2010 and 2,009,086 in 2011. Total sprayers numbered 4300 in 2012 and 2650 in 2011. This was supported by transport, warehousing and storage system. Standardization was needed regarding supply chain management and warehouse and inventory management standard operating procedures (SOPs). Bulk procurement mechanisms were established to reduce labour costs, procurement processing time, shipping costs, and sometimes insecticide costs. This was supported by QA/QC of procured commodities.

1.7.2. Operational programme support

Operational programme support aimed to establish country partnerships with MoHs, NMCPs and other in-country stakeholders, followed by pre-IRS operations planning meetings with the involvement of district and community structures. Community mobilization was essential with >21,000 mobilizers trained annually. There is also comprehensive training of spray personnel (13792 in 2010 and 13777 in 2011).

1.7.3. Personal safety and environmental compliance

USAID required Supplemental Environmental Assessments (SEA) to be completed in every country where IRS was carried out. Guidance was provided through Best Management Practices for Indoor Residual Spraying in Vector Control Interventions (http://pmi.gov/technical/pest/bmp_manual_aug10.pdf). A supporting infrastructure was established including secure warehousing and storage, insecticide evaporation tanks and soak pits, washing areas and personal protection equipment (PPE). Annual training of spray operators and other IRS personnel was held. Environmental compliance inspections were conducted pre-, mid- and post-operations, together with insecticide disposal and incineration and soil sample and crop monitoring for DDT residue.

1.7.4. Monitoring and evaluation platform

The M&E platform consists of leaders and supervisors with checklists and daily data entry with data verification. Quality monitoring with QA/QC is conducted of insecticide application: wall bioassays and insecticide detection kits. Entomological impact monitoring of vector ecology, insecticide susceptibility and resistance and insecticide residual efficacy is also conducted. The economies of scale of IRS were found to improve as the number of household structures sprayed increased (i.e. costs per person sprayed simultaneously decreased).

1.8. AIRS project highlights – Brad Lucas, Abt Associates, USA

In 2012 the Africa Indoor Spraying program (AIRS) project was implemented in 14 countries in Africa for US-PMI. The program protects 7.31million people protected of which 199,681 are pregnant women and 1.38 million are children under five years. 730,483 insecticide sachets were used with 2.12 million houses targeted and 2.06 million houses sprayed. The project averages 97% coverage of target houses. Private sector involvement in IRS, through contractors, companies and corporations, is essential to advocate for funding, develop capacity in-country and to improve the quality of spray operations through the development of monitoring tools.

1.8.1. Building capacity for environment compliance

- Hundreds of soak pits and wash areas have been constructed or rehabilitated.
- Local ECOs in each country office.
- Pilot Smart Phone Technology (the use of checklists on smart phones to conduct pre and post-inspections of soak pits).
- Annual environment compliance assessments and inspection overviews.

1.8.2. Building entomological capacity

- Entomologist staff position in each country office.
- Standardized entomological monitoring.
- Spray quality assurance and insecticide residual life testing.
- Insecticide resistance testing.
- Vector bionomics analysis including baseline data.
- Regional entomological training.
- Insectary-in-a-Box (converting a container to a entomological laboratory for less than US\$20,000).
- Low resource setting staffing.

1.8.3. Building operational capacity

The following checklists and tools are available for managers to plan and organize field operations:

- *Race to the starting line*
 - Enables project managers to assess progress in preparations to launch spray campaigns.
- *Spray supervision checklist*
 - Provides criteria for monitoring the implementation of spray operations activities in the field.
- *Logistics dispatch plan*
- *Spray team performance tracking*
 - Provides IRS project managers and spray operations field supervisors with the information required to track the performance and progress of spray teams on a daily basis throughout the spray campaign.
 - Tracking daily indicators such as number of sachets used and structures sprayed.

- *AIRS spray performance calculator*
 - Guides IRS project managers on how to determine spray operator performance standards, set performance targets, and use the Performance Tracking Sheet.
- *IRS supply chain and warehouse management guide*
 - Quantification of IRS commodities, equipment, supplies and human resources.
 - PMI BMP requirements for IRS warehousing.
 - Insecticide stock tracking and management.
 - Inventory management.

1.8.4. Building capacity for monitoring and evaluation

- New spray database and reporting tool.
- Increased M&E capacity at the country level.
- Spray data quality assurance monitoring.

1.8.5. Country capacity assessment

- AIRS Country Capacity Assessment Framework.
- Uganda Capacity Assessment Dashboard.

1.9. Scaling up Indoor Residual Spraying in Ghana: Strengthening public-private partnerships - Sylvester Segbaya and Steve Knowles, AngloGold Ashanti Malaria Pvt Ltd, Ghana

AngloGold Ashanti (AGA) is a global gold producer which operates in over 20 countries including Argentina, Australia, Brazil, Ghana, Guinea, Mali, Namibia, South Africa, Tanzania and United States with explorations in Alaska, China, Malaysia, Philippines and Laos. The company feels strongly about Corporate Social Responsibility and partnerships for sustainable development.

Extract from AGA mission statement:

- *'...strive to form partnership with host community, sharing their environment, traditions and values, we want communities to be better off for AngloGold Ashanti having been there.'*
- *'In addition to benefiting the people, the reduction of malaria in our communities and mine makes good economic sense and the lessons learnt have been used to initiate similar projects in our other operations as well as scale up to other parts of Ghana.'*

Extract from the AGA Report to Society 2004:

- *'...Malaria remains the most significant Public Health threat to AngloGold Ashanti operations in Ghana, Mali, Guinea and Tanzania.'*

When maps of AGA global operations are superimposed over world malaria maps it is clear why AGA has a need for an overall group malaria strategy.

AGA has an integrated malaria program that consists of:

- Indoor Residual Spraying.
- LLIN distribution.
- Larviciding.
- Environmental Management.
- Surveillance, M&E, Research.
- Insecticide Resistance Management.
- Information, Education, Communication.
- Early, effective diagnosis and treatment.
- Community engagement.

The core of AGA IRS operations in Ghana started around in Obuasi and is now in its 7th year of implementation operations. A >78% reduction in malaria cases has been observed during this period with increased school attendance. Expenditure on malaria treatment has been reduced by 93%. Work lost in man days has been reduced from 6983 to less than 100 per month. The programme has 130 jobs for local communities. The programme costs AGA US\$1.5 million per year. Similar programmes exist in other AGA mine sites.

AGA together with the NMCP and MoH of Ghana, and with the support of GFATM, has started scaling up IRS in the whole of northern Ghana. This consists of a stepwise, sustained expansion of the number of districts covered by IRS annually, based on a five year plan. Insecticide susceptibility studies are conducted annually to support the choice of insecticide. An IRS weekly performance tracker is used to track cumulated target structures sprayed against estimated target structures sprayed.

1.9.1. Types of Partnerships

GOVERNMENT	ANGLOGOLD ASHANTI
<ul style="list-style-type: none"> • MoH nominated AGA as principal recipient for GFATM grant • Government Health facilities serve as sentinel sites for M&E activities • Government provides infrastructure in districts e.g. storage facilities, offices, security, etc • Labour is hired from communities being sprayed-job creation 	<ul style="list-style-type: none"> • AGA provides IRS expertise • Conducts procurements • Entomology Laboratory for vector control activities • Managerial support and infrastructure • Building local capacity for sustainability

1.9.2. The key partners are:

- MoH Ghana/Ghana Health Service/NMCP Ghana.
- Environmental Protection Agency (Regulation).
- USAID/PMI (IRS Implementers).
- Noguchi Memorial Institute for Medical Research (Entomology and Epidemiology studies).
- Kumasi Centre for Collaborative Research (Parasite Prevalence Studies).

- Municipal and District Assemblies (Recruitment process, offices, etc).
- Traditional and Opinion Leaders (Community mobilization).
- Community Members (co-operation and appreciation).
- Other mining companies (Newmont, Goldfields, etc).

1.9.3. The main challenges are

- Anticipated government offices in districts are sometimes non-existent.
- Entomological studies showing similar rates of indoor and outdoor biting.
- Occasional refusals due to odour of insecticide (pirimiphos methyl).
- Limited sources of insecticide supply.

1.10. Malaria private public partnership - Tjipo Mathobi, GBC Health Africa, South Africa

GBC Health brings all the private sector partners to support IRS and malaria control and elimination. GBC Health is the focal point for the private sector to GFATM. GBC Health is a catalyst and facilitator. GBC Health has been working with IRS Work Stream and RBM in supporting IRS and malaria control in Southern Africa since 2011 through annual consultation meetings and country follow up. There have been plans to establish the West Africa Platform in 2012-2014 and expand to Central and East Africa. In malaria PPP, the focus is on big corporates and there is a need to increase expenditure and cost savings, and to find ways to demonstrate return on investment.

1.11. IRS scaling up performance, progress and partnerships - Michelle Helinski, NMCP Uganda and Malaria Consortium Uganda

The primary malaria vectors in Uganda are *An. gambiae s.s.*, *An. funestus*, *An. arabiensis*. Six vector sentinel sites are supported by US-PMI, incorporating:

- Six susceptibility surveillance sites.
- Mosquito collections pre- and post-IRS by PSC to assess species composition, density, behaviour, infection rates and resistance mechanisms.
- Vector bionomics studies conducted monthly in two IRS districts and one non-IRS district.

A 2011 resistance map of major public health insecticides used has been produced to select insecticides and manage resistance.

The purpose of IRS in Uganda is to reduce transmission in high prevalence areas and to prevent epidemics. IRS policy is stipulated under national malaria control and prevention policy, 2010-11/2015. National IRS guidelines and training exists with the support of WHO manuals/Abt Associates manuals.

IRS is led by the MoH (NMCP), in collaboration with different sectors:

- Ministry of Finance, National Environmental Management Authority, National Drug Authority.
- Civil society advocacy activities.
- Bilateral development agencies: PMI (Abt Associates).

IRS is now conducted in 11 districts with 10 in the north supported by PMI/Abt Associates and 1 in the east managed by the NMCP. The spray cycle is twice a year between April and June and again in October and December. The insecticide used currently is Bendicoarb 80%WP. 650,000 sachets are required per year to cover around 1million households. The hand compression pumps in use are mainly Hudson X-Pert® sprayers and around 4,000 sprayers are stored in government stores at districts level. There are trained personnel to maintain and service pumps regularly. IRS annual planning meetings take place pre-intervention at all levels (Ministry, District, Sub-County, Parish). This is followed by training of trainers (VCOs, DHTs, supervisors), facilitated by MoH, Abt Associates and other partners. IRS and community mobilization is through use of key IEC materials and media with printed materials, electronic messages (local radio, TV), film vans, community health workers. The IEC and CM activities take place pre-and during the intervention. There is string base to mobilize traditional, local government leaders and members of parliament.

IRS monitoring and reporting is based on core indicators:

- Number of houses sprayed.
- Number population protected.
- Number sachets used.
- Number pregnant women/< 5s protected.
- Outcome: OPD attendance from HMIS data.

House spray cards record daily spray operator activities. This data is entered daily into a central database to map progress. IRS quality is assured by following WHOPES guidelines. This is supported by annual training and supervision and supervision at parish level. The community is vigilant, observing operators empty sachets into the sprayer tanks when requesting water. There is also entomological monitoring by PSC pre- and post-IRS with wall bioassays. There is an annual IRS program reporting system through PMI/Abt Associates bi-annual reports and NMCP activity reports.

IRS protected approximately 8% of the total population at risk in 2012 (around 3million people and 950,000 households).

The main challenges to the programme are funding for scaling-up and monitoring insecticide resistance to inform the insecticide resistance strategy.

The plans for the future are:

- To sustain IRS in the 11 districts with 2 rounds of spraying with bendiocarb and longer-lasting operations.
- To discuss the future of IRS in the northern districts.
- To consider universal coverage with LLINs in IRS districts in 2013.

1.12. Financing and results for IRS in Global Fund-supported programs - Jan Kolaczinski, Global Fund for AIDS, TB and Malaria (GFATM), Switzerland

GFATM has 125 active malaria grants in 76 countries. US\$10.6 billion has been approved by the board, of which US\$7 billion has been committed and US\$5.4 billion has been disbursed. The majority of grants (69) are for the WHO-AFRO region, followed by SEARO (18), AMRO (14), EMRO (11), WPRO (9), EURO (4). The ten largest investments have been made in Nigeria, Ethiopia, Tanzania, Uganda, DRC, Ghana, Kenya, Madagascar, Sudan and Angola. The largest investment has been made in procurement and delivery of LLINs (US\$1.3 billion since 2003, while approximately US\$212 million has been spend on IRS).

1.12. Number of countries implementing IRS with GFATM funding

Cluster	2009	2010	2011	2012
East Asia and Pacific	3	4	5	5
Eastern Europe and Central Asia	4	4	4	4
Latin America and Caribbean	2	3	4	4
Middle East and North Africa	3	3	3	3
South and West Asia	2	3	3	3
SSA: East Africa	2	3	4	4
SSA: Southern Africa	5	5	5	5
SSA: West and Central Africa	1	2	2	4
TOTAL	22	27	30	32

2. New tools and technology for IRS

2.1. Insecticide Quantification Kits - Chris Helm, IVCC, UK

Insecticide Quantification Kits are new quality assurance tools for IRS programs. Field reports suggest spray coverage can be variable, sometimes as low as 70%. The only options previously for gauging the effectiveness of spraying have been cone assays and HPLC, but both have practical challenges to use in the field.

2.1.1. IQK™ (Insecticide Quantification Kits) have the following qualities:

- Innovative, new quality control technologies for IRS.
- Quickly assess the level of insecticide on a surface.
- Cost effective and easy to use.
- Cover most common anti-mosquito insecticides.
- Proven in the lab and in the field in IRS programs.

2.1.2. The current scope and status of IQK development

To use on house surface and on LLIN are as follows:

- Pyrethroid IQK (for class II pyrethroids).
- Carbamate IQK.
- Organophosphate IQK.
- DDT IQK.

2.1.3. User feedback on benefits of IQKs

<p>Experience</p> <ul style="list-style-type: none"> • Field trials of IQKs have been carried out with early adopters in Tanzania, Bioko and Vanuatu • 23 locations in total • Kits work well 	<p>Development</p> <ul style="list-style-type: none"> • Aim for further simplification • Pre-package reagents ready for use • Reduce sensitivity to ambient conditions
<p>Effect</p> <ul style="list-style-type: none"> • Focussed supervision • Tailored training • Selective re-testing and follow up • Improve sprayer awareness and behaviour 	<p>Development</p> <ul style="list-style-type: none"> • Aim for further simplification • Pre-package reagents ready for use • Reduce sensitivity to ambient conditions

2.2. New tools to improve IRS Applications - *Íñigo Garmendia, Goizper Group, Spain*

IRS is an important method of malaria vector control. However it requires:

- Efficiency.
- Operator safety and comfort.

2.2.1. Objectives of IRS operators

To apply the correct dosage of insecticide on all surfaces (specified by the insecticide manufacture) at the correct droplet size ($\phi > 200$ microns WHO).

2.2.2. IRS spray parameters

- Concentration of insecticide in the tank.
- Nozzle: Even Fan 8001 or 8002.
- Pressure in the nozzle/tank.
- Distance from the surface: 45cm.
- Spray speed: 2.5 sec/m.

2.2.3. Challenges to spraying uniform dosages on walls

- Concentration of insecticide in the tank.
- Nozzle: Even Fan 8001 or 8002.
- Distance from the surface: 45cm.

- Spray speed: 5 sec for 2m wall.
- Pressure in the nozzle/tank: variable.

2.2.4. Pressure variation in the tank and nozzle

Not easy:

- Tank pressure will vary considerably.
- Nozzle flow rates vary considerably.
- Spray operator decides when to stop.
- Frequent checking of pressure gauge.

The result is considerable variation in the DOSAGE of insecticide (approx. $\pm 25\%$) measured on wall surfaces.

2.2.5. Low Pressure Constant Flow Valve (CFV)

Easier:

- No need to worry about pressure.
- Uniform flow rate (lower value) and dosage (median value).

This ensures a uniform dosage of insecticide is sprayed throughout the operation. 20% less water is used to sprayed 250 m² (8 litres in-stead of 10 litres).

2.2.6. Nozzle erosion

Main factors responsible for nozzle erosion are:

- Nozzle material and internal design.
- Insecticide type.
- Pressure in the nozzle (bar/psi).
- Working temperature.

Brass and hardened stainless steel nozzles result in erosion and increase flow rates which is inefficient. There is need to consider low erosion nozzles.

2.2.7. Blockage of nozzles

Blockage of nozzles is one of the common problems faced by spray operators, caused by dirty water and nozzles being placed on the ground. Possible solutions are a triple water filter system comprising a nozzle filter, filling mouth filter and on-handle filter. Nozzles can also come with guards for protection when not in use.

2.2.7. IRS spray operator safety

A high volume of inhalable insecticide droplets are sprayed. In the past only the pressure valve was used however there may now be a need to consider new tools such as the use of low pressure control flow valve and low drift nozzles.

2.2.8. IRS operator comfort

There is a need to consider the number of house sprayed in one day and in one IRS spray round, which may number 55 days. A spray operator's work is tiring and uncomfortable. The risk is a loss of precision in spraying technique.

2.2.9. New materials and manufacturing process

Changing technology from steel to new light weight materials presents new opportunities:

- Very light sprayers (less than 2kg when empty).
- More comfortable (possible to carry in the back).
- Pressure- corrosion- and UV-resistant.

2.2.10 Cleaning and maintenance

New materials offer new design possibilities for new sprayer designs (fewer parts)

- Very easy.
- 100 % tool free.

IRS remains an important intervention for malaria control and elimination. Continued use of traditional metallic equipment is not efficient, not safe and uncomfortable. Better tools are already available.

2.2. IRS Commodity Calculator - Manuel Lluberas, H. D. Hudson Manufacturing Company, USA

An IRS Commodity Calculator (IRSCC) is in its final stages of development and should be released by May 2013. The IRSCC will be web-based and will allow users to design IRS campaigns based on country-specific parameters. It takes the user through a questionnaire with options and recommendations used to generate a 4-page summary of the IRS plan, a multi-year budget, and a IRS calendar. The IRSCC is designed to save program managers' time and money by automating a good portion of the IRS needs-assessment phase.

3. IRS Work Stream Work Plans 2013-2014

3.1. IRS advocacy

Objective	Activity	Responsibility	Timeline
Advocacy at all levels that IRS is key VC intervention that should be used where applicable Advantageous	Generate evidence for advantageous application: resistance management, combined use, sole use. Secure funding for generating evidence: researchers and government	NMCP IRS WS WHO RBM	December 2013 December 2014
Secure funding for IRS from all levels: Inter-national; Local Governments, Partners-	Determine funding gap to advocate for resources where IRS is applicable Development of appropriate	NMCP IRS WS RBM	December 2014 July 2014

Private	advocacy materials		
Advocacy to manufacturers for provision of better and more longer lasting tools/insecticides for IRS	Product development and testing evaluation and recommendation	Private Sector and IVCC RBM WHOPES	December 2014 December 2016
Advocacy at global, regional and national levels for human resources, tools/equipment and infrastructure	Development of appropriate advocacy materials	NMCP IRS WS RBM	July 2014
Support for Africa Fighting Malaria	Communication	IRS WS IVCC RBM	May 2014
Private Cooperate Sectors Support for IRS	Central Africa Meeting East Africa Meeting	NMCP IRS WS RBM	October 2014

3.2. IRS capacity building

Objective	Activity	Responsibility	Timeline
Develop symposium on malaria in Africa for 2014 AMCA conference	1. Invite key NMCP members from Africa 2. Identify keynote speaker for AMCA 3. Visit US Senate and Congress to support IRS and malaria control and elimination	IRS WS RBM	March 2013 April 2013 March 2014
IRS Country Reporting	IRS country database IRS regional database IRS country profile	IRS WS WHO RBM	December 2013
Produce training modules specific to IRS operations	1. Collect existing training materials and modules from NMCP and private sector partners 2. Evaluate and review materials 3. Prepare consolidated draft	IRS WS WHO RBM	April 2013 July 2013 October 2013 June 2014

	4. Evaluate and field test		
Regional Training Centers for IRS	Identify and support centres	IRS WS WHO RBM	October 2013

3.3. IRS new tools development

Objective	Activity	Responsibility	Timeline
Finalize the IRS Commodity Calculator (IRSCC) tool	Finalize web-based IRSCC and release to NMCP	Hudson IRS WS RBM	May 2013
Constant flow valve	Make available a constant flow valve for IRS spray operations	Goizper IRS WS RBM	April 2013
IVCC- QC Kit	IRS quality assurance kit to be rolled out in IRS programs	IVCC IRS WS RBM	July 2014

4. Poster presentation

- Africa Fighting Malaria (Jason Urbach).
- IRS in Uganda (NMCP Uganda).
- Reduction of malaria prevalence by Indoor Residual Spraying-A meta-regression analysis (Doheyeong Kim, Kristen Fedak, Randell Karamer).
- Insectary in Box (Abt Associates-Brad Lucas).
- Community based IRS (Abt Associates-Brad Lucas).

5. Summary

5.1. Key questions and issues

- Tanzania started targeting spraying in 2011. This was based on inpatient data (stratification). Admissions can skew stratification, depending on the quality of case management practices and supply of medicines. However, they see it as a starting point.
- The East Africa region needs to consolidate efforts across borders to consolidate gains. Tanzania will focus more on the lake region, where Kenya is now spraying.
- In Uganda in the north where IRS is being carried out, the human biting rate was previously 6 bites/person/night. Malaria has declined in this region and the issue now is sustaining gains, building capacity at district level and among health officers. This might be put onto the VCWG website as a success story. The story could be worked on with AFM.

- In terms of the South Africa and Zimbabwe cross border initiative, differences have been noted on the two sides of the border, even though both have been sprayed for a long time. South Africa has been sharing resources and logistical support for malaria control with Zimbabwe.
- Capacity building of local programs could be conducted with local implementing partners and not just outside the private sector. Contractors should support country programmes to establish sufficient capacity to sustain IRS after donor funding ceases. Too often, once funding ceases, malaria returns. A model is required to create a private sector support mechanism.
- PMI advocacy, sustaining IRS beyond PMI. The contractors should advocate and build strong advocacy teams within the country so when they pull out something is left in place.
- Tools and spreadsheets should be available on the VCWG website so we can advocate and communicate these to other countries and programs.
- Contractors should leave a legacy of improved capacity, including permanent laboratories for entomological surveillance, as PMI contributed in Ethiopia.
- Capacity building: planning and implementing expertise should be strengthened.
- How constrained are we by the types of insecticides we use? Assurance that insecticides are registered in-country is necessary. Often a lack of assurance is a blockage to implementation. Planning needs to include insecticide resistance management strategies (rotations). This will incur increased costs.
- Insecticides arriving for an emergency enter under a different scheme: exception rules.
- To secure more GFATM resources for IRS, there is need for more advocacy through vehicles such as African Leaders Malaria Initiative (ALMA) and costing of IRS in Africa and globally.
- In private-public sector partnerships it is noted that the return on investment is high with IRS, since it quickly reduces transmission. However it is necessary to find ways to sustain the gains. There are new tools and it is noted that more advocacy is needed.
- Focused private-public workshops at the regional level can be productive.

5.2. Summary of main points

- IRS should be considered a major vector control tool as countries move towards elimination and blanket spraying is replaced by more targeted spraying. Countries need to determine criteria based on the local context for this shift; mapping and surveillance of a wide range of variables will be required.
- There is a need for increased capacity building within countries, particularly in the areas of entomological monitoring and surveillance. National programmes should involve local implementing partners with experience in the local context, not just private contractors.
- There is a need to streamline activities and manuals between partners and countries. The VCWG website should be used to disseminate and provide updated manuals and management tools such as the planning calculator tool, supervision and capacity assessment tools.

- Global and national advocacy for sustaining IRS beyond big agency funding is needed. The private sector is becoming increasingly involved through corporate social responsibility programmes.
- A large number of new materials and tools are under development or undergoing field testing and these have the potential to improve the quality and management of IRS operations.

4th Durability of LLINs in the Field Work Stream Meeting
13.00-15.00, Tuesday 29th January 2013
Auditorium, IFRC, Geneva

Chairs: Albert Kilian and Steve Smith
Rapporteur: Lucy Tusting

Ongoing and planned durability work: field work

Uganda and Nigeria– Albert Kilian, Trop Health, Spain

A prospective LN study is underway in four villages near Kyenjojo, Western Uganda. Seven LLIN brands (150 per brand) are being tested, all 100-150 denier. The study is ongoing however preliminary data indicates that a 12% attrition rate after 24 months, with 6% loss to damage. In terms of physical integrity, there is ≈90% survival after three years and little difference between brands to date.

Multiple cross-sectional surveys are being conducted to determine the physical survival of LLINs from campaigns in three ecologically different states in Nigeria. Imbedded into this is an intervention-control study to evaluate the impact of improved care and repair on deterioration of the nets. This is a three-year study with 20 clusters in each of 4 sites, with 15 households per cluster. A care and repair of nets BCC campaign was conducted at one site. Another site in the same state serves as control. All nets distributed were 100 denier. Year 1 data from 900 households and 2,028 nets indicates little difference between intervention and control sites with little or no repair of holes.

PMI studies – John Gimnig, Centers for Disease Control and Prevention (CDC), USA

The President's Malaria Initiative (PMI) has made significant investments in LLINs with 22.5 million procured in 2012 and US\$120 million set aside for procurement and US\$30 million for delivery in 2013. Durability studies have been established in eight countries: Angola, Benin, Kenya, Malawi, Mozambique, Rwanda, Senegal and Zambia. Insecticidal activity and content, physical integrity and attrition are all being assessed. In the Kenya and Malawi studies, 600-800 nets of each brand were distributed and revisited every 6 months. In addition, 30 nets of each

type are randomly sampled and replaced every 6 months, to allow for analysis of holes and biological efficacy.

Preliminary data from Kenya indicates that a large proportion of nets were lost after 24 months, the most common reason for attrition being that nets were moved or taken from the house, lost or stolen, sold or given away. After 24 months, there is a range of 1 to 4 holes per net across all brands and large differences in the median hole area between brands. In Malawi, more holes have been observed earlier, and these holes are larger. There are differences in socio-economic conditions between Kenya and Malawi and the types of sleeping place differ, with palm and reed mats more common in Malawi which may cause damage. In Mozambique, a study was conducted to assess differences in LLIN durability by fabric type. Polyethylene LLINs had significantly more damage than polyester nets. To conclude, many nets last less than three years, although insecticidal activity may last longer. Polyester nets may be more durable physically. Durability is most likely linked to environmental or socio-economic factors. Further work should include defining a threshold for 'net failure' (at what point do nets cease to provide a physical barrier?), defining the useful life of a cohort of nets and fine-tuning BCC after establishing a scientific definition of net failure.

ABCDR study, Tanzania – Hans Overgaard, Norwegian University of Life Sciences, Norway

The objective of this new study is to determine the useful life of LLIN products through (1) a retrospective study of Olyset nets distributed by the Tanzanian government in 2009 and (2) a prospective study. The study aims to evaluate attrition (A), biological efficacy (B), chemical residue (C), physical degradation (D) and insecticide resistance (R). The retrospective study will enrol 100 villages with 45 household per village and use a three-stage random sampling survey to assess ABCD components for Olyset nets. The prospective study will enroll 100 villages with 45 household per village, with households randomly assigned different brands of net (Olyset, Permanet 2.0, LifeNet). Follow-up will be conducted at 12, 24, 30 and 36 months to assess overall attrition and deterioration. A further sub-sample of nets will also be assessed for BCD components using WHO recommendations for testing. A spatial analysis will be conducted to identify potential risk factors for net loss or loss of effectiveness.

Ongoing and planned durability work: laboratory work

Development of laboratory tests for the physical durability of LLINs – Steve Smith, CDC, USA

Work conducted at North Carolina State University was presented. Textile structure affects durability of nets. Net fabric is manufactured through warp knitting, with different knitting patterns for polyester, polypropylene and polyethylene. Severing one or more yarns leads to raveling in parallel to the yarn orientation hence oval holes in the warp direction. Potentially useful tests include susceptibility to initial hole formation, strength loss after hole formation and resistance to raveling. These properties were tested in a variety of net brands. Olyset and DuraNet performed best in a test of resistance to tearing by snagging, building on methods developed by Skovmand and Bosselmann (2011). In a test of strength loss after yarn severing,

polyester and polypropylene nets perform best. An abrasion tester was used to assess raveling resistance using was also conducted with inconsistent results. To conclude, multiple tests are required to predict durability. Users should be encouraged to repair even small holes. Correlation with field results is needed.

GMP/WHOPES project on LLIN fabric strength – Morteza Zaim, WHO, Switzerland

WHOPES currently recommends 13 LLINs. The current WHO specifications for quality control of nets currently list one marker of net strength only and it is therefore necessary to revisit WHO criteria and specifications for quality control. There is also a lack of comparative data on durability of LLINs in different settings to support procurement decisions. To address this, a GMP/WHOPES project on LLIN fabric strength is planned as a medium-term solution. As part of this study, WHO invites all manufacturers of nets to submit three intact nets from separate batches for an evaluation of fabric weight per unit area, tear strength, bursting strength, tensile strength and flammability. A standard form will also be required to be submitted alongside the nets. The deadline for registering interest is the end of January. A WHO consultation with LLIN industry partners and textile research institutions will review the outcomes of the study.

Causes and modes of deterioration – Albert Kilian, Trop Health, Spain

Guidance on the expected performance of LLIN products is required. It is also necessary to develop a test battery that can predict expected performance, and for that a better understanding of ‘modes of failure’ is needed. Current field tests do not correlate well with laboratory textile tests. In a project funded by the Bill and Melinda Gates Foundation, LLIN samples aged 1-2 years will be collected and analysed, with findings submitted to WHO to update procurement guidance. 500-600 net samples will be collected from existing CDC/PMI studies, from active sample in Nigeria and Cambodia and from ongoing WHOPES Phase III studies. Laboratory forensic textile analysis will include visual inspection and microscopy. The textile testing data will be combined with household and environmental data. Field work will commence in March and Phase I will be complete by October 2013. It will then be decided whether the study will move to Phase II in November/December 2013, to develop a suite of suitable textile tests which better reflect expected LLIN performance in the field and which can be used by WHO to develop a procurement guidance of LLIN durability.

Mosquito entry, effects of hole size and location – Robert Wirtz, CDC, USA

A project was conducted to analyse mosquito entry into failed bednets with holes. First, the interaction of mosquitoes with holes was assessed. It was found that there is a fringe area 2.6mm wide around the edge of a hole, where mosquitoes are likely to come into contact with the net. This fringe area therefore reduces the effective size of the hole, with longer, thinner holes having a greater fringe effect. It was also investigated how mosquito pressure varies across bednets, i.e. at what points does a mosquito attempt to enter a net with a CO₂-baited light trap. It was found that holes in the net roof had a disproportionately high impact on mosquito entry. Results also varied depending on mosquito species used. Different individuals catch different numbers of mosquitoes. These findings were used to analyse whether the WHO

hole index is a sufficient metric to describe net failure. Field tests in CA and FL were conducted. In FL, of a total mosquito pressure of 2637, a 10cm hole diameter allowed 639 (24%) adults to enter and a 25cm hole diameter allowed 888 (33%) to enter. Work is also underway to develop a SOP for use in endemic settings to evaluate a new attractant mixture with CO₂, to assess hole size and location, untreated and treated nets and resistant vectors.

Discussion - All

It was suggested that more tests may need to be considered (e.g. an alternative to the hook test for susceptibility to hole formation), and the standards for assessing nets clearly laid out. There have been two WHO consultations on this to date, and WHOPES would like to work with industry experts to clarify the tests used. It was suggested that it may be better to postpone the re-analysis of different net brands until the test procedures have been finalised. Given the importance of holes, it would be valuable to increase BCC efforts to encourage the repair of nets.

7th Continuous LLIN Distribution Systems Work Stream Meeting

15.30-18.30, Tuesday 29th January 2013

Salle V, IFRC, Geneva

Co-chairs: Jayne Webster and Kojo Lokko

Rapporteur: Richmond Ato Selby

Sustaining Fragile Gains – Lucy Paintain, LSHTM, UK

Over the past five years, unprecedented funding has been made available for malaria control, peaking at US\$2 billion in 2011. Between 2008 and 2011, approximately 385 million LLINs were distributed in sub-Saharan Africa and this has led to significant reductions in the burden of malaria in several countries. However funding appears to be plateauing and may have started to decline in 2012. Preliminary findings were presented from the ‘fragile gains’ project which seeks to examine LLIN coverage in relation to the current funding gap, with the objective of drawing attention to the consequences of decreased resources and to make recommendations on potential strategies to sustain gains. Based on available data from the latest country gap analyses on LLINs in-country and those in the pipeline, about 586.2 million LLINs are needed for the period 2013 to 2015. However, only 271.2 million LLINs are currently funded, leaving a gap of around 315 million LLINs for the same period.

According to predictions made using the Lives Saved Tool (LiST), over 90% of potential under-5 malaria deaths arising due to the gap in LLIN funding for 2013 to 2015 are predicted to occur in 8 sub-Saharan African countries, with Nigeria alone accounting for around 50% of avoidable mortality.

Further analysis of available data is on-going with plans for sensitivity analyses around the key assumptions, discussion of findings in relation to proportion of identified needs for campaigns versus continuous distribution, and development of peer-reviewed articles and other advocacy documents.

Discussion

During the discussions, the group agreed that it was imperative to ensure that people 'stay' under nets and that it is equally important to highlight the resources required to maintain the coverage achieved and also the resources required to reach universal coverage. It was pointed out that the analysis is based on the 'one net per household' indicator which does not paint the real picture on the ground. It is therefore important that results from modeling are triangulated with information from the field. It was agreed that the data analysis and documentation of gaps can serve as a good advocacy tool however specific commodity (LLIN) lives-saved analysis is only an example and malaria deaths averted could be due to other malaria control interventions being implemented. The group agreed that further analysis with all issues and recommendations will be valuable.

Targeting LLINs for epidemiology – Matt Lynch, Johns Hopkins University, USA

The presentation highlighted the dwindling funds available for LLIN using data from the Net Mapping Project. Based on this data, 145.2 million LLINs were delivered in 2010 whereas in 2012, about half this quantity (70.2 million) was delivered. The current funding situation therefore presents us with the challenge of resources being too limited to provide nets for everyone in endemic countries. Do we therefore now need to consider prioritizing and identifying households (communities?) at highest risk? If so, who and how do we target? Should the possibilities for consideration include:

- Targeting communities at the highest risk for free or with highly subsidized LLINs.
- Targeting households (communities) from lowest socio-economic groups.
- Targeting vulnerable groups (moving back to personal protection?).

Maximizing efficiency in LLIN distribution – charting the strategic process – Matt Lynch, Johns Hopkins University, USA

This presentation sought to stimulate discussions on maintaining coverage with dwindling financial resources impending. A number of assumptions were made during the presentation, based on which the following issues were raised:

- Resources are constrained and becoming more so considering the fact that the allocations of a country's funds between HIV, TB and malaria will be decided by the CCM.
- Malaria risk is unevenly distributed, and prioritizing on epidemiological risk is feasible
 - Urban areas generally have lower risk, and Africa is rapidly urbanizing (~50%). The proportion of the population living in moderate- and high-transmission settings is not large, but needs careful quantifying. What would be the pros and cons of focusing subsidies and resources on high-transmission areas? Could low-

transmission settings (especially urban areas) find more cost-effective LLIN distribution methods?

- Prioritizing LLINs and subsidies will not leave the poor more vulnerable:
 - How can the measure of 'need' be operationalized, considering the combination of epidemiological risk of infection, biological vulnerability and financial/socio-economic status?
- Prioritizing will increase the efficient use of funds.

The presentation concluded that it will be important to identify evidence gaps and to find existing evidence and opportunities to collect data to fill these gaps, in order to help determine how best to prioritise coverage and to inform technical guidelines from GMP.

Discussion

The group agreed that after ten or more years of efforts to control malaria, there is still huge progress to be made. Central systems for making decisions regarding efficiency should be developed to support countries in their planning.

Reports on institutional and country strategies for increasing efficiency in LLIN distribution

Potential ways to improve efficiencies - Jan Kolaczinski, GFATM, Switzerland

Providing examples of best practice for dissemination to countries, holding workshops and conducting study tours could help country teams (including those from funding organisations) to learn about strategies and ways of efficiently distributing LLINs. Avoiding delivery of LLINs to people not in need (because they live in non-endemic areas or already have a net) should be considered. A clearer description or understanding of continuous distribution strategies within countries could help in planning for efficient LLIN distribution and in securing the funds to do so.

Strategies for improving efficiencies of LLIN distribution in the face of dwindling resources: A UNICEF perspective – Valentina Buj, UNICEF, USA

Based on evidence from studies and research, UNICEF continues to support net distributions through ANC and EPI programmes. Integrated campaigns, such as child and maternal health weeks during which nets are distributed, have been shown to help improve LLIN coverage. Country-level data has also shown that integrated campaigns cost less than delivering standalone interventions. These integrated campaigns also enable more equitable coverage of nets, an agenda that UNICEF pursues to ensure that the most vulnerable are reached with LLINs. Coupled with the scaling up of BCC for LLINs to improve use of nets distributed and ensure proper net care, UNICEF is also increasing M&E especially at the community level, through innovations such as Monitoring for RESults (MoRES).

Country examples of targeting to improve efficiencies – Lamine Diouf, NMCP, Senegal and Evan Mathenge, KEMRI, Kenya

Examples of resource prioritisation in Kenya and Senegal were given. These include targeting interventions according to malaria epidemiology and risks, a strategy used in Senegal during the development of the Global Fund Round 10 proposal. The presenters from these two countries recommended, based on their experience, that in the context of stringent resources there is the need for strategic planning. This should consider epidemiological and risk stratification (free LLIN distribution for high transmission and high risk areas, cost recovery schemes in low transmission areas and surveillance programs focusing on low transmission areas), define criteria for combining interventions and define which other interventions should be rolled out in each strata.

General summary discussions and actions

- The Fragile Gains data analysis will continue. The Continuous Distribution Work Stream should discuss how best to focus advocacy messages using the data generated.
- Countries have already begun to prioritize LLIN distribution to improve efficiencies in the light of constrained resources and are asking for guidance.
- Continuous Distribution proposals at country level are not well conceptualized or described in proposals. There is need for country support.
- Prioritisation of interventions based on epidemiology/transmission data should be considered whilst ensuring that those who are biologically vulnerable and at risk are given the highest priority.
- What kind of evidence is needed to help with prioritisation?
- GMP/WHO must develop guidelines for country-level planning and decision-making. The VCWG can provide the operational support for planning.
- Guidelines should be simple and easy to understand and use at country level, and should be developed quickly.
- Domestic funding is needed to augment other funding sources and this should be raised at different levels and in various forms.

2013 Work Plan

- Develop a request for consideration to GMP to develop guidelines for prioritisation.
- Update existing strategic decision making document to aid countries to prioritise.
- Several products to be developed giving simple operational support for continuous distribution.
- Country support: explore working with AMP to provide extended support beyond Work Stream guides and tools.
- Capacity building with stakeholders to provide technical and funding support to countries.
- Complete fragile gains data analysis and packaging of advocacy messages for maximum impact.
- Produce a guide for country programmes to explore options for domestic funding.

**5th Entomological Monitoring and Integrated Vector
Management (IVM) Work Stream meeting
15.30-18.30, Tuesday 29th January 2013
Auditorium, ICRC, Geneva**

**Chairs: Jacob Williams and Raman Velayudhan
Rapporteur: Lucy Tusting**

National IVM course 2012, Kuala Lumpur – Chang Moh Seng, University Malaysia Sarawak, Malaysia

Following a consultative workshop on the management of vector control programs for entomologists in eight endemic countries, a regional IVM TOT course was established in 2010. In 2011, Malaysia became the first country in WPR region to organise a national IVM course. The 2011 course had 40 participants from Malaysia and eight other countries in the region. The WPR training course has six modules ranging from basic vector biology to program management and M&E and follows the WHO curriculum and publications on IVM. IVM is now part of the National Vector Control policy in Malaysia. The preparation phase for this lasted from 2010 to 2012 and involved training for entomologists and health personnel and a preliminary workshop. Participants developed follow-on projects, which will be implemented and reported on. The projects included country-specific initiatives as well as cross border projects targeting dengue, malaria, and lymphatic filariasis.

Discussion

- There are more opportunities for IVM in South East Asia for the combined control of malaria, dengue, chikungunya and other diseases, as is conducted in the Philippines where malaria and dengue are co-endemic and are being addressed together using the IVM approach.
- It was confirmed that a standard certificate is awarded to course participants. Further WHO-certified training courses in IVM are planned for 2013.

USAID IVM project activities – Jacob Williams, Research Triangle Institute (RTI) International, USA

At the global level, this project facilitates effective partnerships to further clarify the IVM concept and to develop a global agenda and guidance for implementation. In 2012, the project collaborated with WHO on seminal publications on IVM and to organise technical meetings. At the country level, the focus was on supporting appropriate policy and institutional frameworks for IVM, to strengthen capacity for more efficient and sustainable vector control. Tools developed in 2012 include entomology training videos on standardized entomology monitoring techniques and an Entomology Training Manual.

In 2012, the IVM project supported countries to conduct vector control needs assessments (VCNAs); develop national policies and strategies on IVM; develop national strategies specific to IRS; train entomology technicians; strengthen or establish insectaries and entomological laboratories; procure equipment and supplies and/or conduct entomological monitoring to support national vector control. Countries supported in 2012 include Burundi, DRC, Guinea, Liberia, Rwanda and Zimbabwe.

The Amazon Malaria Initiative (AMI) involves 7 countries in South America and 5 countries in Central America. A VCNA preparatory workshop was held in May 2012 in Ecuador, followed by assessments in 5 countries. A joint three-year AMI vector control plan was then developed with AMI partners in Washington DC, August 2012, to support country capacity strengthening for IVM, including entomological monitoring

Discussion

There is a need to generate capacity within country programmes to analyse and interpret local data and to reduce dependency on external partners. Ghana and Mali were discussed as examples, where collaboration between specialised research institutions and country programs provides an opportunity to review local data.

Overview of Labiofam activities – Aramis Martinez Arias, Labiofam, Cuba

Larviciding by Labiofam is underway in a number of countries in sub-Saharan Africa. Activities normally begin with a review and planning, followed by implementation and monitoring. The implementation phase involves sensitisation of the local community, followed by distribution of *Bti* and *Bs* to target areas. Staff and field workers are trained as part of efforts to strengthen national capacity (e.g. 2,784 trainees in Zambia). A surveillance system is introduced, followed by mapping and larviciding. Data from the Zambia, Angola, Dar es Salaam, Nigeria, Ghana programs was presented. A factory is being constructed in Dar es Salaam, which will have the capacity to produce 1 million litres microbial larvicide per year.

Discussion

The quality of the Labiofam product was queried. It was confirmed that Labiofam strictly complies with good management practice. Independent assessment of the Labiofam product was suggested and it was confirmed that Labiofam products would be submitted to WHOPES for evaluation within 15 days. It was suggested that granules are advantageous over liquid formulations, due to greater stability at high temperatures and ease of application by members of the community.

Framework for IVM - Steve Lindsay, Durham University, UK

An 18-month initiative is underway with the overall aim of developing a global, strategic framework for IVM, funded by the Bill and Melinda Gates Foundation. The objectives are:

1. To produce a global map showing the combined distribution of all major vector-borne diseases.

2. To select specific vector control tools that are effective at reducing each major vector borne disease and selection of surveillance tools for monitoring these diseases.
3. To select interventions for IVM.
4. To develop a strategic framework for rational decision-making for selecting interventions for vector-borne diseases.
5. To produce IVM manuals for sub-Saharan Africa, South America, SE Asia, to be approved by an independent group of WHO experts.

Deliverables will include global disease distribution maps, a literature review, a mathematical model to determine the effectiveness of key interventions using malaria and LF as an exemplar, a manual to describe the Framework for Integrated Vector Control (FIVC) and the IVM manuals outlined above.

Discussion

- The causes of insecticide resistance were discussed:
 - How much have agricultural pesticides increased selective pressure on mosquitoes? There is not a vast literature on the overlap between the use of agricultural insecticide and public health insecticide and it is difficult to find data for the developing world on agricultural pesticide use.
 - How much is resistance driven by household use of coils and household pesticide aerosols and residual effects of IRS?
 - What is the selective pressure from the use of pesticides in livestock on zoophilic vectors?
 - How much selective pressure is from IRS itself?
- There are many potential areas of collaboration with the agricultural sector, e.g. in water management.
- It was queried whether the resolution of the MAP data is of sufficiently high resolution to be useful operationally.

Towards a more efficient vector control delivery – where are the bottlenecks and how can they be overcome?

A discussion was held to identify the major factors limiting successful vector control and to propose opportunities for addressing these issues. It was highlighted that there is a belief among many program managers that vector control is too difficult to achieve and there is a need to communicate the value of vector control to a wide audience. For example, there was a recent misunderstanding in two countries in East Africa that a dengue outbreak was linked to IRS implementation.

Initial discussions on the challenges to effective vector control highlighted the following:

Communication and advocacy

- The need for good communication about challenges and new technologies including mass media. Good communication for program managers.

- Political support at the appropriate levels of governance.
- The need for good feedback to governments about program successes.
- Demonstration of the need for funding even as programs take effect.
- The need to target permanent secretary-level beauracrats for advocacy.
- The need to develop multi-year plans.

Funding constraints

- Donor fatigue and insufficient internal country allocation.
- Making programs sustainable without external funding.
- Insufficient communication with funders.

Knowledge and research

- Poor understanding of the most appropriate interventions for a given vector and disease.
- The need for further research to improve methods of combining interventions.
- The need for a model of the critical components of IVM programs.
- The need for research on interventions outside the health sector.
- Discrepancies between knowledge among expert groups and field staff.

Program capacity

- Practical experience is crucial yet often lacking.
- The need for specific training for field staff in order to generate local data.
- The need for training in research and statistical analysis for mid level program administrators.
- The need for good monitoring and evaluation.
- Attrition of trained staff due to low salary and absence of incentives to stay.
- Inadequate placement and vested authority of country programs.
- Distortions in staff placement from excessive decentralisation.
- Excessive centralisation constraining initiative, problem solving and innovation at the lower levels (regional/district) of country programs.

Procurement and logistics

- Insufficient utilization of current tools including LLINs and IRS.
- Excessive centralisation.
- The need for better training on application methods.
- The need for better storage and distribution of products.
- Capacity for effective quantification and timely procurement.
- Short residual efficacy of insecticide products requiring multiple rounds of intervention per year.

Insecticide resistance

- Insufficient collaboration between agricultural staff and control program managers regarding insecticide use.
- A lack of understanding of the drivers of insecticide resistance and how best it can be managed.
- The need to harmonise insecticide resistance management across all vector borne diseases in areas of overlap for better planning and management.

- The need for multiple tools to help manage resistance.
- Inadequate application of tools leading to ineffective interventions (not necessarily from resistance).

Next steps

- *'Towards a more efficient vector control delivery – where are the bottlenecks and how can they be overcome?'*
 - A discussion-board will be established by March 2013 to continue Work Stream discussions, with a view to concluding discussions, by June 2013.
 - Group consensus on the draft document that also includes case studies, by July 2013.
 - Peer input to be solicited from the wider VCWG and country program managers, with a view to finalizing the document by August 2013.
- *Work Stream funding:* The meeting also initiated discussions to identify opportunities to generate resources (technical and financial) for Work Stream activities. The need to establish a pooled-fund and mechanisms that will address potential conflict of interest was highlighted. It was agreed that the matter should be raised at plenary session to find VCWG-wide mechanisms, which the Work Stream may then utilise to generate the resources required.

Day 3: Wednesday 30th January 2013

**4th Insecticide Resistance Work Stream Meeting
9.00-12.00, Wednesday 30th January 2013
Auditorium, IFRC, Geneva**

**Chairs: Janet Hemingway and Maureen Coetzee
Rapporteur: Lucy Tusting**

Cochrane Review of the effect of insecticide resistance on malaria transmission – Janet Hemingway, LSTM, UK

The review is in the final stages before being submitted for peer review. It is envisaged that the review will be published in PLoS One or PLoS Medicine. The main conclusion is that there is insufficient evidence to substantiate whether insecticide resistance is having an impact on malaria transmission, although there may be some evidence on its impact on entomological outcomes. The review will be circulated to the VCWG once accepted.

Discussion

It was suggested that the review could be made available on the VCWG website if all members of the VCWG approved it. The review highlights the need to assess the extra evidence required to examine the effect of insecticide resistance on clinical outcomes, and how should this be collected. A major priority is research that demonstrates which of the approaches recommended by GPIRM are applicable in different settings, i.e. what must be done now to preserve pyrethroids for nets? A multi-country study ongoing in five countries is assessing the impact of insecticide resistance on prevalence and incidence from cohort data. It will also be necessary to continue working with countries running IR management programs to evaluate available data, as in Bioko.

It is important to draw careful conclusions since if no action is taken before evidence for any effect of insecticide resistance becomes available, it may be too late to manage resistance. It also may be damaging in terms of funding. It was queried when the next Cochrane review would be undertaken and whether it might be updated with additional categories such as nets designed for resistance management. It was clarified that the review will not conclude that there is not a resistance problem, but will state that there is insufficient evidence. The review will also be updated regularly.

Since so many studies were not eligible for inclusion, it would also be useful to characterise a minimum set of criteria for future studies to evaluate, in more detail than existing WHO guidelines.

There was some discussion of the value of conducting small-scale cage experiments to compare different resistance management strategies rather than running large-scale trials which can take years to generate data. A limiting factor may be a lack of genetic markers for resistance genes. Some new markers are being developed but the process is made difficult since markers are difficult to find. There is also a danger that the markers will be used as a substitute for full testing, for example *kdr* markers are sometimes used as a definitive test for pyrethroid resistance, which is not correct practice.

Discriminating dosages – Janet Hemingway, LSTM, UK

Janet Hemingway described work ongoing to establish updated discriminating dosages. Data has been collated to make recommendations. It is planned that WHOPEs will then set new guidelines. It is important to test dosages on susceptible strains in order to allow comparability between studies. It is important to establish the discriminating dose for new insecticides before they are used operationally.

Discussion

It was queried whether one standard insecticide per class should be selected, given that the end goal is to standardise testing for insecticide resistance. It was agreed that this is not appropriate since different insecticides within the same class have different resistance profiles and mechanisms. Clarification was requested regarding the criteria for establishing whether a particular colony can be defined as susceptible for insecticide resistance testing. Previously, WHO-collaborating centres held colonies of resistant strains, insecticides were tested on at least 10 strains and the dosage was set at double that which killed 100% *An. sacharovi*, which tends to be the most robust species. It is important to remember that changes in mortality with a discriminating dose are not evidence of resistance but simply indicate that changes may have occurred. In situations where insufficient mosquitoes are available for testing, a priority list of insecticides for testing should be drawn up. Since mosquito catches are often the limiting factor in testing, alternative trap schemes and sample sizes should always be considered.

It is necessary to have clear guidance not only on how to conduct WHO bioassays but also how to analyse, interpret and disseminate data.

It was suggested that an additional indicator to assess whether resistance is present and where mitigation strategies are effective may be useful. In response, Janet Hemingway stated that there is not likely to be a simple solution to this.

Gold standards for IR testing and data interpretation– Janet Hemingway, LSTM, UK

To examine how data from country programs can be used to inform resistance management strategies, Janet Hemingway described ongoing work in Bioko and Zambia. These case studies serve as examples of good practice and it is hoped that careful dissemination will encourage further similar evaluations.

In Bioko, IRS with deltamethrin began in 2004 which was associated with suppression of *An. funestus* but not *An. gambiae*. Bendiocarb was then introduced, with a consequent decline in *An. gambiae* and parasite prevalence, which might be explained by pyrethroid resistance (40-60% survival and high kdr frequency) in both molecular forms of *An. gambiae*. Since the introduction of IRS, *An. funestus* has virtually disappeared although *An. gambiae* M and S and *An. melas* are still present (see publications by Brian Sharp and colleagues). After seven years of the program, there is no evidence of resistance to bendiocarb while resistance to pyrethroids remains high. In 2007/8, large scale LLIN distribution was conducted but usage was low. In 2012 LLIN coverage increased. Despite dramatic reductions in prevalence, transmission has not yet been interrupted and further work is examining the reasons for this (possible explanations include the low residual efficacy of bendiocarb and its need for reapplication every 3 months, together with poor application).

Evidence for gene flow between *An. gambiae* on the mainland and in Bioko indicates that it may not be sensible to continue with bendiocarb given high levels of resistance to bendiocarb on the mainland. Since the NMCP has carefully catalogued and stored mosquito samples, these are being revisited to examine various factors, including the premise that kdr resistant vectors have been contributing proportionally more to transmission. The data showed that kdr homozygotes were actually less frequently infected with parasites than were heterozygotes or susceptible mosquitoes.

Since the length of the deltamethrin spray round is 3 months, the data from window exit traps was disaggregated to establish which mosquitoes were collected pre- and post-spraying. These data indicate that *An. gambiae* populations declined immediately after spraying, while increasing in un-sprayed houses. This suggests that, despite resistance, deltamethrin was still having an impact on *An. gambiae* during the period in which it was used for IRS. The samples have also been used to examine whether there is solely kdr resistance in Bioko. Poor correlation between kdr and survival on the discriminating dosages indicates that other resistance mechanisms are also present. Recent sampling in 2011 showed in microarray analysis that there was no difference between surviving and unexposed mosquitoes but a large difference between these two groups and the susceptible laboratory strain. None of the major P450 genes were upregulated.

In summary, although the correct decision was made to stop deltamethrin spraying, today there is only low underlying increased metabolism and some kdr resistance and this is not sufficient justification for not resuming IRS with a pyrethroid. The decision has therefore been made to reinstate deltamethrin IRS for one year with careful IR monitoring to safeguard against the introduction of bendiocarb resistance genotypes from the mainland.

In Zambia, a similar process is underway. Here, *An. funestus* has high-level metabolic resistance and *An. gambiae* has weaker resistance (both kdr and metabolic). CDC, PMI and IVCC amongst other groups have pooled data in order to stratify the country by levels of resistance and an in-

country mosaic may be introduced. This work is ongoing and hindered to some extent by a lack of a strong link between resistance and prevalence data.

Discussion

The problems with using kdr as a pseudo-marker for resistance were again highlighted. Assessing for correlation between survival on the discriminating dosages and kdr prevalence is not a robust method for assessing which markers are present.

Possible reasons for a lack of reversion (kdr) in Bioko may be due to selective pressure from LLINs or agricultural pesticide use, the kdr mechanism being present for many years since DDT (implying that it does not confer a selective disadvantage) or low gene flow from susceptible mainland populations. Reversion has occurred rapidly in Zimbabwe, India and Pakistan and these data, together with data on reversion from other locations such as Sri Lanka and Gezira, Sudan will inform our understanding.

The rationale for resuming spraying with deltamethrin rather than an alternative in Bioko is that a new 12-month formulation will be assessed in a trial for the first time operationally, negating the requirement for frequent reapplication. If possible the full report from Bioko will be made available in English, French and Portuguese.

Decisions must be made regarding the need to switch from pyrethroids when resistance is detected, given that coverage may subsequently decline due to the increased costs of alternative insecticides (e.g. PMI switched insecticide in 2012 in Liberia with a consequent reduction in IRS coverage from 23% to 11%). In these settings, it is suggested that further tests are conducted to confirm which mechanisms of resistance are present and the prevalence of these.

National level entomological surveillance data will be highly valuable in the long-term and the example from Dar-es-Salaam shows the value and feasibility of community-led entomological surveillance. In general the quality of entomological data is highly variable.

In Zanzibar, there has been resistance on Pemba Island to all types of pyrethroid since 2010. In 2010, there was no evidence of DDT resistance, in 2011 survival was 3% and in 2012 at one site 25% survival was observed. Furthermore, resistance is now present where previously it was absent. A recent study shows that mortality is higher in older mosquitoes, concurring with similar work elsewhere.

The new WHO guidelines on susceptibility tests should be published both in French and English given the number of francophone countries with a resistance problem. It was suggested that WHO, together with partners such as PMI, could hold regional workshops this year to manage communication and to disseminate information in a formal manner with program managers.

Data sharing - request from ANVR – Maureen Coetzee, University of the Witwatersrand, South Africa

WHO-AFRO is responsible for maintaining the African Network on Vector Resistance to Insecticides (ANVR) database, which is used for producing maps of resistance. The data being used is largely unpublished and ANVR relies on countries providing this. It is however necessary to make it clear that sharing data with ANVR does not preclude publication in an academic format and the data will not be used unscrupulously. It may be helpful for editors of key journals to make a joint statement with WHO to clarify this.

There are plans to create a South East Asia network on insecticide resistance.

Michael Macdonald closed the meeting by highlighting the need for specific action points for 2013 to collect the evidence to guide policy over the coming years.

4th Larval Source Management Work Stream Meeting
13.00-15.00, Wednesday 30th January 2013
Salle V, IFRC, Geneva

Chair: Steve Lindsay
Rapporteur: Lucy Tusting

Summary of main conclusions

1. 26 countries are conducting Larval Source Management (LSM), therefore the priority is not whether LSM should be used, but the emphasis of the Work Stream should be on providing guidance on where and how best to implement and evaluate LSM so that it is used effectively and efficiently.
2. LSM is playing a role in elimination in many countries (e.g. Morocco) and is likely to do so elsewhere, especially as malaria declines and if long-lasting insecticidal nets (LLINs) and indoor residual spraying (IRS) and are perceived by local communities as less necessary, where residual outdoor transmission is maintained or hotspots remain. There is scope for LSM in Africa and elsewhere.
3. LSM should also play a role in integrated vector management (IVM), with opportunities for sectors outside health to contribute e.g. those involved in water management. LSM in USA evolved from malaria and other disease control into general mosquito abatement and as Africa develops this is likely to be a natural progression.

Update on Work Plan – Steve Lindsay, Durham University, UK

The main conclusions from the 3rd meeting were summarised and an update on the 2012 Work Plan given.

Case studies: Four case studies have been completed and are available on the RBM website:

1. Khartoum, Sudan – Hmooda Toto Kafy (NMCP, Sudan).
2. Dar-es-Salaam, Tanzania – Prosper Chaki (IHI, Tanzania).
3. Mauritius - Shahina Aboobakar (MoH, Mauritius).
4. India - Rajander Sharma (NVDCP, India).

Information on LSM in Malindi from Charles Mbogo is also available at

http://www.rbm.who.int/partnership/wg/wg_itn/doc_s/ws6/ChMbogo-LSMinUrbanMalindi.pdf

LSM Operational Manual

- March 2012: It was agreed that the LSM manual would be better as a WHO document; funding was offered by GMP.
- May 2012: First draft completed and submitted to WHO and four reviewers for preliminary review.
- October 2012: Draft manual circulated to LSM Work Stream members nominated in February 2012 for input.
- December 2012: Revised draft of manual submitted to WHO for further review.

Decision-making tool

- First draft complete: 'When and where to use Larval Source Management (LSM) for malaria control and elimination in Africa.'
- 27 page A5 document designed for program managers to decide when and where to use LSM.
- To be completed once the LSM Operational manual is finalised, so that the two documents exactly correspond

Update on Cochrane Review – Steve Lindsay, Durham University, UK

The Cochrane Review of LSM aims to compare mosquito LSM for malaria control with no LSM, applied either alone or in combination with other interventions. Progress over the past year has been as follows:

- February 2012: Preliminary analysis complete; entomology data to be added.
- March 2012: Analysis completed; first draft submitted for peer review.
- July 2012: Peer review and editors comments received. Major revisions required.
- October 2012: Search updated to include studies published since first search in October 2010; further work on finalising analysis begins with financial support from Cochrane Infectious Diseases Group.
- Spring/summer 2013: Submit again version for peer review.

Discussion

- Three years ago, LSM was not considered by WHO and many others as an intervention that could play any significant role in malaria control, however this situation is changing (LSM has featured in the 2012 World Malaria Report).
- Guidance is greatly needed for LSM; the Operational Manual should be disseminated by WHO to countries as soon as possible.
- It was suggested that it would be valuable to consider a LSM manual for dengue and other mosquitoes also. However it was highlighted that malaria is the focus for RBM and that since larviciding for dengue requires a different approach to malaria, this may overcomplicate the manual. A draft larviciding manual for dengue has also been recently submitted to WHO and manuals are also planned for IVM. There is a rich body of literature on general mosquito abatement from the USA, both historical and contemporary, for example the Florida Mosquito Control Association has recently published a manual on larviciding.
- There was some discussion over whether the main outputs and conclusions of the Cochrane Review will be incorporated in the Operational Manual. It was confirmed that, since the review is still in progress, its conclusions have not been included in the manual. Nonetheless, the manual could be updated online at a later date. It was suggested that this may not be necessary as the main objective of the review is a 'how to' document, not an advocacy statement. Furthermore, WHO has already published an interim position statement on larviciding. It was agreed that the Cochrane review and manual should run in parallel.
- The case study of LSM from Khartoum is an excellent example of IVM.
- Many countries are carrying out LSM today however not all programs have been rigorously evaluated in terms of impact on clinical outcomes.

Next steps for LSM – Steve Lindsay, Durham University, UK

The following discussion points were proposed:

1. Is there further need for operational indicators of success? We have described how to evaluate LSM in the Operational Manual, but is there a need for further guidance here?
2. Should we recommend specific branded products for LSM? WHOPES currently only has a list of recommended formulations, so for specific products one has to delve into the WHOPES meeting reports.
3. What (if anything) should we be doing to encourage LSM? Such as capacity building for environmental management (e.g. training courses for program managers run by entomologists and engineers).
4. What (if any) further research on LSM is needed?

Discussion

- There was some discussion of the role of LSM in resistance management, in targeting outdoor transmission and in reducing nuisance biting by *Culex* spp. to improve quality of life. In the USA, malaria was one of the main drivers of LSM and programmes then

evolved into the general mosquito abatement programs of today; this may be a logical progression for sub-Saharan Africa.

- 26 countries are conducting LSM but this is often not carried out as part of the NMCP, but at a municipal level for general mosquito abatement (e.g. in Lusaka). This might explain the lack of published data on LSM; perhaps WHO could help to assemble a directory of these efforts to ensure that information is systematically collected?
- It should be remembered that WHO does not necessarily oppose LSM; rather, WHO aims to base policy on evidence and in the case of LSM this is incomplete. It was highlighted that current WHO insecticide resistance strategies are based on very little evidence. The Cochrane Review and case studies will help inform the debate. However, LSM is so context-specific that locally derived data are crucial to determine whether LSM is appropriate in that particular ecology and program environment. A tool for rapidly assessing whether LSM is appropriate will be useful, taking into account current levels of insecticide resistance, the status of other malaria control interventions and other factors, in order to carefully plan control programs.
- Methodology to assess the relative contribution of different interventions is required, especially because larviciding is often used to complement LLINs and IRS. This is technically difficult however, without removing an intervention.

WHOPES-recommended products

- Many countries are adopting LSM, however it is not clear which products should be used since the WHOPES website does not list recommended products clearly on its website. It would be useful to have a list of specific branded products.
- There was discussion on larvicidal products that may be registered in a country but are not WHOPES-approved. It was suggested that a list of such products be compiled and the manufacturers encouraged to submit for WHOPES approval. This could encourage manufacturers of other products to submit for WHOPES testing and provide clear guidance to program managers. One member of the Work Stream has already compiled a draft list of larvicides which numbers over 300; this will be circulated to the Work Stream for further input.
- The Operational Manual should give guidance on quality control for microbial larvicides.

What should we be doing to encourage rational use of LSM?

- There is scope for LSM in the context of urban agriculture (see Systemwide Initiative for Malaria and Agriculture (SIMA)) and farmers could be trained in LSM particularly for urban agriculture where microdams and furrows have been shown to offer anopheline vector breeding sites.
- Borrow pits should be targeted for LSM and this should be highlighted at the forthcoming colloquium on housing and malaria organised by Habitats for Humanity and Harvard University.

- The concept of sanitary engineering (to reduce production of mosquito breeding sites in infrastructure projects) should be introduced into African universities and schools. WHO contacts with country NMCPs could be used to make connections in countries. Collaborations already exist for IVM and these can be drawn upon. Associations such as the South African Civil Engineering Associations could also be used as a starting point to offer training in larval source management to engineers.

What (if any) further research on LSM is required?

- Tests for resistance to larvicides could be helpful. The 2005 WHOPES 'Guidelines for laboratory and field testing of mosquito larvicides' may need expanding to fill this gap.

How to make LSM work for IVM – Silas Majambere, Ifakara Health Institute, Tanzania

LLINs and IRS target indoor transmission, whilst missing transmission by vectors such as *An. arabiensis*. There is also evidence of behavioural resistance, together with physiological insecticide resistance to all classes of insecticide available for LLINs and IRS. LSM is currently being used in a number of countries in Africa; therefore the question is not *whether* LSM should work, but *how* LSM can work wherever it is being undertaken. Countries therefore need guidance on how and when to integrate LSM in IVM and how to navigate around current business-driven models. The WHO Interim Position statement does not cover this in sufficient detail.

LSM has specific requirements including an understanding of the local ecology, strong management and strong entomological capacity and should be implemented in the context of 'sustained control' rather than 'scaling up for impact'. There are specific areas where LSM could complement LLINs and IRS, including areas where outdoor transmission or resistance are problematic or hotspots remain, as in Fillinger & Lindsay (2011). There are also questions over who should implement LSM. Ideally, NMCPs should have a LSM with full involvement of the local community, and where personnel are incentivised or paid. The involvement of insecticide suppliers should be limited to logistical or technical support. NMCPs should involve all other sectors working with water. There is also a need to monitor adult entomological outcomes and for impact assessment to be conducted by independent institutions.

LSM for malaria elimination – Birkinesh Ameneshewa, WHO-AFRO, Zimbabwe

An introduction to LSM was given and the settings where it might be best utilised were outlined. For elimination, there are opportunities for LSM where breeding sites are localised, easily identifiable and in locations where transmission is focal. LSM may be needed for elimination since complete interruption of transmission is difficult to achieve. For example, LSM can help with outdoor biting, especially where *An. arabiensis* is a dominant vector or where *An. gambiae* or *An. funestus* are maintaining residual low-level outdoor transmission. Local support for LLINs and IRS may decline as malaria declines and is perceived as less problematic and lower compliance may undermine their effectiveness. LSM can also be important in the prevention of reintroduction.

Discussion

- Opportunities for LSM advocacy were discussed. For example, if LSM can contribute to LSM elimination in settings such as Haiti this could be helpful. CDC has attempted LSM in Haiti but failed to secure support for this outside vector control experts.
- LSM was mentioned in all of the WHO case studies on malaria elimination. LSM is likely to play a crucial role in malaria elimination.
- LSM has contributed to malaria elimination in Morocco.

2013 Work Plan

- A list of specific products available for LSM should be drawn up with information on WHOPE status.
- As well as training program managers in LSM it is important to engage with those in the areas of urban agriculture, 'healthy homes', sanitary engineers and others outside the health arena:
 - Make contact with relevant contacts in water etc. through WHO/IVM, SIMA, habitat for humanity, Danish architecture networks and through associations e.g. South African Civil Engineering Association.
- Publish and disseminate the LSM Operational Manual as soon as possible.

5th Outdoor Malaria Transmission Work Stream Meeting
13.00-15.00, Wednesday 30th January 2013
Auditorium, IFRC, Geneva

Chairs: Marc Coosemans and Chusak Prasittisuk
Rapporteurs: Olivier Briët and Lucy Tusting

Outdoor transmission in Africa - Gerry Killeen, Ifakara Health Institute (IHI), Tanzania and LSTM, UK

Gerry Killeen presented work conducted in collaboration with Dan Msellemus, Isaac Namango, Katarina, Nicodem Govella and Heather Ferguson. Work has investigated biological coverage indicators for eliminating malaria transmission. Behavioural resilience to LLINs and IRS in Tanzanian *An. arabiensis* populations has also been investigated, by assessing the proportion of bites received indoors given local patterns of human behaviour. Recent work has also outlined target product profiles for protecting against outdoor malaria transmission.

Discussion

There was some discussion of the relative importance of individuals sleeping indoors and outdoors. Outdoor sleeping is an important consideration where indoor transmission has been controlled. The priority is high LLINs and IRS coverage. With appropriate interventions, models

indicate that it would be possible to achieve *An. arabiensis* population reductions similar to those observed in *An. gambiae*.

Review of outdoor and early transmission - Marc Coosemans, Institute Tropical Medicine Antwerp, Belgium

A recent review of outdoor and early transmission by Durnez and Coosemans was outlined. The principle of residual transmission was introduced, followed by examples of outdoor biting in South East Asia and Uganda and early biting in east and west Cambodia, Eritrea, Vietnam and Uganda. The 'gap' in control methods existed prior to the scaling-up of vector control. However the effect of vector control measures may have been to shift the ratio of indoor biting and indoor resting, as in Burundi (Smits et al., 1995); to alter species compositions, as in Kenya (Bayoh et al., 2010); to produce a shift to outdoor and early biting, as in Tanzania (Russell et al., 2010); and to produce a shift to early biting, as in Papua new Guinea (Charlwood et al., 1987). Other effects of indoor vector control interventions include an increase in the length of the oviposition cycle, induced by disrupting feeding behaviour, deterrence of vectors by insecticides such as DDT, plasticity in host selection and selection for secondary vectors such as *An. barbirostris*.

Mechanisms for shifts are as follows:

- *Protective avoidance*: Behavioural plasticity in response to insecticide, unavailability of host. Trigger of gene expression of accumulated gene variants, phenotypically neutral in normal environment. e.g. excito-repellent effect.
- *Protective behaviour*: exophily, exophagy, zoophily, early biting resulting in a minimum contact with insecticides used indoors.
- *Behavioural resistance*: develops gradually under insecticide pressure resulting in selection for mutations and recombinations. This is difficult to demonstrate due to confounding factors such as environment changes.

In conclusion:

- Although current vector control tools (LLINs and IRS) are effective, they only tackle indoor and night biting, and indoor resting malaria vectors, leaving a gap in protection.
- Before the scaling-up of vector control, there was large heterogeneity in vector behaviour.
- With the scaling-up of vector control efforts, the importance of outdoor and early malaria transmission is increasing.
- Additional control tools are required for addressing this residual malaria transmission.

Discussion

Points raised during the discussion included the importance of distinguishing between differences in plasticity and genetic shifts in behaviour that has evolved and remains. True evolution is likely to be rare. It was highlighted that programmes should continuously assess

human and vector behaviour. The efficacy of vector control in reducing *P. vivax* during the final stages of elimination was discussed. A hypothesis was formulated that saliva of uninfected anophelines may activate the hypnozoites.

Topical and spatial repellents - Sarah Moore, LSHTM, UK

The benefits to vectors of outdoor and early evening feeding when intra-domiciliary control tools are used were outlined and data illustrating differences in the ratio of indoor to outdoor biting were presented for South America and the Mekong region. Data from a recent meta-analysis of topical repellents was presented. Repellency was defined as a general term referring to a range of insect behaviours induced by chemicals that result in a reduction in human-vector contact, including: (1) movement away from a chemical stimulus, (2) interference with host detection (attraction-inhibition), (3) interference with feeding response and (4) incapacitation. Data for various spatial repellents including transfluthrin-treated hessian strips was presented.

Discussion

It was debated whether evidence of personal protection would count as sufficient epidemiological evidence or whether evidence of community protection must also be demonstrated. Interference of repellents with attract-and-kill tools should be considered, for example several topical trials have been conducted in combination with LLINs. Diversion is important for endophagic endophilic mosquitoes but not for zoophagic vectors. It was highlighted that there is a strong retail market for repellents. If proof of principle for spatial repellents, who will fund the development of new tools and will repellents compete with the funding for current tools? Costs could be reduced through subsidies where LLINs and IRS are not fully appropriate (for example, for particular risk groups such as forest workers and miners).

Personal protection tools from the deployed warfighter research program – Scott Gordon, Armed Forces Pest Management Board, USA

The views and opinions expressed in this presentation were solely those of the author. Mention of a trade name, product or company does not constitute endorsement by the US Department of Defense (DoD).

Current research efforts by the AFPMB Deployed Warfighter Research Program include: (1) permethrin-treated uniforms, (2) non-toxic insect resistant textiles, (3) mosquito attraction inhibitors, (4) new fast acting volatile pyrethroids, (5) functional micro-dispensers. The overall vision of the program is to recommend and exercise DoD policy, execute technical oversight, provide scientific advice and enhance coordination among the Military Services on all matters related to medical entomology and pest management and to ensure deployed combat forces have the most effective disease vector control and pest management capabilities to prevent adverse effects on troops, weapons systems, supplies and equipment, and installations using environmentally sound techniques with maximal risk reduction. The program is currently in its 9th year, with annual funding of US\$5.1 million, with particular focus on (1) novel insecticide

chemistries and formulations, (2) personal protective systems and (3) pesticide application technology, primarily targeting mosquitoes, sand flies and filth flies.

Current projects include the development of permethrin Treated Military Uniforms, Mosquito Attraction Inhibitors, New Fast Acting Pyrethroids, a Velcro wrist band with natural fiber matrix, Reverse Band-Aid, Functional Micro-Dispensers. Other work includes outdoor barrier treatment to reduce sand flies and mosquitoes (Dr Ken Linthicum, USDA CMAVE; Dr Alon Warburg, Hebrew University), enhancing the efficacy of pyrethroid insecticides against mosquitoes using plant essential oils and individual terpenoids (Dr Joel Coates, Iowa State University), development of a New Indoor Residual Spraying Formulation for Mosquito Control (Dr Mike Willis, Clarke), new safe carbamates (Dr Jeff Bloomquist, University of Florida), attractive targeted sugar baits for sand fly control (Dr Günter Müller, Hebrew University; Dr Amir Gallili, Westham Industries; Dr Laor Orshan, Israeli MoH) and molecular pesticide development (Dr Jimmy Bechnel, USDACMAVE; Dr Catherine Hill, Purdue University).

Discussion

WHOPES does not have guidelines for risk assessments for long-term exposure to permethrin-treated clothing, although industry and AFPMB do. Interventions such as these are appropriate for certain target groups, but not for the general population. It was queried whether there are any WHOPES plans to evaluate insecticide treated clothing in terms of personal protection. A risk assessment of permethrin treated clothes should be available before these products can be tested by WHOPES.

Session 3: The way forward for 2013

Chairs: Michael Macdonald and Jo Lines

Summing up the outcomes of the Work Stream meetings

Larval Source Management – Steve Lindsay, Durham University, UK

The 4th meeting began with a discussion of the 2012 Work Plan ((1) LSM operational manual, (2) country case studies and (3) decision-making framework for LSM), followed by presentations from Silas Majambere (IHI) on how to make LSM work for IVM and Birkinesh Ameneshawa (WHO) on LSM in malaria elimination.

Main conclusions:

1. 26 countries are conducting Larval Source Management (LSM), therefore the priority is not whether LSM should be used, but the emphasis of the Work Stream should be on providing guidance on where and how best to implement and evaluate LSM.
2. LSM is playing a role in elimination in many countries (e.g. Morocco) and is likely to do so elsewhere, especially as malaria declines and if long-lasting insecticidal nets (LLINs) and indoor residual spraying (IRS) and are perceived by local communities as less

necessary, where residual outdoor transmission is maintained or hotspots remain. There is scope for LSM in Africa and elsewhere.

3. LSM should also play a role in integrated vector management (IVM), with opportunities for sectors outside health to contribute e.g. those involved in water management. LSM in USA evolved from malaria and other disease control into general mosquito abatement and as Africa develops this is likely to be a natural progression.

Next steps:

1. A list of specific products available for LSM will be drawn up with information on WHOPEP status.
2. As well as training program managers in LSM it is important to engage with those in the areas of urban agriculture, 'healthy homes', sanitary engineers and others outside the health arena:
 - Make contact with relevant contacts in water etc through WHO/IVM, SIMA, Habitat for Humanity, Danish architecture networks and through associations e.g. South African Civil Engineering Association.
3. Publish and disseminate the LSM Operational Manual as soon as possible.

Discussion

It was queried whether the LSM Operational Manual could be extended beyond Africa, reflecting initial comments from the peer review. It was confirmed that the manual at this stage will focus on Africa, with two further manuals for Asia and South America possibly to follow.

Durability of LLINs in the Field – Albert Kilian, TropHealth, Spain

Main conclusions:

Field data on LLIN durability presented during the meeting indicates that:

1. Both attrition and integrity data are crucial for estimating physical net survival.
2. Attrition is to a large part due to factors unrelated to product durability and this needs to be taken into account.
3. Differences between brands in the first two years of follow-up are generally small and due more to local than material factors.

The potential of BCC to improve net survival is being explored and the first results are expected by the end of 2013.

Recent and ongoing experimental and laboratory studies on LLIN durability indicate that:

1. A first break in the yarn integrity is the most critical step in net deterioration and understanding the mechanisms involved is crucial.
2. The vulnerability of a product to damage depends as least as much on the knitting pattern as on the physical properties of the material.
3. The location of holes is important and very small holes (<0.5cm diameter) are functionally ineffective.

Next steps:

In 2013, clear guidance from WHO is needed on analysing and combining data on attrition, integrity and insecticidal protection into an estimate of 'net survival'. An inventory of ongoing field and lab studies will be drawn up to aid future data dissemination.

Insecticide Resistance – Janet Hemingway, LSTM, UK

Main conclusions:

1. Cochrane Review:
 - The Review will be submitted to PLoS One or PLoS Medicine within weeks and circulated to VCWG members when accepted.
 - The main conclusions are that:
 - There is insufficient data to substantiate, either way, whether resistance is having an impact on disease transmission.
 - There is a need to close this gap as soon as possible.
2. Discriminating dosages:
 - Communication with WHOPES is needed to finalise the pirimiphos-methyl discriminating dose.
 - Determination of discriminating dosages for new insecticides should happen in parallel with their development.
 - Care should be taken when choosing which chemicals to use to run WHO tests for monitoring; it is not always possible to extrapolate from one chemical to another within the same class.
3. Implementation of GPIRM:
 - Examples from Bioko and Zambia were outlined and the Bioko plan for resistance management will be shared with all stakeholders soon.
4. Data sharing through ANVR and WHO should be encouraged.

Next steps:

1. Develop a generic resistance management strategy.
2. Sub-regional workshops for Resistance Management Strategy Development.
3. A joint statement from WHO, RBM and journal editors should be made regarding publication of data.

Entomology Monitoring and IVM – Jacob Williams, Research Triangle International (RTI), USA

Summary of meeting:

Presentations on the following were made:

1. WPRO regional training on IVM.
2. 2012 output of the USAID-funded IVM Project in Latin America and Africa.
3. Larviciding by Labiofam in Africa.
4. BMGF-funded project for developing a global, strategic framework for IVM.

A group discussion was then held to identify major bottlenecks limiting the efficiency of IVM programs.

Next steps:

1. Finalise the document entitled 'Towards more efficient vector control delivery: A review of major bottlenecks and opportunities for their resolution' by August 2013.
2. Develop a review document to guide countries in establishing a functional and effective national system for entomological surveillance. This will address concerns over human landing catches.

Continuous LLIN Distribution - Kojo Lokko, John Hopkins University Centre for Communication Programs (JHUCCP), Uganda

Main conclusions:

1. The 'fragile gains' data requires further analysis.
2. Countries are beginning to prioritize LLIN distribution in the context of constrained resources and guidance on this from both WHO and the Work Stream amongst other partners is needed.
3. Continuous Distribution proposals at the country level are not well developed and there is a need for increased support.
4. Domestic funding is needed for LLIN distribution.

Next steps:

1. Submit request to GMP for the development of guidelines for LLIN prioritisation.
2. Update the existing decision-making document to aid countries to prioritise.
3. Explore working with AMP to provide extended support to countries beyond the Work Stream guides and tools.
4. Capacity building with stakeholders providing technical and funding support to countries.
5. Complete the 'fragile gains' data analysis and packaging of advocacy messages for maximum impact.
6. Produce a guide for country programmes for exploring options for domestic funding.

Capacity Building for Indoor Residual Spraying – Manuel Lluberas, H. D. Hudson Manufacturing Company, USA

2013 objectives:

1. Advocacy at all levels that IRS is a key vector control intervention that should be used wherever applicable or advantageous.
2. Advocacy to manufacturers for the provision of better and longer lasting insecticides.
3. Advocacy at global, regional and national levels for human resources, tools and equipment and infrastructure.
4. Provide support for Africa Fighting Malaria.
5. Produce training modules specific to IRS operations.
6. Regional Training Centers for IRS.

7. Develop symposium on malaria in Africa for 2014 AMCA conference.
8. Develop IRS country reporting.

Optimising Evidence for Vector Control – John Gimnig, CDC, USA

The following areas of work were discussed:

1. Systematic reviews, identification of gaps and testing guidelines for new vector control paradigms (in collaboration with ESAC3 of IVCC). New paradigms include spatial and individual repellents.
2. LLIN-IRS interactions: evidence from Sudan, Bioko, The Gambia and Tanzania.
3. Developments in VC technologies (insecticide-treated plastic sheeting and durable linings).
4. How the Work Stream can work productively with VCAG and VCTEG.

Outdoor Malaria Transmission – Marc Coosemans, Institute Tropical Medicine Antwerp, Belgium

Next steps:

1. To explore the mechanism of a shift in species and behaviour of vectors (exophagic, early biting, exophilic, zoophilic) as a consequence of scaling-up vector control.
2. To collect further evidence on the epidemiological efficacy of topical, spatial repellents and protective clothing, and on personal versus community protection.
3. To develop standard designs to evaluate variation in time (biting time) and space (outdoor vs indoor) of malaria transmission.
4. To conduct a risk assessment of insecticide treated clothes.
5. To improve designs for the evaluation of the protective efficacy of repellents (topical and spatial, and both personal and community protection).
6. To conduct informative research to improve adherence to personal protective method.

The next meeting of the Work Stream is to be held on March 25-29th in Bangkok, Thailand.

Key Messages from the RBM VCWG to the WHO Technical Expert Group

As a final plenary session, there was a discussion of priority issues that the members of the VCWG would like to see addressed by the newly formed WHO Vector Control Technical Expert Group (VCTEG) that would help program managers set national policy and strategies.

Communications

- What mechanisms will there be to facilitate communications between the RBM VCWG and the WHO Technical Expert Group and the WHO Vector Control Advisory Group (VCAG)?

Long Lasting Insecticidal Nets

- How to interpret data from durability monitoring to give estimate of net median lifespan (or whatever other criteria that can be used in procurement decisions)?
- When not enough LLINs for universal coverage everywhere:
 - Should programs do geographical targeting? This would mean that some geographical areas would not be receiving free nets.
 - Should program focus on biologically vulnerable group targeting such as pregnant women and children under five years old? In some situations this would mean moving back from mass effect community vector control to personal protection.
 - What are the implications of geographic or vulnerable group targeting for delivery strategy policies?
 - What is the role of subsidies, cost recovery and social marketing?
 - Should we be selling nets that were procured with public funds?
 - What is the role of commercial markets? Can there be supply-side interventions? What is the role of local production?

Larval Source Management

- The LSM Operational Manual and decision-making framework is vitally important for the national programs, should it be reviewed by the TEG?
- Is there a role for LSM in elimination scenarios?
- Training and capacity building for planning, implementation, monitoring and evaluation?

Indoor Residual Spraying

- When and where do we “graduate” from blanket spraying to focal spraying?
- Insecticide Resistance Management: how do we balance the short-term costs and the long term consequences?
- Should the Insecticide Quantification Kit be more widely rolled out?
- IRS-LLIN interactions: the working hypothesis now seems to be that if one intervention is conducted well, adding another intervention may only bring a small incremental epidemiological benefit. Other issues for resistance management and transition to long-term control may be other considerations.

Additional points raised by country program managers

- Cross-border collaboration is necessary for malaria control and this is a major challenge in some areas (e.g. Iran, Pakistan, Afghanistan).
- Advocacy on the importance of vector control is essential.
- When should new insecticides be introduced in the context of insecticide resistance?
- Technical support for continuous distribution is required.

- Technical assistance is needed with new policies.
- Regional training for IRS should begin soon and training for other issues could be included.

Points raised by the wider VCWG:

- Elimination is not feasible at present in much of Africa; how can this be explained to national political leaders?
- Renewed commitment from presidents is important and another summit may be necessary.
- Industry needs guidelines for testing new tools e.g. new nets with no pyrethroid vs existing nets.

All VCWG were invited to join the AMP meeting on Thursday 31st January and Friday 1st February.

In closing the meeting, Michael Macdonald, Jo Lines and Konstantina Boutsika thanked all the funders: Roll Back Malaria (RBM); Swiss TPH, Swiss Agency for Development and Cooperation (SDC), International Federation of Red Cross (IFRC), Innovative Vector Control Consortium (IVCC) and USAID through the NetWorks project.