# Meeting report of the 19th Annual RBM VCWG Meeting

## Anticipating future challenges in malaria vector control

The annual meeting offers a platform for the malaria vector control community to share the latest best practices and research relevant to current and future malaria vector control operations. The activities of the dedicated Work Streams, which focus on their work plans, are complemented by plenary sessions and panel discussions. During the meeting, the Work Stream Co-Leaders and the Co-chairs of the Working Group ratify the main projects, and present the next steps and way forward. The work plan activities are funded by Partners, and coordinated by the Work Stream Co-Leads and the Co-chairs of the Working Group.

**Radisson Blu, Kigali, Rwanda**
**15-17 April 2024**

**Co-chairs:** Corine Ngufor & Justin McBeath & El Hadji Amadou Niang (newly elected Co-chair)
**Coordinator:** Konstantina Boutsika
**Technical & administrative support:** Sunghea Park
**Rapporteur:** Aqib Ali

# Monday 15th April 2024

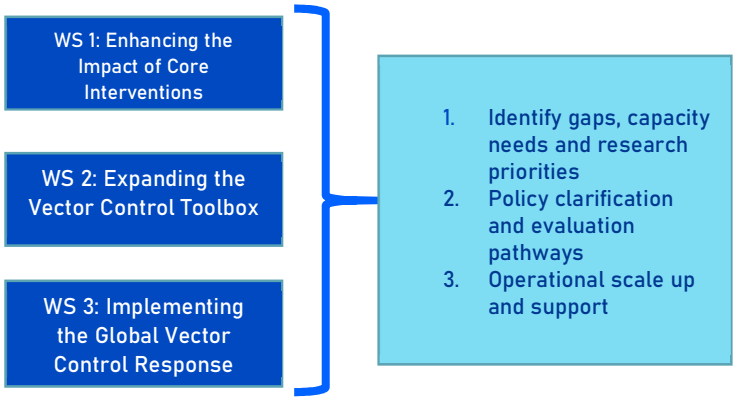
## Plenary: Introductions, objectives, and key updates

**Welcome, new elected Co-chair announced, introductions of participants (Justin McBeath & VCWG El Hadji Amadou Niang, VCWG)**

Justin McBeath (JM) welcomed the attendees to the 19th Annual RBM to End Malaria Vector Control Working Group (VCWG) meeting in Kigali, Rwanda. The second time in Africa, after the 18th Annual RBM VCWG meeting was held in Accra, Ghana in 2023 addressing the great turnout and consistent diversity of attendees. JM told it is his last session as Co-chair and expressed how it has been a pleasure occupying the role of Co-chair for the last 6 years. He announced that the title of Co-chair would be passed over to Dr El Hadji Amadou Niang (EHAN), the newly elected Co-chair. After highlighting the packed agenda and encouraging active contribution throughout the meeting by the audience, he proceeds to describe the purpose of RBM VCWG.

**Purpose:**

- To align RBM partners on best practices to reach and maintain universal coverage with effective vector control interventions.
- To support the implementation of Vector Control Guidance generated by WHO and to galvanise efforts towards achieving specific country and global malaria elimination targets.
- To convene, coordinate and facilitate communication between the diverse members of the Working Group including national programmes, product manufacturers, academia, implementers, policy makers, multi-laterals and Civil Society Organisations (CSO).




**VCWG structure**

**Work Stream 1:** Enhancing the impact of core interventions (ITNs and IRS). Leads: Allan Were and Mary Kante

| Task Team 1 | Task Team 2 | Task Team 3 | Task Team 4 |
|---|---|---|---|
| • Using data to inform optimal selection of core interventions.<br>• Leads: D. Levi Hinneh and Chrispin Williams, NMCP Liberia; Sarah Burnett, USAID; Ketty Ndhlovu, NMEP Zambia | • Addressing biological threats; new insecticides for vector control (for IRS and ITNs)<br>• Leads: Christen Fornadel, IVCC; Mulamuli Mpofu, Chemonics International | • Private sector involvement for sustainable vector control<br>• Leads: Samuel Asiedu, AGAMal Ghana; Jessica Rockwood, International Public Health Advisors; Andrew Saibu, IVCC, Ghana | • Addressing non-biological threats: ITN quality, access and use, durability/replacement<br>• Leads: El Hadji Amadou Niang, UCAD Senegal; Lucia Fernandez, CHAI |

**Work Stream 2:** Expanding the vector control toolbox. Leads: Eric Ochomo and Derric Nimmo

| Task Team 1 | Task Team 2 | Task Team 3 |
|---|---|---|
| • Larval Source Management<br>• Lead: Elijah Juma, PAMCA | • Innovations in vector control and vector surveillance<br>• Lead: Tullu Bukhari, ICIPE Kenya; Yang Hu, CHAI | • Anthropology and human centered design (interface between vector control and human behavior)<br>• Lead: Fatou Jaiteh, ITG, The Gambia |

**Work Stream 3:** Implementing the global vector control response. Leads: Chadwick Sikaala and Anne Wilson

| Task Team 1 | Task Team 2 | Task Team 3 | Task Team 4 |
|---|---|---|---|
| • Integrated Vector Management<br>• Leads: Jo Lines, LSHTM; Charles Mbogo, KEMRI Kenya | • Capacity and collaboration<br>• Lead: Givemore Munhenga, NICD South Africa | • *Anopheles stephensi* response<br>• Leads: Melissa Yoshimizu, USAID; Sarah Zohdy, CDC; Susanta Ghosh, Mangalore University India | • Vector Control in Humanitarian Emergencies<br>• Leads: Joe Lewinski ; Julius Kasozi, UNHCR Uganda |

**Overview of agenda and objectives for VCWG-19 (Corine Ngufor, VCWG)**

Corine Ngufor introduced herself as Co-chair of VCWG. She states how we have 221 participants in this year's meeting from 43 countries, 30 of which are malaria-affected countries (as of 8 April 2024). After directing the audience to the RBM website to access information about the previous year's meeting information (VCWG-18), she proceeds to give an overview of the structure of the meeting over the coming days. CN described the upcoming agenda, stated the housekeeping rules, and instructed on how to use the attendee app during the course of the meeting.

CN informed the attendees about the Malaria Open Online Course (MOOC) on "The Resistant Mosquito: Staying Ahead of the Game in the Fight against Malaria." A free course, spanning 6 weeks, from May 13th (MOOC Course).

She ended her introductory segment by introducing Professor Claude Mambo Muvunyi (Director General, Rwanda Biomedical Centre) and Dr Michael Charles (CEO, RBM Partnership to End Malaria)

**Opening Remarks (Prof. Claude Mambo Muvunyi - Director General, Rwanda Biomedical Centre & Dr Michael Charles - CEO, RBM Partnership to End Malaria)**

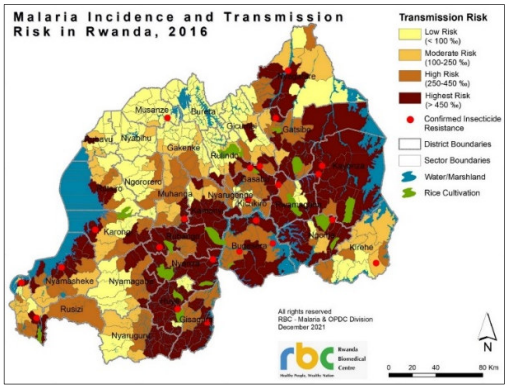
Prof. Claude Mambo Muvunyi began by stating that Rwanda is honoured to host the VCWG-19 meeting, emphasising its importance as a vital platform for vector control research and best practices. Over the next three days, the aim is to outline a path forward and addressing the burden of malaria vectors on both the economy and public health. Rwanda acknowledges the continued struggle and the necessity of embracing new technologies to tackle these challenges, emphasizing the importance of united efforts for effective malaria control. Thanks are extended to the WHO collaborators and stakeholders in the fight against VBD underscoring the need for collective contributions. Rwanda reaffirms its commitment to the fight against VBD and malaria, with the theme of the event focusing on hastening vector control through innovation towards VBD elimination. Collaboration among attendees is encouraged, and Rwanda pledges to continue its efforts towards VBD elimination and control, expressing gratitude to contributors, including those from the RBM Partnership to End Malaria.

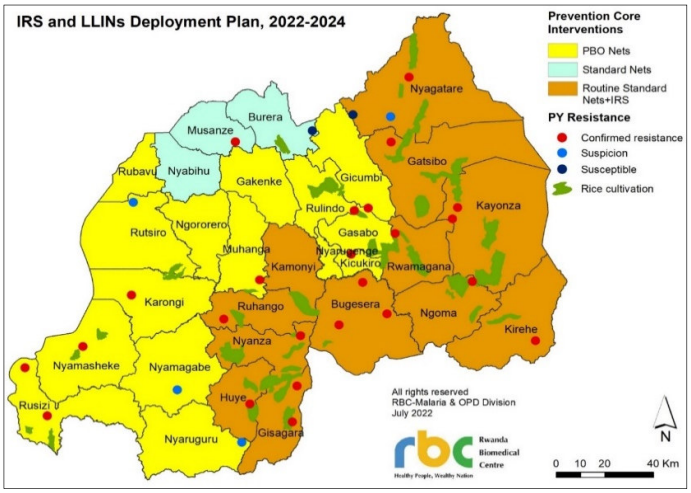
Corine then handed over to Dr Michael Charles for final opening remark. Dr Charles expressed gratitude to all attendees, the focus is on vector control, thanking everyone for their collective commitment towards control efforts. Addressing resistance and biological threats, there's a call for accelerated development and

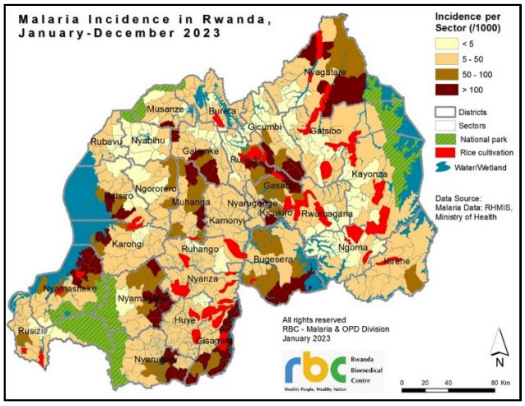
deployment of new tools. The discussion highlighted the critical issue of mosquito behavioural patterns and the need for collective approaches in developing new tools. The spread of *Anopheles stephensi* was acknowledged, with an emphasis on collective efforts to address it. Climate change impacts, including floods in Mozambique and Pakistan, were mentioned, alongside recognition of ongoing innovations. Deployment of IRS and bed nets was noted, with optimism surrounding innovations such as SR, gene drives, and sugar baits and their potential impact on malaria decline. Hosting the meeting in Kigali was celebrated, with anticipation for continued discussions. Gratitude was expressed for the ongoing work in reducing the malaria burden, with a call to maintain momentum.

**Progress towards malaria elimination in Rwanda (Emmanuel Hakizimana, Director Vector Control Unit, RBC/Malaria and Other Parasitic Diseases Control Division)**

Emmanuel Hakizimana began by sharing that in 2013 Rwanda changed its strategy pertaining to malaria from control to elimination. After malaria incidences increased from 36 per 1000 people in 2011 to 409 per 1000 people, a range of tailored strategies were implemented.




Vector control interventions were implemented in blocks based on various factors including incidence rates, resistance status, land use patterns, and the impact of Insecticide-Treated Nets (ITNs). The high impact of sustained Indoor Residual Spraying (IRS) in 12 districts is notable, particularly in controlling indoor biting vectors like *An. funestus* and *An. gambiae ss*. Between 2017 and 2023, the number of malaria cases decreased significantly from 3.4 million to only 160,000 cases.

The effectiveness of new vector control interventions, such as IRS and ITN's is evident. Blanket coverage IRS, significantly reduced malaria and indoor vectors. Utilising local data was crucial for decision-making, aiding in detecting residual malaria transmission foci. Multi-sectoral collaborations involving key ministries, the private sector, and Civil Society Organizations (CSOs) remains essential. Capacity building at all levels ensures sustainability and timely response. Community empowerment is vital, spanning Health Behaviour Models (HBM), Integrated Vector Management (IVM), and Community-Based Communication (CBCC) strategies.

Dr Emmanuel highlighted some challenges Rwanda continues to experience in the fight against malaria. IRS is effective but expensive and reliance on paper-based systems and Health Management Information

Systems (HMIS) leads to delayed responses. Adequate management of mosquito resistance and behavioural changes is imperative. Emerging threats, such as antimalarial resistance and invasive *Anopheles* species, necessitate proactive measures. Effective cross-border collaboration is crucial to combat these challenges.

**Moving towards malaria elimination:** Countrywide digitalization of malaria cases advances surveillance. Community-based interventions, with HBM coverage at 95% and IVM extending to villages, demonstrate grassroots engagement. Strengthening malaria management in transmission hotspots and exploring elimination strategies through research are priorities. Efforts to enhance local capacity and foster collaboration are underway. Integration of surveillance activities ensures comprehensive monitoring. This transition signifies a shift towards progressive malaria control strategies. Elimination strategies reflects a proactive stance towards achieving sustained reductions in malaria burden.

**Update from RBM Partnership to End Malaria (Daddi Wayessa - RBM Partnership to End Malaria)**

RBM is a global collaborative effort to combat malaria, bringing together diverse stakeholders to align efforts and maximise impact. It fosters effective partnerships at both global and national levels, facilitating coordinated action to scale up malaria control and elimination activities. By harnessing the collective strength of partners, it aims to achieve greater progress towards shared goals.

***Vision:*** A world free from the burden of malaria.

***Mission:*** To convene and coordinate an inclusive, multisectoral response to control, eliminate and ultimately eradicate malaria.

***Principle:*** Ending malaria is central to achieving UHC, global health security, poverty reduction and reducing inequalities.

**There are 3 key strategic objectives for 2021-2025:**

1. Optimise the quality and effectiveness of country and regional programming.
2. Maximize levels of financing.
3. Facilitate the deployment and scale up of new products, techniques, or implementation strategies.

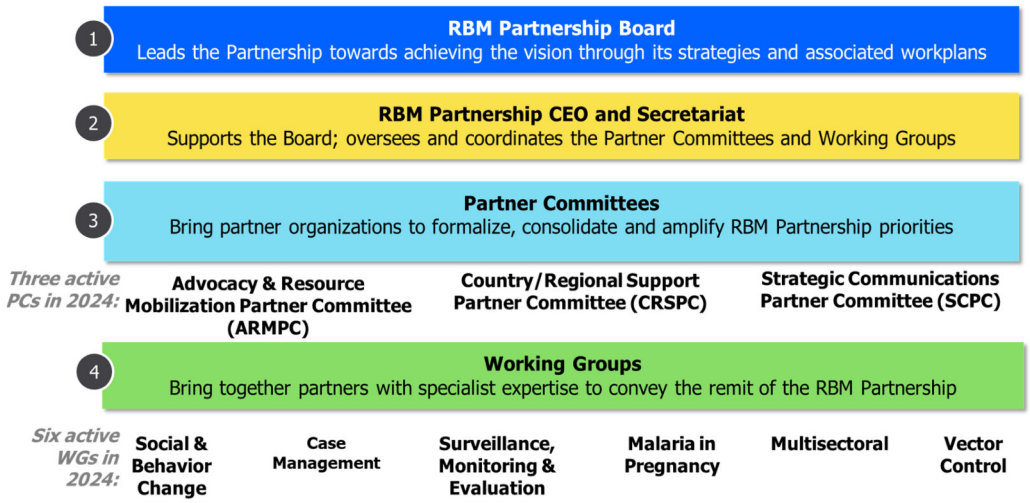
| | | | |
|---|---|---|---|
| **Vision** | **A world free from the burden of malaria** | | |
| **Mission** | To convene and coordinate an inclusive, multisectoral response to prevent, control and eliminate malaria | | |
| **Principle** | Ending malaria is central to achieving UHC, global health security, poverty reduction and reducing inequalities | | |
| **Strategic Objectives and Strategic Actions** | **SO1. Optimize the quality and effectiveness of country and regional programming**<br>1.1 Support countries in the design of quality, prioritized programmes<br>1.2 Support countries in the use of real-time sub-national data in planning, implementation and monitoring<br>1.3 Facilitate timely access to implementation support to address bottlenecks and gaps<br>1.4 Support building local management and technical capacity<br>1.5 Support countries to strengthen multi-stakeholder partnership coordination at the national and sub-national level<br>1.6 Leverage regional alliances and initiatives to ensure cross-border and cross-sectoral coordination and coherence | **SO2. Maximize levels of financing** | 2.1 Advocate for optimizing global resource envelopes from existing donors and new channels of financing<br>2.2 Support countries with mobilizing and prioritizing domestic and other resources for malaria and health |
| | | **SO3. Facilitate the deployment and scale-up of new products, techniques or implementation strategies** | 3.1 Promote and support the inclusion of new interventions in the design and delivery of programmes<br>3.2 Foster peer learning and knowledge exchange to facilitate deployment and scale-up of new products, techniques or implementation strategies |
| **Cross-cutting Strategic Enablers** | | | |
| **Data Sharing and Use** | **SE1:** Open and timely sharing of quality data to drive decision-making, build transparency and foster accountability. | | |
| **Effective Partnership** | **SE2:** Meaningful engagement of partners at the global, regional and national level to leverage their unique capabilities, expertise and perspectives. | | |
| **Targeted Advocacy and Communications** | **SE3:** Targeted advocacy and communications to keep malaria high on global health and development agendas to drive leadership, commitment, and change. | | |
| **Focused Secretariat** | **SE4:** Ensuring a Secretariat that energizes the partnership to deliver the strategy. | | |
| **Adapt to evolving COVID-19 environment** | | | |

The strategic plan was shown in more detail:

Governance documents play a crucial role in outlining the mission, vision, and objectives of the organization, providing guidance for its activities and decisions. Key documents include:

- **RBM Bye-Laws:** Approved in May 2023 following a governance review, introducing a new representative model. Efforts are ongoing to ensure full operationalisation.
- **Partner Committee Standard Operating Procedures (SOPs):** Approved in September 2023, consolidating 9 documents into 1 (covering Terms of Reference, Steering Groups, and Work streams).
- **Working Group SOPs:** Currently under development and set to be approved in May 2024.
- **Partner Committee and Working Group Terms of Reference (ToRs):** Working Group ToRs are currently under review, expected to be available in May 2024. Partner Committee ToRs were last updated in 2016, with refinements possible in May 2024.

The new governance model was shown:




**RBM Partnership Board**

The ultimate decision-making body of the Partnership, it holds a largely representative structure, accountable to the global community, providing oversight, support, and strategic direction to the Secretariat and Partnership mechanisms. Key features include:

- Constituted of up to 23 voting members, along with one non-voting member (Host).
- Constituencies select their representatives based on criteria outlined in the Bye-Laws, with the Board selecting the Unaffiliated members.
- Enhanced voice and representation from malaria-affected countries, with 9 regional constituencies.
- Ensures at least half of all voting members are from malaria-affected countries.

**Partner Committees & Working Groups (WG)**

The Partner Committees and Working Groups (WGs) play a vital role in formalizing, consolidating, and amplifying the core functions of the Partnership. Coordinated by the CEO, these bodies consist of RBM Partners who dedicate their staff and resources to addressing RBM issues. They convene partners with a shared interest, facilitating communication and coordination of activities. Collaboration among committees, overseen by the CEO/Management Team, ensures efficient resource allocation and resolution of concerns. Engagement with regional entities empowers regions and countries in malaria control efforts.

Partner Committees: RBM Partnership to End Malaria engages the global community through three Partner Committees: the Advocacy and Resource Mobilization Partnership Committee (ARMPC), the Country Regional Support Partnership Committee (CRSPC) and the Strategic Communication Partnership Committee (SCPC). Working Groups (Function, Opportunities & Aspirations): These platforms enable partners to exchange information and collaborate on specialised topics, primarily focused on implementing country

programmes. They self-convene, aligning with the needs of their target partner groups with minimal support from the RBM Secretariat. Coordination is managed by externally funded Working Group (WG) Coordinators. There are six Board-accredited WGs, each chaired by two Co-chairs and supported by an external WG Coordinator. Key priorities include enhancing communication with other governance structures (Board, CEO, Partner Committees) and improving coordination across WGs.

The Bye-Laws mandate funding for WG coordination, but transparency in RBM Secretariat funding is lacking. Adequate funding for country participation in annual WG meetings is essential, requiring a call for funds from the RBM Partnership. Strong engagement of in-country members and NMCPs is vital for maximising WG impact and aligning with country needs. Elevating the profile of WGs within RBM's governance is crucial, recognising their value to partners and the need for increased visibility within Partnership mechanisms. In line with strategic objective 1, RBM provides technical assistance to countries and regional entities in the following areas:

1) **Technical Strategies and Implementation Plans**: Coordinating support for the development and validation of country-led malaria control and elimination strategies, alongside sustained financial plans. This includes activities such as Malaria Programme Reviews, updating national malaria strategic plans, and developing regional strategies.
2) **Resolving Implementation Bottlenecks:** Identifying and addressing implementation bottlenecks through an early warning system and rapid response mechanisms. This support encompasses various initiatives, including COVID-19 mitigation, campaign planning and implementation, and responding to emergencies.
3) **Mobilizing Resources:** Providing technical assistance for financial gap analyses, funding proposal development, and engagement with donors. This includes activities such as securing Global Fund funding, exploring flexibility in existing funding sources, and innovating financing mechanisms like End Malaria Funds.

Additionally, the Data Initiative is a strategic component of the RBM 2021-2025 strategic framework aimed at addressing gaps in global data coordination. It seeks to overcome challenges such as limited opportunities for countries to highlight current issues to the global stakeholder ecosystem, insufficient visibility of near real-time data on bottlenecks within the malaria community, and the scattered nature of available information across various websites, which often requires advanced IT skills for access.

Daddi ended his segment by describing how we are facing a “perfect storm”, comprising the biggest threat to malaria control in 20 years:

- **Increased Costs:** Global inflation has led to a significant rise in the costs associated with delivering malaria control tools to end users. This, coupled with the severe impact on country economies, particularly in low-income African nations, has posed challenges to sustaining malaria control efforts.
- **Climate Change:** The effects of climate change, including cyclones, increased rainfall, and flooding, have contributed to the spread of malaria. Projections suggest that climate change could significantly increase the number of people at risk of malaria by the 2030s, exacerbating the existing burden of the disease.
- **Humanitarian Crises:** Humanitarian crises and the displacement of populations have further strained efforts to combat malaria. These crises disrupt healthcare systems and hinder the implementation of effective malaria control measures.
- **Access to New Tools:** While new tools and products for malaria control, such as nets, insecticides, medicines, and diagnostics, offer promise, they come with higher costs compared to traditional commodities. Efforts to shape the market and reduce prices have been made, but additional resources are needed to ensure widespread access and deployment of these new tools.
- **Funding Gaps:** Countries are confronted with substantial funding gaps, which jeopardize essential life-saving services. With a funding shortfall estimated to be at least US$1.5 billion by 2026, there is an

urgent need to secure additional resources to fully implement national strategic plans for malaria control.

**Updates on malaria vector surveillance and control (Seth Irish, WHO GMP)**

Seth Irish started by highlighting the aims of the Vector Control and Insecticide Resistance Unit:

- To support optimal resource use for malaria control by WHO member states and their implementing partners.
- To support generation and reporting of data related to malaria vectors and interventions.
- To develop or revise evidence-based WHO recommendations and programmatic guidance on vector surveillance and control, including for new tools.
- To support timely dissemination of vector surveillance and control guidance and contribute to its implementation through technical support and capacity building activities based on identified priorities.

The activities from the past year were reviewed. A survey conducted from 30th June 2023 to 15th October 2023 received 36 responses, highlighting several points for improvement:

- Plastic: Investigate the costs of alternative plastics.
- Glue: Replaced with acoustic transducer glue in 2019.
- Mesh screen: Increase durability and fineness to prevent sand-fly escape.
- Spring clips: Increase in number.

There was a continued call to action against *An. stephensi* in Africa, referencing the "Partners convening: A regional response to the invasion of *Anopheles stephensi* in Africa" meeting held in Addis Ababa, Ethiopia, in March 2024. The Malaria Threats map was reviewed, with new entries highlighted. Experiences and advice from countries like India and Sri Lanka are being sought to aid in the surveillance and control of *An. stephensi* in Africa.

Since the VCWG-18 meeting in February 2023, three Vector Control Advisory Group (VCAG) meetings have taken place: 18th (see report), 19th (see report) and 20th (report publication pending, see agenda). Topics covered included topical repellents, eave tubes, SIT, systemic endectocide treatments, bait stations, spatial repellents, and reducing pathogen transmission using *Wolbachia*.

A technical consultation assessed the comparative efficacy of vector control products. The non-inferiority of four products (three ITNs and one IRS) was evaluated, aiming to ensure uniform quality of interventions. The protocol is to be published in April 2024.

Preferred product characteristics of vector control products targeting outdoor malaria transmission were reviewed (see review). Guidelines for recommended net usage were updated on 16th October 2023 (see guidelines). The operational manual on indoor residual spraying was expanded to provide guidance on IRS for other VBDs, covering concepts of IRS, programme requirements, operational aspects, and monitoring evaluations (operational manual).

Regional offices provided support for vector control research. The Pan American Health Organisation (PAHO) developed guidance on operational LLIN monitoring. Morphological identification training was given in Oman (Eastern Mediterranean Region Organisation, EMRO). The WHO AFRO region supported countries on VCNAs (Vector Control Needs Assessment) and built capacity through the African Network for Vector Resistance to aid in monitoring insecticide resistance in malaria vectors. The funding of the AFRO II project was completed. Seth ended his segment by describing the plans for the upcoming year. To address insecticide resistance and other threats: A multi-centre study to define discriminating doses of broflanilide and isocycloseram will be taking place. Quarterly calls on *An. stephensi* update will be taking place. A

technical consultation to convene, discuss issues, share and learn from experiences in testing new compounds over the past few years to take place. Along with the VCAG meetings continuing and an expansion to the MINT (Malaria Intervention Tool). A series of updates to guidance and guidelines will be taking place, including:

- A comprehensive update of the LSM manual.
- Systematic reviews on SR and attractive targeted sugar baits (ATSBs).
- An update of the Update of Norms, standards and processes underpinning development of WHO recommendations on vector control.

**WHO vector control products prequalification updates and implementation roadmap for the new ITN guideline (Geraldine Foster, WHOPQT/VCP)**

Geraldine introduced the "WHO guidelines for the prequalification assessment of insecticide-treated nets" published in December 2023, outlining essential components for assessing ITNs and offering standardised guidance. Implementation advice supplements the document to aid in compiling comprehensive product dossiers.

She highlighted major changes in the revised guideline:

- Enhanced physical durability requirements
- Storage stability studies
- Regeneration studies
- Expanded bioassay methods
- Additional semi-field study

Updating the guidelines ensures data consistency and improved policy outcomes, providing a future-proof and flexible framework. The revised guidelines ensure product characteristics align with intended use and duration of effect rather than just meeting outdated 2013 standards.

The guidelines for PQ assessment now require additional studies and detailed information regarding ITNs' formulation, manufacturing, and physical and chemical characteristics, thus necessitating updated product dossiers. All submitted information, including previously reviewed studies, must remain pertinent to the current manufacturing process. Throughout reassessment, items will stay on the prequalified list. WHO PQT/VCP will collaborate with manufacturers to establish data submission timelines as needed. For further information, see the implementation plan.

In March 2024, the Working Group discussed continued activities and plans, including revising long-term community studies protocol, due in June 2024. The updated protocol will include considerations for adequately powered studies and detailed criteria for ITNs (physical criteria, efficacy, and community acceptability). Methods for data analysis and a schema for interpreting quantitative, qualitative, and statistical results will be included, to be finalised by August 2024 and published on the PQT/VCP website guideline page as implementation guidance.

Developing recommendations to WHO for additional post-market data requirements for ITNs, possibly through an annual reporting procedure, is due by December 2024. These recommendations may involve providing summaries of all batches produced, recipient countries, and the relevant procurement agency. The focus will be on aspects indicative of product performance and durability, ensuring a cohesive data package throughout the ITN's life cycle.

Guidance for conducting post-market monitoring and surveillance of ITN products for stakeholders is also planned for late 2024. A review of existing protocols for post-market monitoring of ITNs will identify commonly sought information about product compliance with specifications and performance, analysing this information against the updated pre-market data requirements. This is due to be finalised, communicated, and published in June 2025.

Geraldine concluded her presentation with general updates: WHO public assessment reports now have a new structure consisting of five parts: a Letter of Prequalification, Executive Summary, and assessments of Quality, Safety, and Efficacy. Additionally, WHO has initiated Collaborative Registration Procedures (CRP) to streamline product registration in certain countries. A pilot scheme, involving six countries and two products, has been launched with plans for expansion.

**Global Fund update on vector control financing (Kate Kolaczinski, The Global Fund)**

Challenges to malaria programmes were discussed.

Deploying the most effective tools:

- Cost:
  - Chlorfenapyr (CFP) Dual AI (Dual Active Ingredient) nets have demonstrated promising outcomes in trials, reducing cases by approximately 50% compared to pyrethroid-only nets.
  - IRS has a higher absolute cost than ITNs.
- Challenges with unclear solutions:
  - Residual transmission
  - Urban malaria
  - *An. stephensi*

Programmatic issues:

- ITN coverage - not maintained between campaign years.
- Field performance and durability - challenging to maintain effective coverage given ITN durability.
- Use - whilst most people who have a net use it, there is still sub-optimal use given access in some places.

External issues:

- Financing - Unprecedented fiscal pressure.
- Population growth - 41% increase in population in Global Fund supported countries since 2002.
- Insecurity - 24 countries classified as COE have 76% of malaria cases.
- Climate - climate change and extreme weather events drive major upsurges.

In 18 countries, gaps in ITN distribution and funding hinder effective malaria control. Despite fiscal challenges, efforts are underway to optimise ITN campaign operations.

Progress is being made in areas with pyrethroid resistance. Modelling tools like MINT, supported by partners such as GMP, CHAI and Swiss TPH, help strategise within available funds. Some models suggest using CFP nets for fewer people can avert more cases than using pyrethroid-only nets for more people. These tools also assist in targeting subnational areas for the highest impact, especially when funding is limited.

Although IRS still plays a role, its activities are being scaled back, with a shift towards more effective ITNs like CFP Dual AI nets, prioritised in areas where IRS is reduced.

Monitoring and evaluation for vector control vary in scope but are prioritised. Monitoring insecticide resistance remains crucial, informing insecticide selection and use. Entomological surveillance is also prioritised within grants.

Funding requests often include plans to expand surveillance and address the *An. stephensi* threat. A Swiss TPH review of current practices and gaps in *An. stephensi* surveillance and control in the Horn of Africa highlights updated national plans with varying capacities. Recommendations for action at national, regional, and global levels are being disseminated. Activities funded from 2024 to 2026 include entomological

surveillance, mosquito breeding site management, capacity building for *An. stephensi* control, and IVM in urban areas.

More detailed data collection is needed for robust sub-national vector control efforts, but limited financing and consensus-building on data collection methods pose challenges.

Evaluation initiatives aim to understand resistance to new actives, Dual AI net performance with other tools like IRS, ITN deployment decision-making, and modelling ITN coverage versus efficacy.

There is growing scepticism about ITN effectiveness, particularly among high-level government officials. Understanding ITN usage remains crucial. Overall coverage is suboptimal and has not improved since 2015, although net usage by owners remains high at over 85%. Access to nets is limited by inadequate funding and distribution.

Kate imparted key messages used by the GF about ITN's:

- ITNs are highly effective and very well used.
- Deploying more nets leads to higher net access → higher net use → greater impact on malaria.
- Per capita malaria funding increased until 2015, which led to progress in net coverage and malaria impact → however, with stalling per capita funding, access, use, and impact have also stalled.
- This does not imply that the tool is not working or has reached impact capacity → Available financing has limited the availability of nets, hindering the maximisation of impact.
- Interventions should be tailored sub-nationally, addressing low access or low use where necessary, or selecting tools that are more appropriate for the context.
- Nets are highly cost-effective → other tools may be more appropriate in some use cases.
- Significant amount of potential impact to be gained from nets in most high-burden areas → low-hanging fruit for impactful and cost-effective use of available malaria funding.

The segment concluded with two key topics:

1. Expanding the toolbox:

Collaboration with partners, including GAVI, is essential as the malaria vaccine is introduced. The vaccine complements existing vector control and other interventions. New vector control interventions show promise, and efforts will facilitate their adoption. Programmes are encouraged to explore modified approaches, such as higher throughput continuous distribution models for ITNs. An evidence base is urgently needed to inform decision-making among the growing array of options.

2. ITN quality and field performance:

In late April 2024, a new Quality Assurance Policy for Vector Control Products will be presented to our Board. Detailed operational guidance will follow ongoing discussions. We will maintain close communication with WHO PQ regarding future plans, especially post-market surveillance. Additionally, i2i/CHAI's "Raise the Floor" initiative is developing guidance on monitoring the performance of insecticide-treated nets (ITNs).

**PMI malaria vector control policy and strategy updates (Sarah Zohdy, PMI)**

The PMI strategic framework 2021-2026 has a continued vision of world free of malaria within our generation, with the goal to prevent malaria cases, reduce malaria deaths and illness, and eliminate malaria in PMI partner countries. The three main objectives are described below, along with the 5 key focuses:

- Vision: A world free of malaria within our generation.
- Goals: Prevent malaria cases, reduce malaria deaths and illness, and eliminate malaria in PMI partner countries.
- Objectives:

1) Reduce deaths by 33% from 2015 level.
2) Reduce illness by 40% from 2015 level.
3) Accelerate towards elimination in 10 countries and eliminate in ≥ 1 country.

USAID's priorities are localisation and climate. By FY 2025, USAID will direct over a quarter of programme funds to local partners, and by 2030, local communities will lead 50% of programming. To address climate, USAID will focus on locally led development, equity and inclusion, private sector engagement, nature-based solutions, and innovation.

PMI operates in 30 partner countries, including Togo, The Gambia, and Burundi (2023), using evidence-based deployment of vector control tools for universal coverage. These interventions are tailored based on sub-national stratification and operational research, ensuring they meet the specific needs of each region.

In 2023, PMI Evolve supported 20 countries, conducting entomological surveillance at 160 sites for vector bionomics, 280 for insecticide resistance, and 50 for community-based surveillance. They implemented IRS, ITN, and LSM activities, investing in training programmes that trained 33,700 people in vector control (40% of whom were women) and 469 people in entomology (28% women), thus emphasising capacity building and gender inclusion

PMI Vector Control priorities include localisation, question-driven surveillance, emerging resistance, and new tools:

- Localisation strategies involve moving towards country-led and sustainable vector control programmes, transitioning to local ownership, and empowering local actors and organisations for direct funding. The goal is to transfer all entomological monitoring activities to local entities.
- Entomological monitoring focuses on question-driven surveillance with tools like (ESPT), decentralised surveillance led by local institutions, and enhanced molecular capabilities for surveillance. Integrated Vector Management (IVM) strengthens systems through malaria vector surveillance, incorporating human-vector integration to aid decision-making processes.
- IRS updates include the implementation of IRS programmes in Madagascar, Ethiopia, Sierra Leone, and Ghana (2023-2024) using broflanilide-based products along with susceptibility testing. Entomological data from these countries, such as that from Ghana, guides control efforts, including IRS programmes targeting animal shelters to reduce malaria transmission.
- ITN updates: In FY 2023, PMI procured Dual AI nets (8,231,343, 18%), PBO nets (31,705,978, 68%), and single pyrethroid nets (6,928,723, 15%). Countries are encouraged to use continuous distribution methods for effective ITN coverage. Ongoing durability monitoring provides data on Dual AI and PBO nets. ITN procurement is supported by insecticide susceptibility and entomological surveillance data. PMI supports countries in using digital tools.
- *An. stephensi* updates: PMI funds LSM responses to enhance surveillance and control efforts. They facilitate the dissemination of reference specimens and molecular identification protocols. Research assistance is provided to Dire Dawa University to assess LSM effectiveness for *An. stephensi*. PMI also coordinates support with US government and global partners.
- Other vector control updates: LSM is used in elimination settings where *An. stephensi* is detected, particularly in rice fields with identifiable larval habitats. Topical repellents are used in elimination settings and among high-risk populations. Housing modifications, such as house screening and eave tubes, are being studied in Uganda. Recent operational research/programme evaluation (OR/PE) investments:
    - In Uganda, the impact of housing modifications combined with PBO ITNs on malaria burden has been assessed. Research in Ethiopia explores the effectiveness of PBO ITNs.
    - In Sierra Leone, the impact of co-deploying PBO ITNs and IRS has been evaluated.
    - Studies on LSM in high malaria areas of Madagascar have been conducted. Studies have investigated LSM effectiveness for *An. stephensi* in Ethiopia. Mozambique's IRS withdrawal

prompted further research. In Cameroon, ITN accelerometers are being explored for usage measurement.

- Research in Senegal focuses on the impacts of case management and vector control in Daaras (Quranic schools in West Africa).

Challenges: Limited funding and availability of vector control tools require difficult decisions in malaria control. Emerging resistance to clothianidin and chlorfenapyr jeopardises ITNs and IRS. New threats like *An. stephensi* spread and climate change complicate malaria control, necessitating innovative solutions.

Opportunities: Transitioning vector control decision-making to local partners and emphasising decentralised approaches like community-based entomological monitoring. Refining malaria transmission risk estimates involves better defining vector-human interactions. Ensuring strategic IVM deployment at the subnational level. Partner coordination is crucial for accountability, quality, and innovation in malaria control initiatives.

**Unitaid's vector control portfolio: an overview and update (Kenny Onasanya & Rachel Evans, Unitaid)**

Kenny introduced Unitaid, an organisation dedicated to saving lives by making new health products available and affordable for low- and middle-income countries. By identifying innovative treatments, tests, and tools, Unitaid addresses market barriers to quickly get these products to those in need.

Unitaid collaborates with partners, countries, and communities to unlock access to tools, services, and care that deliver the best health outcomes and address global health priorities.

Rachel outlines Unitaid's strategic objectives, which focus on products, access, and people:

1 Accelerate the introduction and adoption of key health products.
2 Create systematic conditions for sustainable, equitable access.
3 Foster inclusive and demand-driven partnerships for innovation.

Notable grants in Unitaid's malaria portfolio include:

- The New Nets Project: In partnership with the Global Fund, introduced 56 million new LLINs in areas of insecticide resistance.
- BOHEMIA (Broad One Health Endectocide-based Malaria Intervention in Africa): Aims to develop the vector control tool ivermectin (endectocides), with clinical trials concluding soon and ongoing safety monitoring.
- AEGIS (Advancing Evidence for the Global Implementation of Spatial Repellents) Evaluates spatial repellents as a new product class, supported by social science research.

Unitaid's Vision: Equitable access to health innovations to ensure healthy lives and promote well-being for all. Mission to expand the reach of the best health products for those who need them most. Unitaid aims to deliver on the mission and vision by designing and investing in innovative approaches to make quality health products available and affordable in LMICs.

The benefits and successes of engaging communities were discussed. Raising awareness and disseminating information ensure communities are informed and can demand the best health innovations. This strengthens community voices in committees, conferences, and technical meetings, enhancing the translation of scientific results into treatments and health literacy. This leads to more ambitious funding proposals and a positive feedback loop.

The discussion on Regional Equitable Manufacturing (REM) focused on Africa and Latin America, highlighting similarities and challenges in pharmaceutical manufacturing. Africa, with high disease burdens, imports over 79% of its pharmaceuticals, while Latin America imports ~ 50%. Efforts in Africa aim to boost local production of malaria treatments. Partnerships between MMV, Unitaid, and manufacturers like Swipha and Emzor are enhancing local capabilities, including initiating the first API facility in West Africa. Notably,

UCL received WHO prequalification for malaria drugs, marking significant progress in local pharmaceutical production.

Climate-related challenges were discussed: climate variability, such as changes in temperature and rainfall, significantly impacts the behaviour and survival of malaria-carrying Anopheles mosquitoes. Changes in climate enable mosquitoes to adapt to new environments and develop resistance, potentially putting 700 million more people at risk by 2050.

Increased flooding creates more breeding sites, while seasonal variations disrupt malaria prevention programmes. Extreme weather events like heatwaves and flooding increase malaria transmission by causing population displacement, malnutrition, and hindering access to prevention due to infrastructural damage. Drug and insecticide resistance challenges were also noted. Heat affects treatment stability and disrupts supply chains, making remote or climate-affected areas particularly vulnerable to malaria outbreaks.

Kenny concludes by referencing Unitaid's report From Milligrams to Megatons that assesses the climate impact of key health products and underscores the need for climate-smart strategies. Unitaid aims to reduce CO2 emissions by 50% by 2030, integrate carbon action in proposals, and prioritise decarbonisation in their value chain. Industry responses, coordinated through partnerships, focus on mitigating CO2 emissions, finding sustainable alternatives for high-emission materials like plastics, and addressing supply chain vulnerabilities to ensure resilience against extreme climate events.

**Q&A – Previous speakers**

***It was asked: Why are bed nets not being manufactured non-plastic? Additional comments were made on net usage and longevity.***

Kenny Onasanya answered: ITNs are currently an effective tool and we won't stop using them any time soon. There needs to be improved packaging of nets to reducing plastic usage, more recycling of end of life nets and being conscious of our carbon footprint.

Comment: Data is required from post-market on fabric durability. A standard measure of attrition needs to be fed back into procurement and ITN barcoding should be the standard.

Another comment followed: Strengthening and understanding technical parameters such as attrition is an efficient way to understand durability and bio efficacy of nets. Barcoding of nets is currently happening.

***It was asked: How is localisation practically done?***

**Sarah Zohdy answered:** A key component of PMI is to strengthen capacity, ensuring adequate resourcing and funds are available to go to local actors. This a stepwise process, however in some cases this transition has already occurred. This isn't a rapid quick shift necessarily but institutions should be best equipped to make this transition.

Corine addressed Joel Breman passing and hands over to Steve Harvey to remember the life of a great figure in malaria research. Steve highlighted illustrious career and his extensive contributions to the field.

## Monday 15th April- Work Steam 1 - Enhancing the Impact of Core Interventions

### Global Insecticide Resistance (IR) and Vector Control (VC) trends and their implications for new tools, with a focus on impact and resistance monitoring Team 2 Moderators: Christen Fornadel, IVCC and Mulamuli Mpofu, Chemonics International

**Sylvester Coleman: Global Insecticide Resistance (IR) and Vector Control (VC) trends and their implications for new tools, with a focus on impact and resistance monitoring (Sylvester Coleman, LSTM)**

There has been a significant increase in pyrethroid resistance, which has been rising consistently from 2014 to 2021, with more intense resistance levels noted in later years. Variable resistance to newer insecticides, like clothianidin, emphasises the need for ongoing surveillance and revision of strategies.

Insecticide resistance has been facilitated by various factors including agricultural practices, urbanisation, and environmental changes. Resistance mechanisms include mutations that reduce insecticide sensitivity, biochemical processes that increase detoxification in mosquitoes, and physiological changes like cuticular thickening that decrease insecticide penetration.

The financial and operational impacts of increasing IR significantly undermine the effectiveness of current VC interventions. For example, literature suggests a reduction in the efficacy of conventional strategies such as space spraying and the use of larvicides against *Aedes* mosquitoes. The effectiveness of standard pyrethroid ITNs and some IRS are also less effective in some settings according to IR profiles, contributing to a resurgence of malaria in regions like Uganda. Feedback from researchers in affected countries emphasises the need for capacity building, improved funding to cover the cost of more expensive new generation insecticides and VC tools, and community engagement to adapt traditional methods and develop predictive tools for managing IR.

A global landscape analysis for VC highlighted several challenges and opportunities. There are significant IR issues limiting chemical options for ITNs. There are also concerns surrounding the durability and retention of ITNs, with some lasting less than two years. Economic risks discourage first-in-class innovations, and there is a need for biodegradable packaging solutions in waste management. It was also noted that the shift to more expensive, non-pyrethroid insecticides is a contributing factor to a significant decrease in IRS coverage from 5.5% (2010) to 2.4% (2021). However, innovative implementation strategies like district or community-based IRS approaches along with private sector engagement offers possibilities to expand coverage and enhance effectiveness.

Innovative vector control strategies in humanitarian emergencies were discussed, including targeted IRS, larval control, ATSBs and treated textiles. These strategies aim to adapt vector control measures to be more effective and sustainable in varying conditions alongside tackling the issue of IR.

**PMI Evolve resistance monitoring overview with emphasis on clothianidin and chlorfenapyr (Joseph Chabi, Abt Associates)**

The PMI Evolve project plays a critical role in supporting NMPs, in combination with USAID, through the planning, implementation, and monitoring of VC initiatives. These efforts include entomological monitoring, IRS, ITN use and LSM. The initiative operates across 22 PMI partner countries in Africa, providing crucial data on vector bionomics and IR, informing effective control strategies.

Recent data on insecticide susceptibility were presented: chlorfenapyr (100 µg per bottle concentration), showed varying results across different regions and years. In Cameroon, reduced mortality was observed in 2021 at two sites but mosquitoes were susceptible in 2022, with new sites tested in 2023 still showing susceptibility. Similarly, in the DRC and Ghana, although reduced mortality was seen in 2021, mosquitoes were susceptible in subsequent years. Earlier results of reduced mortality may have been due to testing issues. It was also noted that, Côte d'Ivoire has consistently reported reduced mortality to chlorfenapyr, pointing to the need to better understand whether the reduced mortality is due to resistance or remaining challenges with assay.

In contrast, clothianidin (4 µg per bottle concentration), exhibited persistent resistance in several areas. Côte d'Ivoire and Cameroon consistently reported resistance at about 30% of their sites over multiple years, while Burkina Faso and Niger saw over 30% resistance in recent years. This suggests a growing problem of resistance that could undermine the effectiveness of this insecticide. Contrastingly, while most West African countries have reported some level of IR, East African countries largely remain susceptible. This geographical variation could influence future strategies in malaria control.

While chlorfenapyr and clothianidin are relatively new to public health applications, having been used primarily in agriculture since the 1990s, their adoption has not been challenge-free. The detection of growing resistance among mosquitoes towards clothianidin is potentially due to its widespread use in agriculture, while further investigation is needed into the reduced mortality seen towards chlorfenapyr as its use in agriculture in Africa is not documented. There is a need for ongoing surveillance and adaptation of malaria control strategies to ensure they remain effective in the face of evolving IR.

**Indications of differential efficacy of chlorfenapyr based ITNs between sites (Rosemary Lees, LSTM)**

Experimental hut trial (EHT) results suggest that chlorfenapyr-based ITNs, and dual-AI ITNs exhibited variable performance across different sites, highlighting the complex challenges in combating mosquito-borne diseases. In Burkina Faso, over 3 years, there were significant differences between two locations:

- Tengrela: mortality induced by chlorfenapyr-alpha-cypermethrin nets consistently <20%.
- Tiefora: where these nets demonstrate a more pronounced impact, with varying mortality rates annually.

This differential efficacy, supported by a meta-analysis, underscores the impact of local conditions and mosquito resistance levels. Potential factors which could be responsible for the differences could be: varying mosquito populations, specific mosquito-product interactions, and differences in methodology. There is also between-observation variability in EHTs (the gold standard for measuring entomological impact). Methodological inconsistencies suggest a need for more standardised testing protocols to reduce variability and ensure robustness of data, particularly for chlorfenapyr-based products.

Insecticide resistance could also be a contributor to these inconsistencies. Performance of dual AI ITNs may be undermined by resistance to one or more of the active ingredients in the nets and/or the interaction between insecticides.

This is exacerbated by interactions between pyrethroids and chlorfenapyr, which might affect the nets' performance, especially in areas with intense pyrethroid resistance potentially altering chlorfenapyr metabolism. Characteristics of the mosquito populations may be impacting the performance of CFP-alpha-cypermethrin ITNs even in areas of no resistance to CFP. High intensity pyrethroid resistance could be affecting metabolism of chlorfenapyr in the presence of a pyrethroid and/or altering behavioural responses to ITNs.

Chlorfenapyr-based nets may be more effective in some sites than others; however, the evidence is not yet strong enough to make decisions on this basis. It remains important to continue monitoring for IR, given the increasingly widespread deployment of chlorfenapyr-based interventions.

**Results from field evaluations of IRS and PBO nets – Ethiopia and Sierra Leone evaluations (Emily Hilton, PATH)**

The presentation detailed retrospective impact evaluations of malaria vector control interventions in Ethiopia and Sierra Leone, emphasizing the need for local evidence to guide the choice and deployment of VC products. The studies assessed the effectiveness of PBO ITNs alone versus combinations with IRS.

In Ethiopia, data collected from September-December, 2019-2022, compared PBO ITNs alone against standard pyrethroid ITNs combined with pirimiphos-methyl-based IRS. An open-label, stratified block-cluster randomised trial approach was used.

- *Epidemiological outcomes:* The overall reduction in all-ages confirmed malaria cases post-intervention was significant, with a 55.9% decrease using PBO ITNs alone, and a 53.6% decrease when combined with IRS. However, a notable year-to-year increase of 98.1% was observed in cases with PBO ITNs alone from the first to the second year post-intervention.

- *Entomological outcomes:* Indoor resting density experienced significant reductions with the IRS + ITN combination, dropping by 71.1% in the first year and the PBO ITN only arm dropping by 63.5%. Vector density per trap also decreased notably; the IRS+PBO net campaign saw a 51.6% reduction, while the PBO ITN only arm saw a 21.6% decrease.

In Sierra Leone, the study compared PBO ITNs alone to PBO ITNs combined with clothianidin-based IRS and the data collected from May-April, 2017-2023.

- Epidemiological Outcomes: Overall post-intervention changes compared to baseline revealed a 32.0% reduction in routinely reported all-ages confirmed malaria cases with PBO ITNs alone and a 28.4% reduction when combined with IRS in the first year. In the following two years post-ITN/post-IRS, cases decreased by 40.2% for PBO ITNs alone and 39.3% for the IRS + PBO ITNs combination. The second year showed a 38.5% reduction for PBO ITNs only and 35.3% for the combined intervention. The third year results were a 41.9% decrease for PBO ITNs alone and 43.4% for the combination.
- Entomological Outcomes: Post-intervention measurements showed no significant differences in indoor resting density reductions between the intervention arms, with an Incident Rate Ratio (IRR) of 0.95. This suggests that both interventions had a comparable effect on reducing the indoor mosquito population. There was a 10% greater reduction in the human biting rate in areas where IRS was combined with PBO ITNs compared to areas with only PBO ITNs (IRR: 0.90). This indicates that the combination of IRS and PBO ITNs is more effective at reducing mosquito-human contact, potentially leading to lower malaria transmission.

Key Findings: In Ethiopia, both PBO ITNs alone and in combination with IRS reduced malaria cases, but PBO ITNs' effectiveness decreased in the second year. In Sierra Leone, there was no significant difference in malaria reduction between the two methods. However, combining PBO ITNs with IRS may sustain effectiveness as ITN durability declines.

**Using routine data to estimate intervention impact**

Bias in malaria incidence estimates could come from:

- Changes in care-seeking behaviour.
- Differences in access to parasitological diagnosis.
- Incomplete registration of patients.

However, these biases would be expected to vary in association with the interventions being assessed. Moreover, routine data are considered an important source of longitudinal information, proving effective for evaluating the impact of new VC tools over time.

**The impact of next-generation dual-active ingredient ITN deployment on insecticide resistance in malaria vectors during a three-year cluster randomized controlled trial in Tanzania (Louisa Messenger, University of Nevada)**

In recent years, next-generation nets have begun to replace standard pyrethroid ITNs following WHO recommendations to use PBO-ITNs and CFP ITNs in areas with notable pyrethroid resistance. 58% of ITNs (112.6 million) delivered to sub-Saharan Africa in 2023 were PBO-ITNs. Pyrethroid only ITNs decreased to 22% (39.8 million) in 2023. Since 2018, 404 million PY-PBO ITNs were delivered to sub-Saharan Africa.

In Tanzania and Benin, cRCTs evaluated the effectiveness of various insecticidal nets against standard Interceptor nets. Tanzania's cRCT tested Interceptor G2, OlysetPlus, and Royal Guard nets, while Benin's involved Interceptor G2 and Royal Guard. Both trials used: PY CDC intensity bottle bioassays, PBO pre-exposure bioassays, and CDC bottle bioassays for CFP and PPF to assess insecticide resistance. Large mosquito numbers sampled: 47,258 in Tanzania and 19,292 in Benin.

Tanzania

Interceptor G2 nets showed no significant increase in PY resistance in *Anopheles funestus* over three years, with LD50 values for alpha-cypermethrin remaining stable from 0.42 in Year 1 to 0.99 in Year 3.

Olyset Plus exhibited a significant increase in PY resistance, with LD50 values rising dramatically from 33.26 in Year 1 to 70.22 in Year 3, indicating a sharp decline in effectiveness.

The control arm (standard Interceptor nets treated only with alpha-cypermethrin) also saw an increase in PY resistance, with LD50 values increasing from 9.52 in Year 1 to 59.16 in Year 3, though at a slower rate compared to nets with PBO.

Benin:

Interceptor G2 nets: A significant increase in PY resistance among *Anopheles gambiae s.l.*, predominantly *Anopheles coluzzii*.

No Olyset Plus data was collected from Benin, underscoring a gap in understanding across different geographic contexts, suggesting the necessity for comprehensive regional studies to fully assess the impact of these advanced net technologies.

The control arm in Benin saw significant increases in PY resistance over the three years, similar to Tanzania.

The market share of ITNs delivered to sub-Saharan Africa is now dominated by PBO ITNs, followed by dual-AI ITNs. A concerning escalation of PY resistance and parallel loss of PBO synergy was observed with *Anopheles funestus* s.l. exposed to PBO-ITNs in Tanzania. CFP ITNs displayed variable performance between sites perhaps reflecting differences in relative community-level ITN durability, IR mechanisms between major vector species, fitness costs or initial phenotypic resistance intensities.

## Q&A – Panel Discussion

Comment: To not use the word “resistance” for bioassay survival. We need to reserve that term until that trait is inherited. Until you demonstrate heritability it is not resistance.

***Question: Bottle bioassays may not be best for assessing susceptibility to CFP, due to different mode of action- having found differing results despite using mosquitos from the same population. Experimental huts have shown the contrary, displaying consistent high levels of mortality. How could we identify the best method?***

***Question: Controlling environmental conditions when bioassays are performed?***

Rosemary answered: Bottle bioassays historically were used and were designed when we had a more straightforward entomological end point. New insecticides, from different manufacturers and with different entomological end points, may mean that bottle bioassays may not be the best current methods. As new insecticides have come out, these existing methods have simply been adapted, and we do need to find appropriate methodologies to test these new insecticides- on a case by case basis. Additionally, test conditions should be tightly monitored, reporting this data alongside your results, and interpreting your findings within their context.

***Question: Is there a change in resistance mechanisms in An. funestus within the PBO arm that can explain the increase in tolerance?***

Louisa answered: We are looking into changes in resistance mechanisms. We have done whole genome sequencing and RNA sequencing to look at the molecular and metabolic resistance mechanisms. Pertaining to the PBO arm in the study, the data is not available yet to share.

***Question: Is the bottom line that if we do not achieve elimination we should not deploy PBO nets?***

Louisa answered: We have such limited ITNs at our disposal it would be foolish not to. However, they should be deployed with a level of pragmatism. Stating that the study in Tanzania and *Anopheles funestus* is a discussion point that in some places PBO net deployment may not be having the intended effect.

***Question: Would it be better to use untreated nets than pyrethroid only nets?***

Louisa answered: That's probably a durability question about whether or not you want to explore a barrier effect. Pyrethroid do still have a role to play, especially when they are intact and because their durability is greater than some of the PBO in the field. Data needs to be consolidated and a discussion needs to be had about how best these nets can be deployed.

***Question: How would you rank tunnel tests in the evaluation of resistance to CT and CFP. Should they be considered higher level than tube/bottle assays?***

Rosemary answered: There is a continuum of bioassays, from a bottle bioassay where you're simply observing knockdown, to tunnel tests which are a longer experiment and capture more of the behaviour effect of the insecticide, to EHTs which involve free flying mosquitos and are more reflective of a real-life setting. Each one provides more information about the insecticidal product. However, each one comes with their own resource needs, costs, and limitations. Similarly to bottle bioassays, tunnel tests have also shown variable data. To get robust results you need to run many tests, which is very resource intensive. However, it may be that with novel insecticides we may need to look at using tunnel tests more.

## Optimizing VC resources – Implications of Global IR and VC trends for national planning, global funding, prioritization, and domestic financing Team 4 Moderators: Sylvester Coleman-LSTM, El Hadji Amadou Niang-UCAD

**Experience in optimising VC resources**

**Ghana NMEP (Otubea Owusu Akrofi, NMEP Ghana)**

The National Malaria Elimination Programme's approach to strategically allocate limited resources for maximum impact through stratification is based on epidemiology, entomology and IR. The country uses 20 sentinel sites to gather strategic information that guides the implementation of VC interventions.

The key interventions include case management, preventive treatment for pregnant women and school children, seasonal malaria chemoprevention, mass drug administration, post-discharge malaria chemoprevention, the malaria vaccine, IRS, ITNs, and LSM. The presentation highlighted a decrease in malaria prevalence among children under five, from 27.5% in 2011 to 8.6% in 2022, with regional variations. Challenges such as limited core VC tools, insufficient funding, and ITN use (39.7%) were noted.

Lessons learnt and conclusions were highlighted:

- Stratified interventions: Emphasise the success of tailoring VC strategies to specific regional needs, ensuring the most effective resource use.
- Efficiency and impact: The importance of using the right tools in the right places, which enhances both the efficiency and impact of interventions.
- Advocacy for resources: Discussed the crucial role of advocacy in securing additional funding, which is necessary to bridge gaps and sustain efforts.
- Early planning: The value of early and thorough planning in implementing VC measures effectively and avoiding confusion was stated.

**Zambia NMEP (Ketty Ndhlovu, NMEP Zambia)**

The optimisation of VC strategies in Zambia to combat malaria were discussed, emphasising the integration of various control methods and strategic resource allocation to achieve the best outcomes. Global trends in

IR and VC were addressed and their relative implications for: product development, national planning, prioritisation, and funding.

Zambia's malaria control strategy for 2022-2026 was outlined. Zambia's NMEP combines ITNs, IRS, LSM, and entomological surveillance. This approach is stratified based on local epidemiological data, focusing on areas with the highest malaria burden, with emphasis on continuous distribution of ITNs through health programs and targeted IRS.

In terms of resource mobilization, the presentation discussed the coordination and collaboration with various stakeholders, including governmental bodies, international donors, and local NGOs. Technical assistance from the WHO and other malaria partners is crucial to implementing these strategies effectively.

Key takeaways: Robustness and alignment of the Malaria Elimination Strategic Plan with Zambia's national priorities and vector control strategy, driven by epidemiological and entomological data. The presentation concluded with acknowledgments to the Zambia Government, MoH, NMEC, international partners, and local NGOs for their support in the fight against malaria.

**Cameroon: harnessing domestic financing and community resilience strategies in sustaining Integrated Vector Management in Africa (Prisca Ngo Tappa, Littoral Regional Fund for Health Promotion Cameroon)**

The impact of climate change and extreme weather on the proliferation and spread of vector-borne diseases in Cameroon was noted, particularly the consequential increase in the range and abundance of *Anopheles* and *Aedes* mosquitoes. The challenges of prolonged transmission cycles, increased co-infections, and rising IR.

One of the major points discussed was the mobilisation of domestic financing to combat these diseases. The presentation emphasizes the importance of public-private partnerships, community participation, and leveraging funds from climate adaptation resources like the Climate Adaptation Fund (CAF).

National efforts, like the "Stop Malaria" campaign and the national malaria strategy programme reportedly received only 50% of the necessary funding (101 billion CAF francs still required). Focus was also placed on community participation along with the involvement of local firms and donors to support ITN and WASH programmes. These approaches stress the need for financial transparency, monitoring, and improved risk management in allocating resources.

Both opportunities and challenges in Cameroon's fight against VBDs were identified such as: the need for better entomological surveillance, healthcare system capacity, and a more efficient setup of IVM projects. The duplication of past efforts and the lack of information which can hinder the efficiency and effectiveness of these control efforts were criticised.

To conclude, there was a call for a robust, integrated approach involving various stakeholders to ensure sustainable financing and effective management of VC programmes in response to the escalating challenges posed by climate change and VBD's in Cameroon and similar settings.

## Discussion – Speaker Panel

***Question: When did you decide to do prioritisation?***

Otubea Owusu Akrofi answered: Ghana has a strategic plan which runs for 5 years, and in the middle there is a review to ensure the plans are on track. When the last one was done, the country (including the government) began to think about elimination. We ended up doing the stratification and prioritisation again, earlier than planned (originally the NMEP was going to do it at the end of the 5 year plan), after looking at our successes and the work that had been done. Region by region there's a reduction in malaria cases, especially malaria related deaths.

**Question: Main challenges with prioritisation/stratification. What was the outcome?**

Ketty Ndhlovu answered: Stratification requires cooperation. The country has been divided into 4 different levels (high transmission-low transmission), and interventions are applied and resources mobilised accordingly. The operational and strategic point is to lower the burden in high transmission areas and eliminate in the lower transmission areas. The strategic plan guides what the need is for each intervention and where the program should focus in each particular area. In areas where resources have been delayed there has been innovation. Last year, PMI had resources to implement, but note enough resources for insecticide. PMI used government insecticide to spray in PMI focused areas. Partnership with the private sector and increased funding from the government, shows the benefit of partnership and coordination.

***Question: You mentioned in passing how some the Ghanaians had a preference for certain ITNs and what the donors think of this?***

Otubea Owusu Akrofi answered: This conversation has been happening for years and was brought to the attention of donors. Evidence was gathered (pictures, videos and field evidence). Donor feedback was that according to procurement principles you cannot give total amount required to only one contractor. The discussions have happened and next steps will be decided between donors and the NMEP.

***Question: Regarding financing and implementation of LSM in Ghana- Partial or blanket? Who is funding this?***

Otubea Owusu Akrofi answered: LSM is a government and private sector partnership. The government has contracted a private sector organisation to do LSM and provides oversight to ensure the right larvicides are used and in accordance with guidelines. LSM is intended to be blanket but there are implementation challenges that occur sometimes.

***Question: Do you have concerns that the GAVI domestic cofinancing requirements for the malaria vaccine will chip away at domestic financing for other malaria interventions?***

Otubea Owusu Akrofi answered: For Ghana, the plans for the malaria vaccine does not sit with the malaria programme, it's with the Expanded Programme on Immunization (EPI) (a different pot of money), therefore there is no concern regarding it taking away funds from other interventions.

***Question: What is the strategy for governments to contribute more? What rationale can be given to encourage vector control impact?***

Ketty Ndhlovu answered: Strategic plan is very key. As a programme, we also have a malaria business plan. encouraging partners and government to buyg in to mobilise resources accordingly.

***Question: Any rotational plans for insecticide usage and protecting their use for future use?***

Otubea Owusu Akrofi answered: A plan exists to ensure that no insecticide, a particular brand or a particular active ingredient, is used more than 2 years at a time, especially for IRS.

## From Policy to Practice: approaches on engaging private sector in vector control Team 3 Moderators: Jessica Rockwood-IPHA, Sam Asiedu-AGAMal, Andrew Saibu-IVCC

**The role of the private sector in Uganda's vector control value chain analysis (Robert Mugerwa, Uganda NMCD)**

A Value chain analysis was conducted to analyse and understand the market chain and partnerships involved in the distribution of malaria commodities in Uganda. This included analysis of the incremental values at various levels of the supply chain, coordination between partners, description of the main actors in the market, understanding market dynamics, regulatory factors, and identifying marketing constraints. The involvement of international, regional, and local manufacturers, as well as public and private in-country importers and wholesalers and healthcare institutions were highlighted.

Gaps and regulatory issues were identified in the value chain analysis: Mosquito nets marketed as treated lack proper branding. Many untreated nets are sold due to consumer preferences. For IRS, the absence of a Public Health Pesticides Board and the challenges in implementing existing policies within the private sector were highlighted- ultimately leading to issues like limited surveillance, lack of price regulation for IRS activities, and challenges in licensing and monitoring fumigation companies arise.

It was concluded that a favourable public-private partnership and a robust engagement of the private sector in the malaria control strategy will support malaria elimination in Uganda. Recommendations included improving the policy environment for the private sector, streamlining the supply chain, increasing awareness and access to malaria prevention products, and building the technical capacity of private sector players.

## Panel discussion: New funding streams and local implementation capacity for IRS through Public-Private Partnership

***Question to All Panellists: Could you comment on what you see as the role of IRS as part of a malaria elimination strategy? Suggest practical ways of strengthening Public Private Partnership for malaria vector control?***

Otubea Owusu Akrofi answered: In Ghana's malaria elimination strategy, IRS is deployed in high transmission areas and has been shown to significantly reduce transmission, highlighting its importance as per the data from these areas. This elimination effort cannot succeed without IRS. A successful public-private partnership has been established with AGAMal and Kill Pest (a local pest control organisation), involving the government, private sector, and malaria programmes. The government provides funding to Kill Pest for IRS implementation. Everything is in place to make malaria control attractive to the private sector, whether through LSM, IRS, or ITNs.

Samuel Asare-Bediako answered: The impact of IRS cannot be understated. Private entities aim to improve the health of their workforce, fostering a sense of confidence in their well-being. There has been at least a 20% reduction in the incidence of malaria following the implementation of IRS.

Wycliff Odude answered: Currently, IRS is being carried out in schools. Pilgrim Africa is the second organisation implementing this under the PMI initiative, with funding from the Gates Foundation. In the first two years, there was an 87% reduction in malaria incidence, leading to increased demand, even in urban settings. ITN coverage is excellent, with over 95% coverage. The government is planning to expand IRS to meet this growing demand. The success of IRS highlights the benefit of public and private partnerships. Collaborations have been established with local telephone companies, local businesses, and international grant providers. These grants are pivotal for purchasing insecticides. Support from IVCC and a partnership with PMI have helped procure cheaper products, ensuring that the cost of IRS implementation remains low. This approach has proven to be most cost-effective under the private sector. Convincing private sector companies of the cost-effectiveness and benefits of IRS has been relatively straightforward. It is essential to present the business case to private sector companies, demonstrating that IRS is a very inexpensive yet highly effective intervention. Ensuring their support is crucial for continued success.

***Question to Otubea: You previously described the approach to receive monetary support from the government - how did you get the money to implement your strategies?***

The government established a parliamentary committee tasked with outlining their objectives. In discussions with them, we were able to highlight the burden of the disease. The committee members understand the disease well enough to recognise the necessary actions when symptoms appear. We presented the gravity of the disease through statistics (malaria deaths), emphasising that while we have the solution, we lack the necessary funds. They reconsidered the strategy used for LSM, recognising that a similar strategy could also be applied to IRS. This approach would support our public/private sector agenda, encouraging private sector involvement.

***Question to Sam: As a profit making private entity, what are the incentives which government would provide beyond money for IRS uptake?***

Firstly, a platform should be created for dialogue. This would allow the private sector to communicate its expectations to the government and vice versa regarding malaria control. Secondly, it is important for both parties to align their expectations in this regard.

Incentives are crucial. The government should offer tax breaks and other incentives to encourage private sector investment in malaria control. Recognising and rewarding private players for their contributions will motivate others to engage. Additionally, providing support to the private sector in acquiring insecticides will help attract more participants.

***Question to Wycliffe: You mentioned that IRS is expensive but partners are making it easier to acquire insecticides and implement training and access. How can malaria programmes more successfully increase uptake of IRS, with schools in particular?***

Public IRS was conducted for a while, but a one-year pause resulted in a rebound in malaria cases. Implementing IRS in schools with a good product covers two terms, proving to be sustainable. The cost savings from IRS are significant compared to previous expenditures, making it easier for the ministry to consider expansion. Currently, private schools have the most capacity for implementing IRS, offering opportunities and resources to expand the programme even further.

**Question to panel from audience**

***Question: Health insurance as a source of income for ITNs and IRS- still looking at this?***

Otubea Owusu Akrofi answered: Money for LSM is coming from the national health insurance pot

Comment: Is it better to be the only person in a sprayed house or in a village where everyone's houses are sprayed but not yours? The latter is better. With schools, if that school is in the country-side, but it's in a densely populated suburb its less likely to work. High coverage is required to be effective.

All 3 panel speakers were in agreement that private sector contribution is integral in the fight against malaria, and the fight will be very tough without this engagement.

## Improving the effectiveness of ITN campaigns: net design, frequency of distribution, and digitizing campaigns Team 1 Moderators: Ketty Ndhlovu-NMEP Zambia, Chrispin Williams-NMCP Liberia, D. Levi Hinneh-NMCP Liberia

**Meta-analysis on the entomological effects of differentially treated ITNs in a multi-site experimental hut study in sub-Saharan Africa (Janneke Snetselaar, IVCC)**

The findings from a meta-analysis of multi-site experimental hut studies investigating the efficacy of differentially treated ITNs for malaria prevention were presented. Conducted at several research facilities across Sub-Saharan Africa, these locations were selected to cover a range of geographies, vector species (*An. gambiae, An. coluzzii, An. arabiensis,* and *An. funestus*), hut designs (east and west style), and hosts (cows and humans).

The development of the "Hybrid ITNs" placed insecticide on specific parts of the net based on observed mosquito behaviours. Mosquitoes are primarily attracted to the roof of the net (attracted by CO2, body heat, and odours), with significantly less activity at the sides of the net. This behavioural information led to the application of insecticide on the roof section of the net (termed "roof-only" treatment), while considering different (potentially more durable materials) for the untreated sides to reduce overall insecticide use and exposure.

The treatment arms for the nets were: untreated, roof-only treated, sides-only treated, and fully treated. Their effectiveness in inducing mosquito mortality and blood feeding inhibition across different trial facilities was assessed. Fully treated nets have a mosquito mortality rate of 53.8% compared to 45.0% for roof-only treated nets. Similarly, blood feeding rates were lower for fully treated nets at 33.8% compared to 38.8% for roof-only treated nets.

It was concluded that while Hybrid ITNs could potentially reduce insecticide use and exposure, they do not offer equivalent protection compared to fully treated nets. The analysis across different vector species and geographic conditions emphasises the many factors influencing mosquito behaviour and ITN effectiveness. Increasing the surface area treated with insecticide enhances the ITN's protective efficacy.

**Fewer Bites for Your Buck: Changing the Frequency of ITN Mass Campaigns for Optimal Cost Effectiveness (Andrew Glover, Imperial College)**

The presentation highlighted considerations for shifting from the traditional three-year ITN distribution cycle to a two-year cycle to enhance cost-effectiveness, particularly in sub-Saharan Africa where the retention and effectiveness of nets significantly diminish before the end of a three-year period.

ITN effectiveness notably decreases as nets age, with many becoming less effective in some settings before reaching the two-year mark, especially in areas with high transmission and pyrethroid resistance. Shorter intervals between distribution campaigns were examined. The implications of using different types of ITNs, such as those treated with pyrethroid-PBO and pyrethroid-pyrrole, were discussed. These ITNs may offer greater efficacy but are more expensive.

In summary, the modelling results showed that switching to more effective ITN types is likely to be more beneficial than increasing campaign frequencies. More cases can be averted for the same cost from switching to fewer, but better nets. Prioritising 2-year pyrethroid-pyrrole campaigns in areas of higher transmission intensity, and deprioritising lower-transmission settings may be optimal under available budgets in some settings.

**Updates from the 2024 Campaign Digitalization Meeting (Giovanni Dusabe, AMP)**

The 2024 Campaign Digitalisation Meeting, led by the Alliance for Malaria Prevention, focused on enhancing health campaign operations through digital tools. The meeting had over 200 participants from various countries and organisations, including: PMI, UNICEF and WHO. The event aimed to exchange knowledge, identify digitalisation bottlenecks, understand operational issues, and introduce new product solutions.

The conference was structured around 3 themes:

1. The digitalisation of health campaigns.
2. The integration of campaign platforms into national health systems.
3. The demonstration of product solutions.

These sessions highlighted the benefits of digital approaches such as improved efficiency via automated data entry and real-time monitoring, which facilitates decision-making and performance tracking.

The BYOD (Bring Your Own Device) initiative was discussed, which reduces costs and logistical challenges by leveraging campaign personnel's own devices. The TraceNet system was also discussed, its functional approach for the traceability and visibility of ITNs highlighting the need for durable barcodes and effective tracking mechanisms.

Lastly, the meeting covered the importance of private sector partnerships in campaign digitalisation, indicating potential collaborations with telecom providers for enhanced connectivity and data services.

Key challenges: Delays due to late device procurement, technical limitations, and the digital gap affecting some community health workers. To conclude, the emphasis was placed on: Leadership commitment,

strong governance, capacity building, and comprehensive planning; to overcome these obstacles and successfully implement digitalisation in health campaigns.

**Q&A**

**Question:** Andrew Glover, how generalised do you think your findings are to other places?

Andrew Glover answered: We have done this analysis for 6 countries, Burkina Faso, Mali, Malawi, Mozambique, and Ghana. Similar trends were observe, where switching to fewer pyrethroid-pyrrole nets were better.

**Question:** The life of the barcode… the barcode has to stay up to lifespan of the ITN?

Giovanni Dusabe answered: Yes, so that it can be used for post market monitoring. It should be capable of enduring potential damages but can also remain until the end of the life of the net; this is currently in the pipeline.

**Comment:** Stating that barcodes are available and traceable since 2006.

Giovanni Dusabe added: PMI and GF are trying to put into place scannable codes for information about the life of the net, throughout the supply chain globally. This is not yet happening at such a scale currently.

## Addressing non-biological threats: ITN quality, access and use, durability/replacement
## Moderators: Mary Kante, ECC, Allan Were, MSH

### Deploying an LQAS-based method to collect ITN post-distribution data in resource-constrained elimination settings: the experience of Honduras and progress on implementation in other countries
### Lucia Fernandez, CHAI [Remote presentation]

Lucia Fernandez introduced a method developed by PAHO to help countries monitor bed net distribution. She explained that this method is essential because malaria transmission is decreasing and becoming more localised, primarily affecting indigenous populations. ITNs have become the primary form of VC, but there is limited knowledge on how populations are accepting and using the nets. Given that malaria is concentrated in a few areas, the number of nets distributed is small, and resources are scarce. Countries needed an affordable and easy-to-implement method to gather this information.

Method: A cross-sectional survey based on the lots, quality, and sampling techniques developed by industry in the 1920s to identify substandard product lots. By sampling 19 units from each lot, lots with substandard results, below determined thresholds, could be identified.

For monitoring ITNs: Countries aim to achieve 80% usage in distribution areas. By sampling 19 individuals from each locality and asking if they used an ITN the previous night, they can identify localities below the target threshold and take necessary corrective actions, such as improving communication and access to ITNs. Aggregating these samples provides a higher geographical level assessment, allowing countries to calculate quantitative indicators and track progress over time. Other indicators measured include: Attrition, coverage, physical integrity, washing and drying practices, bio efficacy and chemical content.

Countries must define their indicators of interest, set targets, and establish a decision rule to evaluate if a locality meets these targets. The method was implemented with a budget of $1,500 and showed promising results, prompting further implementation in places like Roatan Island and Panama. In Roatan, coverage and usage were poor, highlighting specific areas needing attention. Honduras piloted the method, and Guatemala has been using a version for years to monitor wellness after distribution.

Several resources are available for those interested in replicating this methodology: a technical guide by PAHO, Excel files for geographical division and data analysis, SOPs for different process parts, and data collection forms in paper. The audience is encouraged to visit www.fema.gov for more information.

**Raising the Floor Update Presentation (Tara Seethaler, CHAI)**

The "Raising the Floor" initiative aims to enhance the performance and quality of ITNs. Key goals: Stimulating innovation, ensuring product quality, maximising performance through lifecycle data, validating methods, and building trust and effective data communication. The initiative partners with various organisations and follows a vision to drive continuous innovation for higher quality and more effective ITNs.

One focus area is on developing a post-market data collection (PMDC) framework to improve ITN strategies, which will continue as a priority in 2024. Activities to date have involved establishing a Working Group, holding stakeholder meetings, conducting listening exercises, and developing a PMDC matrix of questions from the listening exercises. Future plans for 2024 include developing a consensus framework for PMDC, exploring cost-effectiveness, and increasing the use of durability data.

# Tuesday 16th April 2024

# Work Steam 2 - Expanding the Vector Control Toolbox

**Work Stream Updates (Derric Nimmo and Eric Ochomo)**

## Task Team 2: Innovations in vector control and vector surveillance Spatial repellents: research updates and general discussion Facilitators: Tullu Bukhari-ICIPE, Anna Trett-CHAI

**Spatial repellents: roadmap to global recommendation of spatial repellents for public health use (Nicole Achee, University of Notre Dame)**

Active ingredients include synthetic pyrethroids such as transfluthrin and metofluthrin, assessed for safety and efficacy primarily by the U.S. Environmental Protection Agency. There is also an emphasis on discovering novel active ingredients with similar properties that might offer public health benefits.

The VCAG has identified five main research priorities to support the wide-scale rollout of SRs: demonstrating protection as either a standalone or integrated tool, determining the required product coverage for impact, assessing the potential for diversion, understanding how efficacy varies with setting and vector behaviours, and investigating whether pyrethroid repellents in SR products are affected by pyrethroid-resistant vector populations.

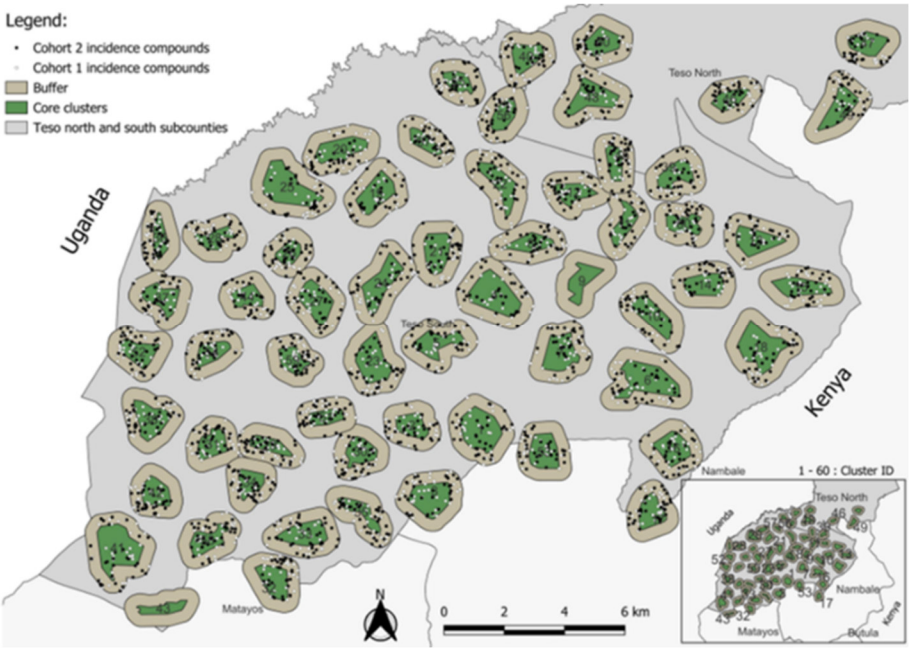
Clinical trials have been pivotal in generating epidemiological evidence. For instance, a study in China showed that transfluthrin coils reduced Anopheles density and malaria infection rates. In Indonesia, metofluthrin coils provided significant protection against malaria. Trials funded by the Bill and Melinda Gates Foundation and conducted by the University of Notre Dame have shown promising results, particularly in Peru, where a transfluthrin-based passive emanator proved effective against dengue. Recent years have seen an increase in evidence generation, with numerous studies and expert reviews being published.

The Aegis program, led by the University of Notre Dame and funded by Unitaid and SCJ, aims to fill data gaps and advance towards a global public health policy recommendation. Ongoing trials in Kenya, Mali, Sri Lanka, and Uganda are expected to provide additional evidence. The SCJ Mosquito Shield, a transfluthrin-based product, is being tested for its longer duration of effect. Preliminary results from Kenya indicate that the trial meets VCAG requirements, and further detailed results will be presented by Eric.

SRs are particularly useful in occupations where impact is highest and where human behaviour may limit the effectiveness of other interventions. They are also valuable in humanitarian situations where traditional vector control measures are challenging to implement.

Considering the variability in transmission dynamics globally, there is a need to develop optimal formulations of SRs. Establishing standardised protocols for product comparisons and revisiting WHO guidelines for SR efficacy testing are essential steps. Operational guidelines for deploying SRs effectively must be established, drawing on existing guidance documents for IRS. The goal is to provide decision-makers with the necessary tools to deploy SR products in the most cost-effective and impactful manner.

**Spatial repellents contribute to the reduction in malaria incidence in an area of western Kenya characterized by high malaria transmission, insecticide resistance and universal coverage of LLINs (Eric Ochomo, KEMRI)**




The study was conducted in Matayos, in Busia County, known for its high malaria prevalence primarily due to *Anopheles gambiae* and *Anopheles funestus*. CRCTs involving 60 clusters, structured in “fried egg”- a core intervention area surrounded by a buffer zone to assess both the direct and indirect effects of spatial repellents (diversion effect: mosquitos moving away from the treated area) 3 cohorts, a baseline cohort (monitored for 4 months), and two subsequent intervention cohorts ( monitored for 12 months). In total, the study included 6,120 children aged 6 months to >10 years. The intervention period spanned 2 years.

Bi-weekly screenings for *Plasmodium* using RDTs and microscopy analyses of monthly blood draws were conducted to measure malaria incidence, allowing for detailed tracking of the intervention’s impact temporally. During the baseline analysis, two clusters with very low malaria incidence were dropped, resulting in 58 clusters between the intervention and control arms. The study was double-blinded, with neither participants nor researchers knowing which clusters received the SRs or the placebo, with treatments assigned by blinded codes. Entomological assessments were integral to the study and conducted in 20 selected clusters. These assessments involved light trap collections, namely to assess the effect of the SR on mosquito density. HLCs were conducted quarterly in 12 clusters, equally split between intervention and placebo arms (blinded).

Social science research to assess community perceptions and behaviours related to mosquito control products. This component involved surveys, key informant interviews, and Trials of Improved Practices (TIPs). Community Health Volunteers (CHVs) played a crucial role in the deployment and monthly replacement of the repellents, ensuring consistent efficacy. ~70,000 household structures were measured to determine the number of repellent units required per household based on their size. Nighttime observations combined with HLC provided insights into where people and mosquitoes were most active during the night. The social science research aimed to identify facilitators and barriers to the adoption and

sustained use of SRs, offering a full view of the community's acceptance and practical challenges encountered.

Results showed a significant protective efficacy of 33.4% against first-time malaria infections (P=0.0029), confirming the effectiveness of the repellents. Additionally, an unexpected protective effect was observed in the buffer zones, with a significant reduction in malaria incidence, suggesting that the repellents not only protected the individuals directly treated but also reduced malaria incidence in nearby areas not directly treated.

This study highlights the potential of SRs as a significant tool in combating malaria, particularly in regions where traditional control methods are less effective. The detailed planning and execution across epidemiological, entomological, and social science domains provided a comprehensive approach necessary to advance public health initiatives in malaria-endemic regions.

Summary:

1. Cluster characteristics : Covariates were balanced between the SR and placebo arms at the individual, household, and/or cluster levels in both the core and buffer zones for all analyses.
2. Protective Efficacy: Study data support the demonstration of conclusive and statistically significant SR protective effect against first-time malaria infection (PE=33.4%, P=0.0029) and overall new infections (secondary endpoint) through the interim timepoint and at the end of the intervention phase.
3. Age Effect: The protective effect of SR against malaria infection was about the same for both older (59 months to 10 years old) and younger (13 months to 59 months old) age groups; however, the results suggest the numerical PE was higher in the older group.
4. Diversion: The hazard rate of malaria in the buffer zone of the SR clusters was significantly smaller compared to that of the placebo clusters, indicating a community-level benefit beyond the area of SR use.
5. Entomology: None of the results from comparative analyses between SR and placebo treatments with pre-planned entomological endpoints (density, parity, blood-fed rate, sporozoite infectivity rate, HLR, and EIR) suggest statistically significant effects of SR.
6. Safety: There were no unexpected, implausible, or extreme AE/SAE reported during the trial; patterns were consistent with disease frequency expected in study communities. The DSMB has specified no significant safety concerns of SR intervention.

Implications: As of March 26, 2024, the VCAG confirmed that this study demonstrates the public health value of SR and satisfies one of the two studies required for WHO recommendation. A second trial in Mali was completed on March 2nd. Kenya is already moving towards adopting SR, with drafted policy and strategy currently under review, distribution in Busia as part of the exit strategy, and planned distribution in areas experiencing flooding where IRS is not feasible. Deployment strategies are currently under discussion.

**Exposure patterns of humans to malaria vectors in western Kenya and implications for malaria control (Julius Odero, KEMRI)**

This study focused on the implications of early morning mosquito biting on malaria control and transmission in Busia County, specifically in Teso South and Teso North regions. 12 villages were randomly selected from a total of 58 project villages, and data were collected from 4 compounds in each village. Data on mosquito biting behaviour were collected through HLC conducted both indoors and outdoors. Human location and activity data were gathered through direct observation of residents, integrating the two to assess when and where humans were bitten. The results showed significant indoor biting rates for *Anopheles funestus* (71%) and *Anopheles gambiae* (59%). The study observed the behaviour of 328 people.

For unprotected individuals, 98% of bites occurred indoors for both *An. gambiae* and *An. funestus*. The PE of ITNs was 92%, reducing bites by 79% for *An. gambiae* and 82% for A*n. funestus*. Most exposure to

mosquito bites occurred indoors. Most bites occurred when people were asleep, peaking in the early morning during routine morning activities. There was an increase in mosquito biting as people started waking up.

The study also examined the population away from home by hour and gender. During the early evening, a higher percentage of the population was away from home, with numbers decreasing throughout the night. In the early morning, the number of people away from home increased again. Combining human and mosquito data made it possible to identify times and locations where people need more protection, especially in western Kenya, despite good coverage with vector control interventions. The study suggests the use of SRs for ITN users, as most mosquito bites occur when people have just woken up and are not protected by ITNs. High percentages of the population being away from home in the early evening and morning highlight the need for additional research on gaps in protection and exposure during these times.

**Trials of Improved Practices to assess communities' initial reaction to a Spatial Repellent product in Busia Country, western Kenya (Moureen Ekisa, KEMRI)**

The presentation examines a social science study showing that epidemiological and entomological efficacy alone are insufficient for new product adoption. Products must also be seen as safe, effective, beneficial, and compatible with daily life. The study assessed the perceived efficacy, user preferences, and social acceptability of SRs over two years.

The study employed modified Trials of Improved Practices (TIPs) in 12 HLC clusters in Teso South, Busia County, involving 30 households split evenly between intervention and control groups. The study team remained blinded, and an independent statistician determined the clusters. Semi-structured in-depth interviews were conducted over two years to gather input on the SR product's acceptability, focusing on installation, usage, and replacement. Each participant was interviewed five times: one week after installation and then at 2, 6, 12, and 18 months. Observations were made on the state of installation, physical condition, and location of missing products, with data collected on tablets.

Participants reported several problems with the installation of the SR products. Tape used for installation left marks on walls, and products frequently fell. In kitchens, products were often covered with soot and smoke, potentially affecting efficacy. Some products also came off their hooks. Participants typically used hooks to hang various items, which could interfere with the SR's efficacy.

Overall, participants provided positive feedback about SR products. They appreciated the protection against mosquitoes without daily setup, unlike mosquito nets, and noticed a reduction in mosquito density and activity. Some even stopped using nets. However, some noted decreased efficacy with subsequent replacements and desired longer-lasting products, suggesting 3, 6, or 12 months instead of 28 days. They preferred fewer products on walls and biodegradable options due to environmental concerns. Physical attributes like size, shape, or colour were unimportant as long as the products were effective. Suggested distribution channels included community health volunteers, village elders, or nearby points, extending to bathrooms, schools, and hospitals.

The study highlighted significant demand for longer-lasting and eco-friendly products. Feedback was mostly positive, with notable requests for longer-lasting products. These insights can help manufacturers tailor products to better meet users' preferences. The study underscores the importance of considering end-users' needs and preferences in expanding the vector control toolbox. Further analysis will follow after unblinding the study results. Manufacturers can enhance product acceptability by incorporating these insights into design and distribution strategies.

**Non-inferiority of SC Johnson Guardian™ a 1-year duration spatial repellent (SR) product to Mosquito Shield™, the first-in-class SR (Kyeba Swai, IHI/Swiss TPH)**

A comparative study between two pyrethroid-based spatial repellents, Guardian™ and Mosquito Shield™. Both products are from SC Johnson, highlighting the study's aim to assess whether Guardian™, which lasts for 12 months, is non-inferior to the established Mosquito Shield™, which lasts for one month.

The study was conducted from 2022 to 2023 at the Ifakara Health Institute's experimental site. The experimental design included Guardian™ tested in eight arms, each with its own set of huts, and Mosquito Shield™ tested in four arms, due to limitations in the number of available huts. Male volunteers were used for collecting mosquitoes within these huts from 6 PM to 6 AM, sleeping under standardized WHO bed nets. The primary endpoint assessed was the number of blood-fed *Anopheles arabiensis* mosquitoes, with secondary endpoints including the proportion of blood-fed and the mortality rates after 24 hours.

The results demonstrated Guardian™'s effectiveness over its 12-month use, significantly reducing mosquito blood-feeding, aligning with the targets set by a 2020 publication from LSHTM, IVCC, and Arctech Innovation. The non-inferiority analysis, with a margin of 7% set by WHO, indicated that Guardian™ was non-inferior to Mosquito Shield™ in reducing the proportion of blood-fed mosquitoes. Although mortality results were indeterminate due to wide confidence intervals, Guardian™ exhibited a trend towards higher effectiveness.

It was concluded that Guardian™ is non-inferior to Mosquito Shield™ in reducing the number of blood-fed and the proportion of blood-fed mosquitoes. The study proposes using this phase 2 experimental hut setup as a standard method for future non-inferiority tests for SRs, advancing the development of public health tools in mosquito control.

## Q&A

***Question: What was the malaria incidence and prevalence in the two study arms?***

Eric Ochomo answered: At baseline, the study area had a prevalence of 39% and an incidence of 3.1 across the study sites. We have not yet shared the detailed end-of-trial data, including specific control and intervention site estimates, as they are currently unavailable for sharing.

***Question: Limitation of collecting mosquito behaviour data through human landing catches and observations. Why is the timeline an issue, given that human landing catches occur in the home? Why haven't we made HLCs easier and less intrusive to households. Could you elaborate on your thoughts regarding the collection of human and mosquito behaviour data?***

Julius Odero answered: We faced limitations in collecting mosquito behaviour data due to several issues. Initially, we planned to collect this data through human landing catches (HLC) from the first day, but this was not possible because the study was conducted during the COVID-19 pandemic. Due to restrictions and the fear of spreading COVID-19, we had to recruit household members to collect human behaviour data instead of the study team. In the future, it will be important to develop methods to collect this data in the shortest time possible to accurately compare exposure to mosquito bites.

Eric Ochomo answered: After the lifting of COVID restrictions, we've now adopted a method where the HLC collector also handles the observation questions. Moving forward, this should result in much higher quality data regarding the timing of the collections.

**Question: Eric, did you consider that seasonality lead to the crash in the surrounding mosquito populations?**

Eric answered: We collected weather data over the two-year period, including a particularly dry year. Despite this, the seasonality was accounted for as the rains arrived consistently each year. Therefore, we don't believe this is a seasonality effect.

**Question: Could resistance be an issue for SRs? For SRs is it the repellence effect or the killing effect?**

Eric Ochomo answered: Regarding your first question about developing resistance, it's a concern we have. We don't fully understand mosquito behaviour in response to spatial repellents. For instance, we observed a reduction in malaria incidence in neighbouring villages, which doesn't entirely make sense and suggests there may be sublethal effects influencing malaria transmission. Whether these could lead to resistance in the future is still unknown.

It was commented: To add more on spatial repellents, the active ingredient used in both Eric's and my studies targets the olfactory neurons of mosquitoes. This means it doesn't directly come into contact with mosquitoes in a way that would cause them to develop resistance. Additionally, studies have shown that this ingredient can disarm mosquitoes for up to 12 hours, preventing them from blood feeding during that time. Therefore, the likelihood of mosquitoes developing resistance is low due to the way the repellent works.

## Expert Panel - Shifting the conventional paradigm on evaluating interventions

1) ***Spatial emanators have the potential to be a major new tool to combat malaria transmission. What are the main criteria you consider crucial for these tools to have the most impact?***

Ingrid Chen answered: Spatial emanators have significant potential to combat malaria transmission, especially if we address some crucial criteria for their effectiveness. Key use case scenarios include outdoor settings in sub-Saharan Africa where people spend time on verandas or in outdoor kitchens, forested areas in Southeast Asia and Latin America, where people work, and refugee and migrant camps where shelter is inadequate. Currently, there's more evidence supporting indoor use. The challenge is to study and enhance outdoor efficacy, considering factors like wind, temperature, and humidity, which can affect performance unpredictably. Focusing on biting inhibition and gathering more outdoor data can inform product development to make spatial emanators more portable, easy to handle and weather-resistant enhancing their impact.

2) ***New active ingredients are required to combat resistance development. Can you highlight the recent successes and the main challenges in finding new active ingredients with the same properties as transfluthrin?***

Ingrid Chen answered: When looking for new ingredients for drugs, you can usually screen compounds using biological assays, often cell-based, allowing you to look at hundreds of compounds at a time. However, with spatial repellents and compounds for mosquitoes, we don't have this capability. Biologically, we don't understand mosquitoes well enough, and different compounds have different modes of action. This requires using live mosquitoes to test each active compound, which is a significant amount of work. Another challenge is safety. There's no other product that volatilizes chemicals to protect public health through continuous emanation, so these ingredients must be very safe. Despite these challenges, we have made progress. Over the past two decades, significant work has been done on mosquitoes to find new active ingredients. For example, the IVCC have screened extensive  compounds for bed nets, finding some that were too volatile but still promising. These range from natural products like essential oils to brand-new synthetic compounds. Methods in entomology have evolved significantly over the past two decades. I want to emphasize that transfluthrin is highly effective, even at low quantities. Transfluthrin's safety profile is also remarkable, being extremely safe for mammals. This is a fortunate combination, and most other compounds will likely require larger amounts to achieve efficacy as a spatial emanator. However, this is acceptable as long as the compounds work well and are safe in the quantities needed to prevent mosquito bites.

3) ***Given that the RCT in Kenya failed to demonstrate a positive impact on entomology indicators, how would you recommend evaluating SRs for local registration?***

Eric Ochomo answering on behalf of Nicole Achee: Given that the RCT in Kenya failed to demonstrate a positive impact on entomological indicators, it’s important to contextualize these results. Factors include a

low number of Anopheles collected overall, large variability within and across collection nights, houses, and clusters, as well as the trial not being powered to detect an entomological effect. The sample size was likely insufficient to generate robust data sets. It's also crucial to note that the outcomes from the Kenya RCT should not be considered definitive regarding the entomological impact of transfluthrin-based SRs. For example, clinical trials in Peru demonstrated a reduction in indoor *Aedes aegypti* female abundance and blood-fed rates and clinical evaluation in Western Yunnan Province, China, showed that a transfluthrin coil reduced indoor abundance of Anopheles. Multiple laboratory, semi-field, EHT studies support a positive impact of SRs. However, entomological endpoints collected in real-world settings may not be robust substitute endpoints for examining the clinical effect of SRs on reducing malaria infection. The mode of action of SRs include: reduced entry, reduced host-seeking, and/or reduced human biting. Current field methodologies used to measure these indicators may not be appropriate due to other mosquito behaviours that might be affected, such as confusion and feeding inhibition.

These points highlight the challenge in establishing entomological correlates of human health protection. The return on investment by funders in trying to attain this goal has been arguably minimal. For local registration: A core objective is to verify product label claims by local regulatory authorities. Data generation, must be practical and accessible. Revisiting current WHO guidelines for the efficacy evaluation of SRS is warranted to assess the ability to verify label claims for first-in-class SRs like the Mosquito Shield. New methods or measures, perhaps other than entomology, such as chemical emanation rates, may be more appropriate.

***4a) Kenya was the site of the first successful RCT evaluating SR; what else is required for Kenya to move to full adoption of SR as a vector control tool implemented by NMCP?***

Lenson Kariuki answered: We are planning to deploy SRs in a small area of the country, and to achieve this, we require comprehensive guidelines. Therefore, we have enlisted our vector control experts to assist in developing these guidelines. These guidelines will aid us in the deployment of SRs and will cover operational, financial, SBCC, and monitoring and evaluation aspects.

Currently, the Guardian SR product is not yet registered with the regulatory body,. We are actively working with this regulatory body to have SRs registered for future use in the country.

***4b) Where do you see SR being most useful in the Kenyan context?***

Lenson Kariuki answered: This should be guided the data. We have observed that in Kenya, mosquitoes are biting very early in the morning, both indoors and outdoors, with the highest proportion being indoors. The outdoor biting is currently not covered by any intervention. Where such gaps exist, we are considering the use of SR. Additionally, we are looking at the peri-domestic population, like children in schools, who are not protected by any intervention. We are also considering the use of SR for displaced populations due to humanitarian crises in the country.

***4c) Given a fixed vector control budget, what factors should be considered in choosing or combining SR, IRS, or next-generation ITNs?***

Lenson Kariuki answered: This should be guided mostly by vector behaviour. However, cost effectiveness is very important. If an intervention must be combined with an existing intervention, we should be guided by cost, the gaps, and the likelihood of achieving maximum impact to achieve the desired outcome when combining interventions.

***5a) We worry that SR may lead to lower usage of ITNs or IRS. How true is this from your social science perspective and experience working alongside the RCT trials in Kenya, Uganda and Sri-Lanka?***

Steve Harvey answered: First of all, let's take Sri Lanka out of the picture because we are discussing *Aedes* mosquitoes and dengue, which are day-biting; in such a context, ITNs are not effective and therefore not used. However, in Kenya, it was concerning when we started hearing reports that people were no longer

using their ITNs because they believed SRs were effective enough on their own. It is crucial to continue encouraging the use of ITNs. This message needs to be effectively communicated through SBC strategies as we introduce new interventions.

We have a love-hate relationship with ITNs. They are a highly effective intervention and have had the most significant impact on malaria transmission over the past 25 years. However, they are also inconvenient and uncomfortable, leading to dislike among users. An equally effective alternative would be a welcome change. It would be ideal if, at some point, SRs proved effective enough to replace ITNs, at least in certain situations. Until we reach that stage, it is essential to continue stressing the importance of using both ITNs and spatial repellents to the population.

***5b) As manufacturers invest in this new product class, do you have any suggestions on how to ensure that the products are highly user-acceptable and maintain their impact over time?***

Steve Harvey answered**:** Feedback from trials and interviews indicated that having someone come in to replace the product once a month was really invasive. This is especially true when we're talking about replacing multiple products in a single room. Therefore, having a longer-lasting product is very important. Additionally, we need to consider disposal and what happens to the product at the end of its life cycle. Current products are made of plastic, which creates a significant problem for waste management. The shorter the product's lifespan, the more waste it generates. It's encouraging to see that the new generation of products by SC Johnson, such as the Guardian, seem to last much longer. However, we still need products that require fewer installations and last as long as possible. Ideally, these products should be made from biodegradable materials to avoid excessive plastic waste.

**Discussion- All**

Comment: The challenge is that new vector control interventions need to be tested against the standard of care, which currently includes nets. This means every new trial includes nets as a control or in addition to nets, making it difficult to prove the effectiveness of alternatives. Given the financial constraints, it's concerning that even highly effective new tools might not reach their full potential if they are only recommended in conjunction with nets, especially when countries struggle to fund nets alone. We need to consider testing new products in areas with low net usage or in emergency settings where nets might not be suitable, despite the challenges of trailing in these contexts. This is an increasingly important issue as we expand our toolbox but continue to layer new interventions without additional money.

Steve Harvey responded: SRs are designed to fill a gap that nets don't cover, such as the period in the morning when people are active and mosquitoes are still biting. This is particularly compelling for use in schools. However, the issue of layering multiple interventions and the associated costs is difficult to resolve. I wonder if there's a way to address this by conducting secondary analyses of existing data or future trials. We could look at the impact of SRs on people who are not using nets, even though we encourage net use. By tracking areas with higher versus lower net use, we might be able to evaluate the effectiveness of these interventions independently rather than layered on top of other measures.

***Question: What I'm hearing is that using ITNs and SRs together is recommended for better impact. However, considering budget constraints, are there any studies comparing the effectiveness of IRS and SRs? Should we always use an integrated approach with all vector control tools despite budget limitations? How can we resolve these dilemmas?***

Eric Ochomo answered: Nicole's presentation mentioned ongoing modelling work at Notre Dame, focusing on cost-benefit analysis and implementation costs. The results, once available, may help answer the question or provide a way to address it. Currently, there is no definitive answer.

**Question: It was presented that in Kenya, most residual biting for ITN users occurs indoors, which can be addressed by SRs. However, in Mali, where people go indoors much later, most residual biting happens**

**outdoors. I'd like to ask for your opinion on whether the use of indoor SRs might affect outdoor biting despite the lack of data.**

Eric Ochomo answered: The impact of SRs depends on when and where the most efficient vectors are biting. In Kenya, where vectors bite in the morning, indoor SRs are effective. However, in scenarios like Mali, where biting occurs outdoors in the evening, indoor SRs would have little effect. There is ongoing work and innovation with products that can be deployed outdoors to address outdoor transmission effectively.

Steve Harvey answered: At the KEMRI Science and Health Conference in Nairobi, a presentation discussed using spatial repellents and measuring their effect outdoors, up to 10 meters from the treated structure. The goal is to protect people when they're outdoors, away from any intervention. Studies on outdoor events, like funerals and weddings, show a gap in protection that current SRS don't fill. Insecticide-treated clothing might be a better option, though it comes with challenges in effectiveness, cost, and distribution. This issue of protecting against residual transmission remains to be addressed.

***Question:*** **How will you weigh operational considerations, such as the complexity of installing SRs versus spraying houses or distributing nets, and logistical considerations like the volume of SRs and frequency of reapplication?**

Lenson Kariuki answered: More studies are needed. As program implementers, we face challenges due to a lack of data on the best combination of interventions for maximum impact. Currently, we don't have sufficient information on the epidemiological impact of combining IRS, LSM, and ITNs. More research is needed to guide us in identifying the most effective combination for reducing malaria incidence.

**Question: Ethical considerations- when you use a repellent, it might drive mosquitoes to neighbouring areas. Can we combine the use of repellents with traps placed in strategic locations to attract and reduce mosquito density?**

Eric Ochomo answered: Initially, we thought repellents might drive mosquitoes to neighbouring areas. However, our study shows that repelling mosquitoes actually protects neighbours too. Within a 400-meter radius of areas where interventions are used, we observe reduced malaria transmission- benefitting the entire neighbourhood.

## Task Team 2: Innovations in vector control and vector surveillance Advances in new tools - Genetic control tools for malaria control Co-leads: Tullu Bukhari-ICIPE, Anna Trett-CHAI

**An update on the development of gene drive mosquitoes for malaria control (Michael Santos, Foundation for the National Institutes of Health)**

The presentation by Michael Santos, PhD, from the Foundation for the National Institutes of Health, revolves around the advancement and potential of gene drive mosquitoes in controlling malaria. Dr. Santos introduces gene drives as a genetic approach to vector control but focuses more on the broader implications and historical context rather than the specific genetic details, which are reserved for subsequent discussions.

Highlighting the advantages of genetic biocontrol: Efficacy in locally eliminating species, its unique mechanism of action that bypasses issues like IR, and its specificity and area-wide effects that do not require individual participation to benefit from the control measures. He acknowledges the continued recognition and support for this approach by global bodies such as the African Union and the WHO, citing various reports and statements supporting the development and testing of GM mosquitoes for malaria control.

The spectrum of genetic biocontrol strategies from temporary, non-persistent approaches like sterile insect techniques (SIT) to self-sustaining gene drives intended to permanently alter mosquito populations were discussed. He contrasts these by detailing the operational requirements, such as the need for continuous

releases in non-persistent methods and fewer releases for self-sustaining methods, which could potentially offer cost benefits and greater control over mosquito populations.

In summation, the complex pathway from current research to tangible malaria control impacts was highlighted, along with the stages from laboratory science to field trials and regulatory approvals.

**From lab towards field: progress in the development of gene drive mosquitoes for vector control (Samantha O'Loughlin, Imperial College London)**

Outlines the progress of the Target Malaria research consortium. The consortium collaborates with various countries, including three in Africa, focusing on the main malaria vectors in Sub-Saharan Africa: *Anopheles gambiae, Anopheles coluzzii, and Anopheles arabiensis.*

Objectives and Genetic Approach: Target Malaria aims to reduce malaria transmission by genetically modifying mosquitoes to suppress their populations. This approach is sustainable, long-term, cost-effective, and complements existing mosquito control methods.

Phases of Development:

1. The initial phase involved importing non-gene drive genetically modified sterile male mosquitoes into Burkina Faso and Mali for contained use studies, followed by a small-scale field release in Burkina Faso in 2019. This phase concluded in 2021.
2. The current phase focuses on non-gene drive genetically modified male-biased strains, with research ongoing in Ghana. Burkina Faso imported this strain in March 2022, and Uganda submitted a dossier in August 2022 for contained use experiments expected to start in 2024.
3. This involves developing gene drive strains designed to suppress mosquito populations by rendering female mosquitoes sterile. These strains have shown success in laboratory settings, effectively crashing mosquito populations in both small and large cage experiments. Efforts are ongoing to validate the efficacy and genetic components of these strains and to prepare for field trials.

The gene drive strain targets two conserved DNA sequences, slowing the development of resistance.

Community engagement and regulatory compliance are crucial. Target Malaria co-develops engagement strategies with local communities and regulatory authorities in Africa. They have established laboratory and insectary facilities, conducted extensive entomological surveys, and conducted environmental and health impact assessments. This ensures the safe and accepted implementation of the gene drive technologies.

As of 2024, the project is validating the gene drive strain's efficacy and preparing for regulatory studies and field trial designs. Significant capacity-building efforts focus on managing genetically modified mosquitoes and engaging stakeholders.

Target Malaria exemplifies a comprehensive approach to combating malaria through innovative genetic technologies. Integrating scientific research, community engagement, and regulatory frameworks, the project aims to sustainably reduce malaria transmission and improve public health in Sub-Saharan Africa.

**Some thoughts on strategies for field trials of gene drive mosquitoes for malaria control (John Connolly, Target Malaria)**

We discussed strategies and considerations for the first field trials of low-threshold gene drive systems designed for malaria vector control. This collaboration, initiated by Mike at FNIH, involves key technology developers. The presentation highlighted gene drive mechanisms, particularly those targeting the doublesex (dsxF) locus, which render female *An. gambiae* mosquitoes sterile and non-biting, leading to population suppression.

Population suppression gene drives: A reduction in mosquito population density would initially occur at the release location and then radiate outward. Population modification gene drives: Reduce the sporozoite rate

in mosquitoes without significantly affecting their density, leading to decreased malaria prevalence over time.

The presentation outlined the WHO-phased testing pathway for gene drive systems, starting with laboratory and insectary studies (Phase 1), progressing to small-scale field releases with some isolation (Phase 2), and eventually moving to larger-scale releases and implementation. This structured approach ensures a gradual and thorough evaluation of gene drive efficacy and safety.

Pilot trials are crucial for gathering initial data on gene drive spread and impact. Three potential approaches:

1) Conducting a pilot trial without control locations.
2) Sing parameters from pilot trials to inform the design of CRCTs).
3) Implementing a pilot trial with randomised release and control locations to gather data on spread and dispersal. These trials aim to manage spillover risks and effectively evaluate the gene drive's impacts.

Buffer zones and adaptive trial designs were emphasised as essential for mitigating spillover effects and ensuring flexible monitoring and efficacy assessments. These approaches allow for the accommodation of stochastic or uncertain dynamics in gene drive spread and impact.

In conclusion, emphasis on designing trials to evaluate the causal pathway, guided by risk assessments and stakeholder perceptions. Buffer zones and pilot trials are essential for understanding gene drive spread, integrating findings into cRCTs, and advancing field trials for malaria vector control.

## Task Team 2: Innovations in vector control and vector surveillance Advances in new tools - House modification and vector proofing Co-leads: Tullu Bukhari-ICIPE, Anna Trett-CHAI

**Evaluation of passive cooling options and vector proofing for indoor heat reduction and mosquito control in western Kenya (Bernard Abongo, KEMRI)**

This study aimed to understand the intersection of climate change and health outcomes by exploring housing modifications that could mitigate indoor heating while preventing mosquito entry.

The research involved a community-engaged approach, selecting and randomizing 40 households into four groups: control, cool roof, mat ceiling, and cross ventilation. Before implementing any modifications, a baseline survey was conducted. Following the interventions, indoor mosquito densities were measured using CDC light traps, and indoor temperatures and humidity levels were monitored. Interviews with household members gauged their perceptions and acceptance of the modifications.

The housing modifications included applying white roof paint to keep the roof cooler (cool roof), installing new windows for cross ventilation, and adding papyrus mat ceilings. All houses receiving passive cooling options also had screened eaves and windows. The results showed a significant reduction in indoor temperatures, particularly with the cool roof, which lowered maximum daytime temperatures by about 7.6°C compared to control houses. Specifically, the cool roof reduced daytime temperatures from a mean of 28.62°C to 26.18°C ($p < 0.001$) and night temperatures from 23.38°C to 23.29°C ($p < 0.001$). Cross ventilation reduced daytime temperatures to 28.31°C and nighttime to 24.09°C ($p < 0.001$), while mat ceilings resulted in daytime temperatures of 27.56°C and nighttime of 25.18°C ($p < 0.001$).

In terms of mosquito control, houses with screened openings showed a substantial reduction in both male and female *Anopheles funestus* mosquitoes. The mean number of female *Anopheles funestus* mosquitoes reduced from 27.14 pre-screening to 12.18 post-screening (Relative Risk (RR) = 0.46, $p = 0.014$). Male *Anopheles funestus* also saw a reduction, with post-screening numbers dropping from 59.83 to 29.77 (RR = 0.71, $p = 0.451$). For *Culex* mosquitoes, female numbers dropped from 8.44 to 6.02 (RR = 0.69, $p = 0.209$) and male numbers from 13.68 to 5.89 (RR = 0.5, $p = 0.002$) after screening.

Community feedback: Overwhelmingly positive, with residents expressing satisfaction with the reduced temperatures and mosquito numbers. They indicated a willingness to invest in these modifications when building their homes. The study highlights the potential of integrating passive cooling and vector proofing to control indoor malaria transmission and address rising temperatures due to global warming. It suggests further research on the health impacts of these modifications, including improved sleep quality, heat stress, overall health, and malaria transmission.

In conclusion: This pilot study demonstrates that combining passive cooling options with vector proofing can effectively reduce indoor temperatures and mosquito populations. This approach offers practical solutions for enhancing thermal comfort and reducing malaria transmission in low-income, rural African communities. The findings provide a foundation for larger-scale evaluations to assess the broader health impacts of housing modifications.

**Household randomised-control trial of insecticide treated eave nets and window screens on malaria prevalence and mosquito density in unimproved house in Chalinze district, Tanzania (Olukayo Odufuwa, IHI/Swiss TPH)**

The resurgence of malaria has been linked to the decline in the use of traditional control methods, such as insecticide-treated nets (ITNs) and indoor residual spraying (IRS) since 2015.

The presentation introduces insecticide-treated screening (ITS) as an effective alternative to ITNs and IRS, particularly for unimproved rural housing. ITS is described as easy to install, using nets manufactured in rolls to cover potential mosquito entry points like eaves and windows. A comparative analysis shows that house screening methods, including ITS, perform comparably to ITNs in preventing malaria. This is supported by data showing significant effectiveness in malaria prevention using finished house materials, insecticide-treated nets, and improved housing materials.

A pilot study conducted in the Chalinze district of Tanzania involved 450 households divided into two groups: 225 using ITS and 225 serving as controls. The study aimed to assess the effectiveness of ITS in reducing malaria prevalence. Results showed that in the ITS group, malaria prevalence was 19.9% compared to 28.0% in the control group. The unadjusted odds ratio was 0.66 (p=0.214), and after adjusting for covariates, the odds ratio was 0.70 (p=0.293), indicating a trend toward lower malaria prevalence, though not statistically significant. The community response to ITS was overwhelmingly positive, with strong willingness among participants to purchase and install ITS themselves. Despite the challenges of high dropout rates and community mistrust during the COVID-19 pandemic, ITS was found to be a feasible and cost-effective alternative to traditional methods.

The presentation confirms the potential of ITS as an additional tool for malaria control that does not require daily compliance and could significantly contribute to combating malaria in high-risk areas. It calls for larger, more controlled trials to evaluate its effectiveness and potential for broader implementation conclusively. This comprehensive approach ensures all aspects of ITS deployment—from statistical analysis to community engagement—are detailed, reflecting the thorough examination and potential scalability of this innovative malaria prevention strategy.

## Task Team 1: Larval Source Management Lead: Elijah Juma-PAMCA

**William Gorgas, pioneer of integrated mosquito control – his legacy is as relevant as 100 years ago (Norbert Becker, University of Heidelberg Denis Kailembo, Swiss TPH)**

This presentation emphasised the crucial role of LSM in combating mosquito-borne diseases. It highlighted the historical and ongoing importance of LSM pioneers like William Gorgas, Fred Soper, and Israel Kligler, whose methods remain relevant for managing diseases, such as malaria.

The presentation noted that despite nearly $3 billion in annual spending, malaria cases have increased by about 5 million in the last two years. However, there has been a 30% reduction in mortality over the

previous few decades. This suggests that while current strategies have reduced deaths, they haven't effectively controlled malaria incidence. Increased resistance to PYs and a behavioural shift in mosquitoes from endophagy to exophagy undermine the effectiveness of ITNs and IRS, indicating a need for more integrated approaches like LSM.

Historical successes of LSM were discussed, including William Gorgas's initiatives in Panama that eradicated Yellow Fever and malaria, enabling the construction of the Panama Canal; Fred Soper's eradication of *Anopheles gambiae* in Brazil using LSM and PY sprays; and Israel Kligler's eradication of malaria in Palestine through LSM and community involvement.

The German Mosquito Control Programme, employing *Bacillus thuringiensis israelensis* (Bti) since 1976 along the Rhine, achieved a 98% reduction in mosquito populations, showcasing the effectiveness of a well-supported LSM strategy with robust community infrastructure and precise mapping.

Additionally, the EMIRA project in Burkina Faso adapted these LSM strategies to African settings, treating villages with Bti and achieving a 70% reduction in mosquito populations. This project highlighted the importance of community education, capacity building, and local infrastructure development for successful LSM implementation.

The presentation concluded that LSM should be a key component in the global mosquito control strategy. It called for expanding the vector control toolkit to include LSM to effectively combat insecticide resistance and changes in mosquito behaviour. LSM not only manages mosquito populations but also supports biodiversity conservation and has shown no resistance development over decades, emphasising its sustainability and efficacy.

**Community-based biolarviciding for malaria control in Tanga region, Tanzania (Jubilate Minja, NMCP Tanzania)**

The presentation focused on the application of locally produced biolarvicides, specifically Bti and *Bacillus subtilis* (Bs), known for their high efficacy and safety for non-target organisms. These larvicides target mosquito larvae in their breeding sites. The intervention follows the existing government structure, utilising community-owned resource persons (CORPs) for application, supervised by various government levels from local to national. The project was piloted in three councils: Lushoto, Tanga CC, and Handeni DC (selected based on varying malaria risk levels to assess the intervention's impact in rural and urban settings). This approach helps understand the intervention's effectiveness across different malaria risk strata and environmental conditions.

Surveillance and monitoring: CORPs collected weekly data on variables such as habitats treated and larval abundance. Climate monitoring informs the timing of larviciding applications, which are strategically planned around the rainy seasons.

Cost analysis shows a significant financial investment, with around $1.09 million spent in the first year for setup and initial application rounds, with reduced costs in the subsequent year. Early results indicate a decrease in larval populations in treated areas, suggesting the biolarviciding approach is effective.

The presentation concluded by emphasising the collaborative effort across multiple stakeholders, including the Tanzanian government and international partners.

**Laboratory and experimental hut trials to evaluate the bio-efficacy and residual activity of Sovrenta 15WP against laboratory-reared and wild Anopheles mosquitoes in Tanzania (Frank Tenywa, IHI Tanzania).**
**Please note that this presentation was a last-minute replacement and not about LSM.**

Summary of a study evaluating the bio-efficacy and residual activity of Sovrenta®, a new indoor residual spray (IRS) for combating malaria vectors in Tanzania. This IRS formulation incorporates a novel isoxazoline

insecticide that targets the GABA and glutamate-gated chloride channels in mosquitoes, leading to hyper-excitation and death.

Objective: To determine the residual efficacy of Sovrenta® at a concentration of 120 mg active ingredient per square meter within experimental huts made of both mud and concrete over a period of 12 months. The research utilised a double-blinded trial design, conducted in eight experimental huts: 4 made of mud and 4 of concrete, each exposed to high mosquito populations due to their location in paddy irrigation areas.

Throughout the trial, data were collected over 20 nights per month per hut, with mosquitoes being exposed to the treated surfaces. The study meticulously measured mosquito mortality after 120 hours and at additional 24-hour intervals up to 168 hours. A critical ethical feature of the study involved using cows as attractants to avoid human involvement.

The results clearly showed that Sovrenta® consistently outperformed the control products, Actellic® 300CS and SumiShield® 50WG, in terms of mosquito mortality. Notably, Sovrenta® demonstrated superior mosquito mortality rates at all time points tested, with significant differences in mortality rates observed at the 120-hour endpoint across mud and concrete substrates. This data suggests a strong and lasting insecticidal effect of Sovrenta®.

Importantly, the study confirms 12 months of residual efficacy of Sovrenta® against wild, pyrethroid-resistant *An. arabiensis* mosquitoes, demonstrating superior performance across various testing parameters on different substrates. This effectiveness and its potential public health impact are currently under review by WHO PQ, hoping for global adoption in the fight against malaria. The findings highlight Sovrenta®'s potential as a powerful tool in public health efforts against malaria, particularly effective in areas facing challenges with pyrethroid-resistant *An. arabiensis*.

## Task Team 3: Anthropology and human-centred design Facilitator: April Monroe

**Urban malaria vector bionomics and human sleeping behaviour in three cities in Senegal (Fatou Ndiaye, Université Cheikh Anta Diop)**

Malaria remains a major cause of morbidity and mortality in Senegal. The government, supported by partners, has implemented interventions such as universal coverage of ITNS, IRS, and intermittent preventative treatments, leading to a substantial decrease in malaria incidence.

Focus areas: Diourbel, Touba, and Kaolack (the most populated regions after Dakar).

Objectives: To suggest appropriate and targeted VC strategies, understand the biting and resting behaviour of malaria vectors, evaluate transmission through entomological indicators, and assess human behaviour in these urban environments.

Methodologies: HLC and Pyrethrum Spray Catches (PSC).

Results: Exclusivity of *An. gambiae* in Diourbel, *An. funestus* in Touba, and a mix including *An. pharoensis* in Kaolack. Monthly variations in Human Biting Rate (HBR) and Indoor Resting Densities (IRD) revealed the highest HBR in Kaolack at 37 bites/person/night, significantly higher than Touba (7 bites/person/night) and Diourbel (1 bite/person/night). Exophagy was significantly higher in Touba, with outdoor biting rates nearly double those indoors ($p < 0.05$). Resting densities peaked at 9 females/room in Kaolack and were lowest in Diourbel at 1 female/room. Entomological Inoculation Rates (EIR) were lowest in Diourbel (3.65 bites/person/year) and highest in Kaolack (40.21 bites/person/year), indicating higher malaria transmission risk in Kaolack.

Sleeping behaviour data indicated that many residents slept outside due to heat and limited indoor space, increasing their exposure to mosquito bites. In Daaras (Quranic schools), ITN usage was higher in Touba, but 59% of residents still slept outside, increasing malaria risk.

Vector densities were highest during the rainy season, with the most significant bite rates in Kaolack. Both indoor and outdoor biting was prevalent, with a higher tendency for outdoor biting. During the dry season, residents spent more time outdoors at night due to heat. The gathering of young populations in Daaras for nighttime learning activities posed additional malaria transmission risks. The study recommends increased education on ITN use, especially outdoors, implementation of IRS and personal protection measures, and LSM in Touba and Kaolack. Raising awareness about environmental cleanliness and proper water storage management could help reduce mosquito breeding sites.

**Late morning biting behaviour of *Anopheles funestus* is a risk factor for transmission in schools in Siaya, western Kenya (Seline Omondi, KEMRI)**

The malaria case burden significantly affects children aged 5-15, who often carry asymptomatic infections, serving as reservoirs for the disease. This age group faces reduced concentration in classrooms, lower school attendance, poorer academic performance, and a cycle of poverty. Despite the high infection rates, existing malaria vector interventions are limited, with household coverage prioritising pregnant women and children under 5. Vector surveillance in Siaya County observed a peak in *An. funestus* biting activity at 6:00 AM, continuing into the late morning. This period coincides with when children arrive at school, indicating a significant risk for malaria transmission. The study aimed to characterise mosquito abundance and biting patterns in primary schools during night and morning hours when children are present.

This study was conducted in four non-boarding primary schools within Alego-Usonga Sub-County, Siaya County: Bukhoba, Gangu, Kanyaboli, and Gendro. These schools are near irrigated fields or around a lake (mosquito breeding sites). Human landing catches (HLC) were performed indoors and outdoors in five classrooms per school over two days in August 2023. Collectors from local villages were trained and tested for malaria; those who tested positive were treated, and all were given prophylaxis.

The results showed a substantial number of *An. funestus* mosquitoes collected, primarily indoors: 79% at Gendro, 85% at Kanyaboli, 70% at Gangu, and 76% at Bukhoba. *An. funestus* was the predominant species, comprising 94-95% of the mosquitoes collected. Hourly biting rates peaked at 6:00 AM and continued until 11:00 AM, aligning with the school arrival and attendance times. There was no distinct difference in indoor and outdoor landing rates, but indoor collections were more substantial.

Further analysis revealed that half of the collected *An. funestus* mosquitoes were fed or gravid, indicating multiple feeding cycles. A high proportion of these mosquitoes were parous, suggesting potential infectiousness, with a sporozoite rate of 2.05%. These findings underscore the urgent need for targeted vector control interventions in schools and peri-domestic spaces during morning hours when *An. funestus* is most active.

In conclusion, the study emphasises the necessity of malaria control strategies focusing on school environments to protect children from morning bites by *An. funestus*, thereby reducing malaria transmission and improving health and educational outcomes.

**Integrating mosquito vector and human behavioural data for malaria prevention: an interdisciplinary approach (Kaci McCoy, Johns Hopkins CCP)**

The presentation described an interdisciplinary approach to enhance malaria prevention by merging human behavioural data with vector behaviour data. The study aimed to identify patterns of human-vector exposure and gaps in protection.

Previous studies have demonstrated that integrating human behavioural data with malaria vector biting data helps identify exposure patterns and characterize protection gaps. The current activity is based on methods and indicators developed by April Monroe and others in 2020. The project sought to leverage existing data sources like the Malaria Behaviour Survey (MBS) and routine entomological surveillance to

calculate indicators of vector-human interaction. This approach addresses the challenge of synchronizing data collection and the relative scarcity of human behavioural data.

Four key data sources were used in this methodology:

1) Hourly nighttime indoor and outdoor human location estimates were derived from MBS.
2) ITN use rates were obtained from MBS household surveys.
3) Hourly nighttime indoor and outdoor human biting rates were collected from entomological surveillance, specifically through HLC.
4) Personal protection provided by ITNs was assessed using data from EHTs.

These data sources were integrated to produce key indicators of vector-human interaction.

The integration focused on two main indicators: the behaviour-adjusted biting rate for an ITN user and the population-wide mean exposure given ITN use. The analysis revealed significant exposure risks indoors during sleeping hours despite ITN use. This discrepancy suggested that low ITN access, rather than low ITN usage, was a critical gap. The high ITN use-to-access ratio indicated that people were using the nets they had, but overall, access was insufficient, pointing to gaps in protection that need addressing.

Gaps and limitations:

- The need for data specific to peri-domestic spaces and individual behaviours.
- The methods did not include IRS or community effects on malaria transmission.
- Entomological data were averaged across multiple sites, which may mask site-specific variability.
- Infection rates were not calculated, limiting the ability to link exposure to malaria transmission risk.

Successful proof-of-concept suggests that this methodology could be extended to other countries where the MBS is implemented. This integrated approach can inform future SBC activities and guide the selection of VC interventions tailored to specific contexts. Timing of data collection is crucial, and data integration should occur close to the time of collection and before major programmatic decisions. This process demonstrates the potential of combining routinely collected human behavioural data with entomological data to enhance malaria prevention strategies.

## Q&A

***Question: What additional social and behavioural research would you like to collect in the future to further improve how you target some of the gaps that you've identified?***

Seline answered: The study we conducted was only two days long and only in schools. More extensive research is needed to find out if it's happening elsewhere, where people spend time during morning hours when mosquitoes are biting when they are away from home and deployed malaria interventions.

Kaci answered: The data we collected was limited to the peri domestic space. Collecting data in the wider community events outside of the peri domestic space would be interesting. It would also be helpful to see how these activities would be affected by season.

Fatou answered**:** There would be more information and data for the behaviour and messaging that can be inspired from the Quran in Quranic schools to bring in faith-based messaging that would resonate with those populations. Additionally, to inform populations most at risk about protection measures and explanations of tools and their importance (like ITNs).

Comment: Different kinds of nets should be distributed deliberately to the same community to make a fair and comprehensive comparison. Talking about mid-morning counting without assuming this is some significant change in the mosquitoes, including Senegal, we are seeing behaviour that was always there. No historical data; it may be a change, but it may not.

# Tuesday 16th April 2024

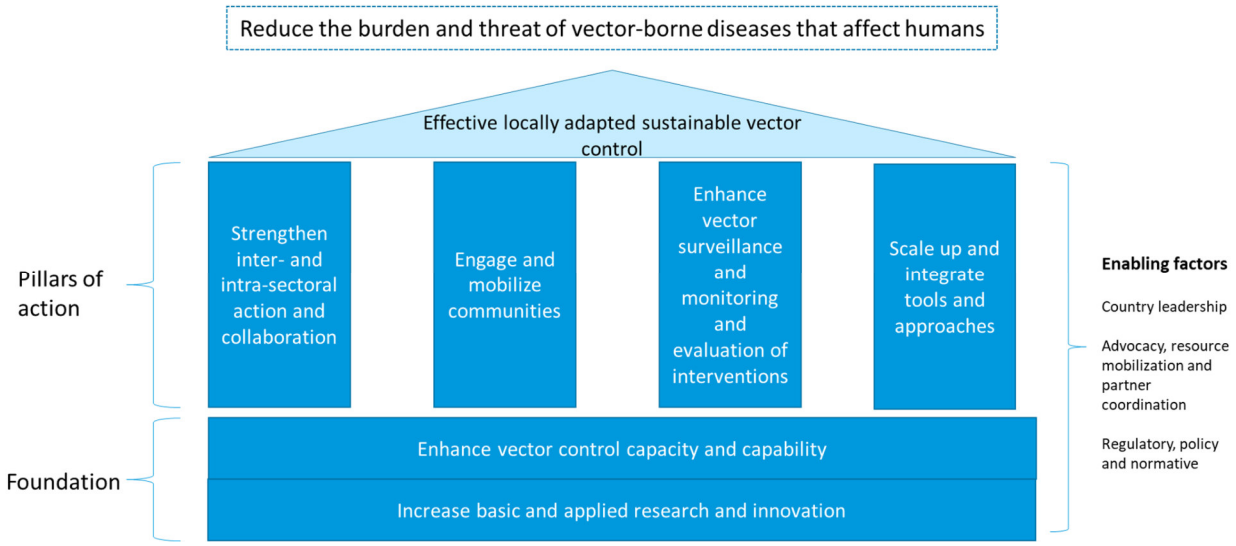
## Work Steam 3 - Implementing the Global Vector Control Response

### Task Team 1: Integrated Vector Management Co-leads: Jo Lines & Charles Mbogo

**Current WHO IVM guidelines (Seth Irish, WHO GMP)**

The central document guiding the IVM approach is the Global Vector Control Response (GVCR), which outlines the prioritisation of vector management, resource allocation, and the involvement of necessary personnel. This framework has been supported by a resolution from the World Health Assembly (WHA).

GVCR depicted:




Despite the structured approach of the GVCR, real-world complexities of implementing IVM acknowledged. Challenges include: Dealing with bureaucratic hierarchies, national registration processes, emergencies, regional differences, weather conditions, political influences, and logistical issues.

Examples of integration challenges were provided using malaria and dengue control programme to illustrate: Field staff may conduct activities for both diseases simultaneously, the lack of integrated reporting systems can double their workload. On the other hand, integrated programmes may struggle if the activities for each disease differ significantly, such as using larviciding for dengue and bed nets for malaria, or different monitoring methods.

Integration also faces temporal challenges: In regions where the transmission seasons of diseases like dengue and malaria do not overlap, staff can sequentially manage control activities. However, in areas with overlapping seasons, the workload may exceed the capacity of the available staff, necessitating additional seasonal workers.

To address these challenges, the presentation highlights the importance of incremental improvements and integrating specific components of vector control programmes where feasible. Opportunities for integration include: Morphological identification, shared insectaries and laboratories, and consolidated data systems. Control logistics, such as insecticide procurement and warehousing, as well as legal frameworks and multi-sectoral communication, are also areas where integration can be beneficial.

The presentation concludes by introducing the WHO's vector control needs assessment tool. This comprehensive tool helps countries evaluate their vector control needs across various dimensions, including:

- Disease situation.
- Policy frameworks.
- Research and innovation.
- Capacity and capability.
- Community engagement.

While the assessment process is thorough and beneficial, it does not simplify the complex challenges, it encourages a detailed, step-by-step approach to addressing vector control issues. In summary, the presentation provides a structured and realistic view of IVM, emphasising the importance of research, capacity building, intersectoral collaboration, and incremental integration to effectively control vector-borne diseases.

**The geographical distribution of the malaria vector *Anopheles arabiensis* in Cabo Verde, 2016-2023: An opportunity for new tools to control and sustain malaria elimination (Adilson De Pina, Programa de Eliminação do Paludismo, Ministério da Saúde, Cabo Verde)**

Cabo Verde has maintained zero local malaria cases since 2018, although it continues to face imported cases from neighbouring African countries such as Angola, Guinea-Bissau, and Senegal. The primary malaria vector is *Anopheles arabiensis*, with Plasmodium falciparum being the predominant parasite. Notably, 73% of malaria cases occur in men, and cases typically peak between October and November.

Extensive entomological studies have been conducted in Cabo Verde since the early 20th century, with recent efforts from 2016 to 2023 focusing on updating the distribution of *Anopheles arabiensis*. Comprehensive surveillance across all nine islands and 22 municipalities involved collecting larvae and adult mosquitoes using various trapping methods. These studies confirmed the presence of *Anopheles arabiensis* in six of the nine inhabited islands, with the first identification in Santo Antão both morphologically and molecularly. The species' low density is attributed to increased mobility and improved surveillance.

Despite achieving zero local cases, Cabo Verde faces challenges, particularly with imported cases. A robust surveillance system is crucial to control these cases and maintain the malaria-free status. There are significant opportunities to enhance VC through integrated vector management and new technologies. The low mosquito density allows for innovative studies on mosquito behaviour and bioecology. Additionally, international collaboration and capacity building are essential for sustaining malaria elimination efforts. Cabo Verde's experience offers valuable insights for other countries aiming to eliminate malaria and prevent its reintroduction.

In conclusion, Cabo Verde has made substantial progress in controlling malaria, but ongoing vigilance and innovative strategies are necessary to address the challenges posed by imported cases and ensure sustained elimination. The presentation highlights the importance of continued surveillance, research, and international cooperation in maintaining a malaria-free status.

**Zika virus: an emerging public health threat in maternal-child health (Ernest Tambo, University of Global Health Equity, Rwanda)**

Begins by highlighting the threat of Zika virus (ZIKV) in Africa, particularly in Cameroon.

Climate change, conflict, and poor urbanisation contribute to the rise of Aedes-linked diseases like Zika and dengue. Zika severely impacts pregnant women, causing microcephaly and Guillain-Barré syndrome, with no vaccine or effective treatment available. Policymakers need to enhance preparedness and response strategies. Zika's history traces back to Uganda in 1947, with significant outbreaks in Brazil in 2014-2015.

African ZIKV strains are more transmissible and pathogenic than Asian strains. More research is needed to inform policies and interventions.

In Cameroon, *Aedes albopictus* is most prevalent in urban areas and *Aedes aegypti* more common in rural areas. The high prevalence of asymptomatic cases complicates detection and prevention. Mapping breeding sites and understanding mosquito behaviour are crucial for interventions. Symptoms include fever, rash, joint pain, and red eyes, with many cases asymptomatic. The importance of counselling pregnant women about Zika risks and improving health services is emphasised.

Zika remains a major public health issue for women of reproductive age. Strengthened health systems, enhanced surveillance, proactive outbreak measures, vaccine development, community engagement, and reliable information channels. Lessons from COVID-19 and Ebola should inform preparedness and response.

Insights from Zika can inform malaria control efforts. Climate change is increasing *Aedes* mosquito populations, leading to increased vector prevalence. Government strategies should focus on controlling and preventing disease spread, highlighting the need for financial mobilisation for preventive and curative measures.

**Combating malaria with the mosquito symbiont *Chromobacterium anophelis* sp.nov cell-free bioactive supernatant (Jacques Gnambani, Institut de Recherche en Sciences de la Santé, Burkina Faso)**

Various mosquito biocontrol strategies targeting different lifecycle stages are highlighted. These include plant-borne mosquitocides, mosquito predators, *Bacillus thuringiensis israelensis* (Bti), entomopathogenic fungi, and releasing mosquitoes with symbiotic bacteria like *Wolbachia*. Non-insecticide-based strategies such as the Sterile Insect Technique (SIT) and genetically modified (GM) mosquitoes are also discussed. *Chromobacterium anophelis* is presented for its mosquitocidal properties, affecting mosquito survival, fecundity, and fertility.

Upon DNA sequencing, *Chromobacterium anophelis* was confirmed to be a new species. This bacterium was isolated in Burkina Faso, and sequencing revealed it as a new species. The study focused on the potential virulence factors of *C. anophelis* and utilised a bacterial cell-free supernatant as a source of bioactive metabolites with mosquitocidal and parasitological properties. The supernatant showed promising results in laboratory and field experiments by reducing mosquito survival and disrupting Plasmodium development.

Laboratory experiments involved feeding mosquitoes with the supernatant using cotton balls, while field experiments used clay pots containing the supernatant. The results demonstrated that all concentrations of the supernatant were effective in killing mosquitoes within 10 days, achieving over 90% mortality. Additionally, the supernatant affected mosquito blood-feeding capacity, fecundity, and fertility. Feeding mosquitoes with the supernatant significantly reduced their survival and reproductive potential. The supernatant also inhibited Plasmodium development, further decreasing the mosquitoes' transmission capability.

To conclude, the use of *C. anophelis*, due to its selective mosquitocidal capabilities, presents a promising option for future mosquito control strategies. The findings suggest that *C. anophelis* could be a crucial tool in future malaria control programmes, highlighting its potential to significantly impact the fight against malaria.

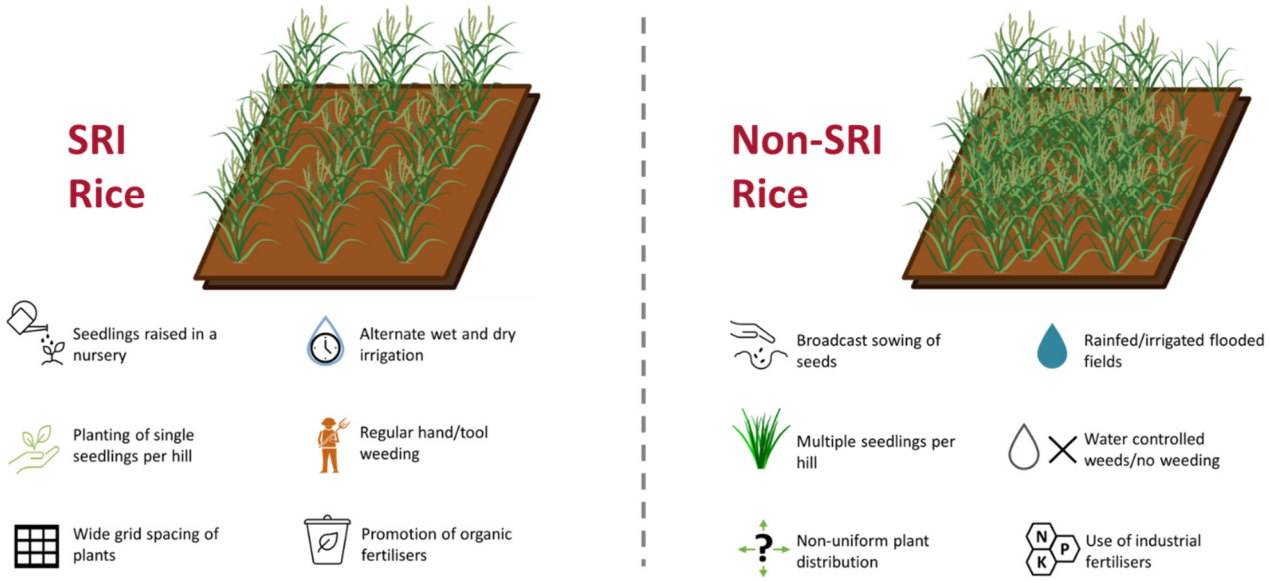
**The System of Rice Intensification can produce more malaria vectors (Harrison Hardy, University of Greenwich, UK)**

The study addresses the significant increase in malaria vector densities linked to different rice cultivation practices, particularly in Africa, where rice production is expanding to mitigate the effects of climate change.

Rice cultivation provides expansive breeding habitats for malaria vectors, leading to higher biting rates and increased malaria incidence in adjacent communities. Africa's rising rice production capacity includes the

adoption of climate-adapted cultivation strategies, such as SRI (System of Rice Intensification). SRI is a set of agronomic practices aimed at increasing rice yields while reducing agricultural inputs, particularly water and agrochemicals.

Differences between SRI and Non-SRI rice depicted:




The study was conducted in the Mkindo irrigation scheme in Morogoro, Tanzania:

- 4 SRI fields with 4 non-SRI fields.
- Each field was divided into four transects with sample points along each transect.
- Sampling commenced two weeks before transplantation and continued until two weeks after harvest, involving larval dipping and emergence traps.

Results:

- SRI fields had significantly higher vector densities than non-SRI fields, with more than twice the number of vectors. Specifically, SRI fields had around 150,000 adult malaria vectors per hectare.
- Larval population growth rates in SRI fields were approximately three times faster than in non-SRI fields. Although adult population growth rates were about twice as high in SRI fields (not statistically significant).
- The majority of mosquitoes found were from the *Anopheles gambiae* complex, with no significant difference in species composition between SRI and non-SRI fields.

The SRI agroecosystem appears to be a more productive habitat for malaria vectors, leading to increased vector densities and potentially higher malaria transmission rates. This is due to a positive linear relationship between vector density and vectorial capacity. The study observed a 148% increase in vector densities in SRI fields, which is expected to proportionally increase vectorial capacity and, consequently, malaria transmission.

In conclusion, it is essential to emphasise the need for rice intensification methods that do not concurrently increase malaria risks. While SRI practices improve rice yields, they may inadvertently exacerbate malaria transmission. Modifying cultivation practices to control vector populations without compromising yields is crucial. Collaboration among rice producers, agronomists, medical entomologists, and policymakers is essential to address the dual challenges of increasing rice production and combating malaria in Africa. A call

for the rice production industry and associated research bodies to take responsibility for their potential role in exacerbating malaria transmission and to be actively involved in finding solutions.

**Phenotypic and molecular characterization of pyrethroid resistance escalation in the African malaria vector *Anopheles funestus* Cameroon-wide (Hervé Raoul Tazokong, University of Yaoundé, Cameroon)**

The introduction highlights the global stagnation in malaria control since 2015, due to factors like insecticide and drug resistance, and service disruptions from COVID-19. In Cameroon, health ministers have stressed the need for detailed resistance characterisation and molecular studies.

From August 2020 to December 2021, the research utilised various methodologies including: indoor mosquito collection, WHO tube assays, synergist assays, DNA extraction, and qPCR. The aim was to characterise pyrethroid resistance, assess its impact on control tools, and investigate molecular mechanisms. Mosquitoes were collected from 4 key locations in Cameroon, primarily agricultural areas, and reared in the lab for testing.

Results indicated significant pyrethroid resistance across Cameroon. In Elende, mosquito mortality after exposure to permethrin increased from 70.6% ± 5.21 to 97.1% ± 1.8 with PBO, showing a strong synergistic effect ($p < 0.0001$). In Njombe-Penja, the combination of bendiocarb and PBO increased mortality from 70.8% to 93.7%, but this was not statistically significant, highlighting complex resistance patterns.

The study examined resistance markers like the L119F-GSTe2 allele, which increased significantly in some areas, correlating with resistance levels. In Gounougou, changes in allele frequency were not significant despite high resistance levels, suggesting other influencing geographical and ecological factors. High sporozoite infection rates of 5.4% and 16.5% were observed in two locations. Phenotypic characterisation showed resistance to all tested insecticides except organophosphates, to which mosquitoes remained susceptible. Synergist assays indicated cytochrome P450-based mechanisms were a primary driver of resistance, though other mechanisms were also involved.

The study noted the reduced efficacy of PY-only nets, emphasising the need for PBO-treated nets. Molecular analysis linked the L119F-GSTe2 mutation to resistance at baseline concentrations, but not at higher concentrations. Gene expression studies showed high levels of candidate gene expression in resistant mosquitoes.

In conclusion, the presentation emphasises the importance of ongoing molecular surveillance and incorporating whole genome sequencing into resistance management strategies. The results support the use of pyrethroid-PBO bed nets, backed by statistically significant data. These findings highlight the need for adaptive strategies in managing IR to sustain malaria control efforts. The take-home message highlights integrating molecular surveillance into VC strategies and ongoing efforts to understand genetic resistance mechanisms through whole genome sequencing.

**Vector control strategies in The Gambia (Ebrima D Bah, NMCP The Gambia)**

The Malaria Strategic Plan (MSP) in The Gambia promotes integrated vector management, focusing on primary interventions like ITNs and IRS, supported by entomological monitoring. Secondary interventions such as LSM and environmental management are part of the plan but currently unfunded.

The distribution strategies for LLINs aim for universal coverage through mass campaigns and routine distribution. Mass campaigns target the general population and specific institutions, with the last campaign in 2022. Routine distribution targets children under one year and pregnant women attending antenatal care. According to the 2017 Multi Indicator Survey, 79% of households own at least one LLIN, and 57% of individuals use them regularly. Challenges include weak internet connectivity for data syncing and difficult access to remote areas during the rainy season.

IRS is implemented in the Upper River Region (URR) and Central River Region (CRR), following the WHO insecticide rotation plan. IRS aims to reduce human-mosquito contact, decrease mosquito density and lifespan, and lower malaria transmission. Key activities include community sensitisation, training of supervisors and spray personnel, and execution of spraying operations. In 2023, URR achieved 89% coverage of sprayable rooms, while CRR achieved 95%. Challenges include community resistance, the impact of oil-painted walls on spray effectiveness, and waste disposal issues.

Entomological surveillance is conducted at twelve sentinel sites to monitor vector density, species distribution, behaviour, and resistance status. Malaria statistics from 2015 to 2022 show a significant reduction in malaria incidence and related deaths, especially in high transmission zones like URR and CRR. Despite a resurgence in cases during 2021 and 2022 due to heavy rains and increased mosquito breeding, the overall trend indicates success in reducing malaria.

## Q&A

***Question: Adilson, given your goal to maintain elimination and the challenge you have with Anopheles arabiensis, do you think there would be interest nationally in local elimination through SIT or another kind of approach?***

Adilson De Pina answered: Of course, we *have Anopheles arabiensis*, and there are many questions about how we can correlate epidemiological and entomological data. We recognise the need to implement IRS, but the history of *Anopheles arabiensis* in Cape Verde is quite unique. We do not have records of *Anopheles arabiensis* biting or resting inside houses, which presents a significant challenge for us, especially as we now face issues with dengue too.

We practice IVM, using different strategies for different mosquito species. The country is beginning to advance in research, and over the past two years with we have worked with Target Malaria. This initiative explores the potential to introduce new tools and technologies, providing us with an opportunity to sustain our efforts towards malaria elimination. The research market in Cape Verde is open and inviting for further investigation. We welcome international collaboration and are open to partnerships to enhance our vector control strategies and research capabilities.

***Question: How can researchers studying rice systems and malaria transmission involve community leaders better to understand why local people some systems over others.***

Harrison Hardy answered: Involving community leaders extends beyond rice cultivation and is vitally important. Working with in-country collaborators is a key way to engage community leaders and involve them in the research. It is crucial to understand why certain people cultivate rice in different ways.

For example, in our study area within the irrigation scheme, most conventional rice cultivators were hereditary landowners following traditional methods passed down to them. Conversely, those practising SRI were primarily motivated by profit. They did not use all the rice for their families but sold the majority of it. Understanding these different motivations and practices is essential for effective community engagement and research.

***Question: What about LSM combined with SRI and Bti?***

Harrison Hardy answered: I believe SRI inherently presents an opportunity for larval source management (LSM) through its utilisation of alternate wet and dry irrigation. When a rice field is left dry for a certain length of time, a proportion of the larval population can be expected to die. However, for alternate wet and dry irrigation to be an effective LSM technique, the dry period must be long enough to kill off a significant proportion of the larvae.

Bti can be easily integrated into cultivation practices like SRI. A recent study demonstrated that the most effective way to use Bti in rice cultivation for malaria control was to add it at the same time as fertilisers are added to the field. This suggests it could also be used effectively in SRI.

However, as I mentioned in my presentation, these strategies need to be informed not just by medical entomologists but also by agronomists. Any changes we make should not only aim to reduce malaria vectors but must also ensure that rice cultivation remains viable. It is essential that these interventions do not negatively impact overall rice yields, as rice production is crucial for the community.

***Question: Is incomplete dryness an issue?***

Harrison Hardy answered: You need around five dry days to kill off the majority of the L4 larvae. However, incomplete dryness due to improper field levelling can also be a factor. When irrigation water recedes unevenly, it leaves behind small vestigial pools that can become highly productive habitats for malaria vectors. These pools may be isolated from predator communities, making them even more productive than usual.

## Task Team 2: Capacity and Collaboration Lead: Givemore Munhenga

**Supporting the setup of a malaria entomological surveillance network in Angola toward sustainable local entomological capacity (Gonçalo Alves, The Mentor Initiative)**

Focusing on Benguela and Cuanza-Sul provinces, the project runs from 2021 to 2024, aiming to establish a sustainable malaria entomological surveillance network.

Key objectives:

- Characterising local mosquito populations, particularly *Anopheles* species.
- Enhancing the capacity of local staff for mosquito monitoring. This involves setting up sentinel sites, two in Benguela and three in Cuanza-Sul.
- Conducting ongoing mosquito surveillance using CDC light traps and larvae collections.

A crucial part of the project is selecting and training provincial entomology teams. Training sessions, conducted over five days covered: theoretical and practical aspects of mosquito collection, sample sorting, and storing. The training targeted provincial and municipal malaria supervisors, with 24 supervisors trained.

To ensure ongoing support and quality control, monthly supervisions were implemented. These included replacing consumables, fixing equipment, collecting samples, and providing on-the-job training. Provincial Vector Control Groups (PVCG) were established to decentralise decision-making and provide forums for discussing surveillance results, sharing experiences, and addressing challenges. Held joint meetings every six months to facilitate broader discussions on mosquito monitoring and integrated vector surveillance.

The integration of Municipal Malaria Supervisors (MMS) into entomological activities began in January 2022. After initial training, MMS were equipped with entomological kits and began conducting monitoring activities independently by June 2022, with regular supervision to ensure consistency and quality.

The project demonstrates the potential of a municipal-supervisor-based approach for sustainable mosquito monitoring in Angola. Structured training, continuous supervision, and collaborative efforts have built a solid foundation for ongoing surveillance and VC, contributing to more effective malaria control efforts in the country. Additionally, integrating other vector-borne diseases into the surveillance activities highlights its adaptability and forward-thinking approach.

In summary: This project showcases a successful model for enhancing local capacities and establishing sustainable entomological surveillance networks. Significant improvements in training outcomes, effective supervision mechanisms, and strong collaborative frameworks are essential for achieving long-term malaria control and potentially eradicating the disease in Angola.

## Panel discussion: Regional capacity development and collaboration: what has been done, current status and way forward (Muhammad Mukhtar remotely)

**PAMCA – Samson Kiware**

**PAMCA is known to have invested in Entomological surveillance, whereby it has developed a project/programme that entails developing capacity for district level public health personnel. This is aside the tremendous work it has done in developing young scientists across Africa. Could you give us a brief background of this project and the current status?**

At PAMCA, we are not a research institution. Rather, we implement programmes and work very closely with centres of excellence to help us execute these programmes. Currently, we have initiatives supported by three centres of excellence: the Research Centre for Health Sciences in Burkina Faso (IRSS), the Centre for Research in Infectious Diseases in Cameroon (CRID), and the Ifakara Health Institute (IHI) in Tanzania.

We initially applied for and received a grant from the Gates Foundation, which enabled us to develop and implement programmes providing training at the district level. In many countries, there are vector control officers at the district level, but some countries lack these officers. Our goal is to ensure that every country has these officers to support vector control activities.

One of our significant achievements was the development of a curriculum for this training. The curriculum was developed by the Ifakara Health Institute, reviewed by the other two centres of excellence, and approved by PAMCA. Under the leadership of key individuals like Charles Adabate and Fredros Okumu, with excellent support from others such as Jesse, the centres trained district officers in Burkina Faso, Cameroon, and Tanzania. This training was conducted in collaboration with the National Malaria Control Programmes to ensure that the training provided met their specific needs.

In addition to training at the district level, we also support master's and PhD programmes. For example, in Cameroon, there is one PhD student and two master's students; in Ifakara, there are two PhD students and five master's students. The students at IHI are from Uganda. This demonstrates our commitment to providing training at both the district level and higher education levels.

Another important aspect of our work is training on data systems. We have developed a system called Mosquito DB, or database management system. In addition to training on surveillance, we ensure that entomologists at the district level are trained to use these data systems. This enables them not only to conduct vector surveillance but also to analyse data effectively to support decision-making at the district level.

**APMEN – Muhammed Mukhtar**

**Having spearheaded some of the impressive entomology courses in Asia; collaboration between governments and research institutions and the recent ORENE online programme you have developed to strengthen capacity in that region, could you explain how this came about and what makes it unique from other regions?**

APMEN is a vibrant international forum dedicated to information sharing and supporting malaria elimination across its 22 member states. APMEN focuses on coordination, innovation, and capacity strengthening for vector surveillance and control in the Asia-Pacific region. Most member states in this region aim for malaria elimination, aligning with the global WHO technical strategy.

Notably, many member states have aligned their malaria elimination targets with the WHO strategy. For example, Pakistan developed a vector elimination roadmap in 2021 with the technical assistance of the APMEN Vector Working Group. This roadmap outlines strategies and actions for effective vector control and malaria elimination.

APMEN's emphasis on vector surveillance and capacity strengthening is based on global surveys that consistently show a shortfall in these areas. This need is highlighted in several international publications, pointing out gaps in current practices.

To address these gaps, APMEN facilitates training programmes, workshops, and collaborative projects to build and strengthen the capacity of member states. These initiatives ensure effective implementation, monitoring, and improvement of vector surveillance and control measures. By fostering collaboration, APMEN enables member states to share best practices and technical expertise.

In addition to technical assistance, APMEN advocates for policy changes and mobilises resources to support malaria elimination efforts. Through its comprehensive approach, APMEN ensures that member states are well-equipped to achieve their malaria elimination goals in line with the global WHO strategy.

**How have you managed to sustain this programme as a region?**

To sustain the programme as a region, APMEN focuses on capacity strengthening through various methods. Each year, we hold a two-week in-person course in different regions. Last year, the Fourth International In-Person Course on Malaria Vector Surveillance and Elimination was held in Indonesia from June to July 2023. This year, the course will be in June in Madang, Papua New Guinea.

APMEN also offers online courses with global representation, enhancing accessibility and participation. Our popular Tech Talk webinar series, featuring over 20 sessions with top experts, attracts 200 to 300 participants per webinar from around the world, demonstrating the relevance and global interest in our topic. Coordination is crucial for sustaining our programmes. APMEN's strategic focus on collaboration, innovative vector control tools, and continuous capacity strengthening ensures effective management and sustainability of our initiatives.

These efforts enhance participants' skills and knowledge while fostering a collaborative environment for sharing best practices and technical expertise, thereby strengthening our collective ability to achieve malaria elimination goals.

**What is the current status?**

Regarding the current status, APMEN is a sustainable collaborative network comprising 22 Asia-Pacific countries and 54 partner institutions. Established in 2009 with strong regional motivation and financial support from the Australian Government and then Prime Minister Kevin Rudd, APMEN has been actively

APMEN works closely with its partners to facilitate regional and multi-sector collaboration aimed at achieving malaria elimination in the Asia-Pacific region. Currently, APMEN supports technical exchanges through its three subgroups: the Vector Control Working Group, the Service Delivery Response Group, and the Vivax Working Group. These subgroups play a crucial role in coordinating efforts, sharing expertise, and developing strategies to combat malaria. APMEN collaborates with developmental partners, scientific and academic organisations, the private sector, and global health agencies. Through this extensive network, APMEN addresses the unique challenges of malaria elimination in the region. Its approach includes advocacy, leadership, evidence-based capacity building, and knowledge exchange.

By fostering collaboration and innovation, APMEN ensures that best practices and cutting-edge solutions are shared across the region, enhancing the effectiveness of malaria control and elimination efforts.

**E8 – Chadwick Sikaala**

The E8 Initiative is a coalition of eight southern African countries—South Africa, Eswatini, Namibia, Botswana, Mozambique, Angola, Zimbabwe, and Zambia—working together to eliminate malaria. Recognising that malaria knows no boundaries, these countries coordinate their efforts, share resources, and harmonise policies to tackle the disease regionally.

The E8S Initiative has clear objectives coordinated by its Secretariat, including:

Coordination, which involves ensuring regional collaboration for malaria elimination, and policy harmonisation, which focuses on aligning policy guidelines across countries to work as a unified community. Advocacy is another key objective, aimed at maintaining malaria as a high priority at the political level. Sustainability is crucial, involving the securing of resources to continue malaria elimination efforts. Finally, engagement is essential for facilitating cross-border collaboration and ensuring a unified approach to malaria elimination.

The genesis of the entomological surveillance fellowship programme involved an assessment conducted around 2016-2017 with support from the University of California, San Francisco, and other partners. The assessment identified the needs of the programmes, particularly around IRS and VC. Based on these findings, the E8 Vector Control Technical Working Group, consisting of vector control specialists from member countries, academia, research institutions, and international partners developed the fellowship programme.

The first fellowship programme was developed to build capacity within the countries' malaria programmes. Eight fellows were selected from the member countries and trained at institutions; Ifakara Health Institute, University of the Witwatersrand and Liverpool Scholl of Tropical Medicine. The training focused on entomology, monitoring, and designing surveillance systems, ensuring that the expertise remains within the national programmes.

**Q&A**

***What are the future plans/ prospects for capacity development in vector control and entomology surveillance that you envision?***

Samson Kiware (PAMCA) answered: With the programme I mentioned earlier, we initially started with three countries but are now expanding the specific surveillance programme to include four countries: DRC, Nigeria, Mozambique, and Uganda. The goal is to maintain momentum and support more countries. Those initially trained, such as Cameroon, Burkina Faso, and Tanzania, are now responsible for training these new countries. This approach ensures the expansion of training by leveraging previously trained individuals. We are keen to collaborate with partners like CHI, USF, EH, and others, ensuring we complement each other in capacity development. Before entering a country, we conduct assessments in collaboration with the National Malaria Control Programme to understand the needs and identify existing capacities, ensuring we work effectively together.

Muhammad Mukhtar (APMEN) answered: APMEN has an ambitious plan for 2024, focusing on capacity strengthening and collaboration. Key activities include three APMEN TED Talks webinars, starting with one on innovative IRS technologies in March. The Fifth Malaria Vector Surveillance Course will be held in June in Madang, Papua New Guinea. A short course on molecular identification of mosquitoes will take place in Pakistan from 6th to 10th May, and an online short course is planned for August. An Africa-South Asia science exchange visit will be hosted by Pakistan in September, and a research project on outdoor biting will occur in October 2024. The annual Vector Control Working Group meeting will be a virtual conference in November 2024. These activities aim to strengthen member states' capacities in vector surveillance and control. APMEN has three thematic subgroups addressing Climate Change and Health, Cross-Border Malaria Transmission, and Outdoor Transmission. Funding comes from the Malaria Consortium, the Bill & Melinda Gates Foundation, national programmes, WHO, and the Global Fund. APMEN emphasises cross-border collaboration for malaria elimination, as seen in initiatives like the Pakistan-Iran-Afghanistan Malaria Network, and collaborations between Indonesia, Timor-Leste, and Papua New Guinea, and India's regional efforts with Bhutan, Nepal, and Bangladesh. APMEN is committed to fostering strong cross-border and cross-regional collaborations, including future exchanges between Asia and Africa, and monitoring

mosquito-borne disease trends in Europe. If you have any questions or need further information about APMEN's initiatives, please feel free to ask.

***Question from audience: we do a lot of training, but really the issue is jobs. And to what extent are the countries working with civil service reform, ensuring that there are jobs, postings, and career opportunities for the people you're training?***

Muhammad Mukhtar answered: Yes, you are absolutely right, because you have such experience of working in Pakistan. Currently the provincial governments are very sensitive, because over the last two decades we have lost a lot of entomologists. But over the last two or three, five years, there is a very big change in the country. Giving the example of the KPK province, with the close to the Afghanistan border, working with Afghanistan, they have recruited 42 district-level entomologists to enhance their capacity for vector surveillance.

Chadwick Sikaala: Summarized by suggesting that the different regional and international organizations can collaborate and work together to ensure best practices are shared amongst themselves to improve and capacitate malaria programmes in entomology surveillance.

## Task Team 3: *Anopheles stephensi* response Co-leads: Melissa Yoshimizu, Sarah Zohdy, Susanta Ghosh

### ***Anopheles stephensi* research agenda (Anne Wilson, LSTM Sarah Zohdy, CDC Melissa Yoshimizu, USAID Susanta Ghosh, Mangalore University)**

The presentation outlines a research agenda addressing the threat posed by *Anopheles stephensi*, an invasive mosquito species first detected in Djibouti and now found in Kenya, Ghana, and other countries. Thriving in both container and natural habitats, *An. stephensi* poses significant challenges to malaria control due to its cryptic adult behaviour, complicating the evaluation of control tools. Genomic studies indicate multiple introductions of *An. stephensi*, with substantial evidence of its role in malaria transmission.

The research agenda aims to identify knowledge gaps, guide funding and research, accelerate action through collaboration, and disseminate prioritised outputs. Developed with input from researchers and programme managers over six months, it is structured around five areas: surveillance (entomological and epidemiological), control, genomics, modelling, and human behaviour.

- Entomological surveillance: Focuses on understanding larval habitat characteristics, optimising adult trapping methods, studying *An. stephensi* biology, evaluating vectorial capacity, identifying entry modes and dispersion routes, and developing new surveillance approaches.
- Epidemiological surveillance: Aims to understand *An. stephensi*'s role compared to native vectors, study malaria cases in sentinel populations, evaluate its role in transmitting Plasmodium falciparum and P. vivax, and develop early warning systems for enhanced malaria surveillance.
- Control strategies: Involve evaluating and optimising existing methods like larval source management and insecticide-treated nets, developing novel methods such as genetically modified mosquitoes and animal-based interventions, and ensuring sustained multi-sectoral engagement. Integrated vector control targeting both *An. stephensi* and *Aedes aegypti* is also highlighted.
- Genomic research: Focuses on using genomic data to improve control, implementing rapid genomic surveillance, studying the temporal dynamics of *An. stephensi* genomic diversity, and developing a genomic data management platform for collaboration and dissemination to policymakers.
- Modelling efforts: Aim to optimise spatial-temporal surveillance, develop models to predict invasion dynamics and assess transmission impact, and identify cost-effective control strategies through transmission-dynamic models.

- Human behaviour research: Explores socio-ecological factors influencing malaria risk in the context of *An. stephensi*, factors increasing the acceptability of control programmes, challenges to multi-sectoral engagement, and effective social and behavioural change interventions.
- Key cross-cutting themes: include understanding the basic biology and ecology of *An. stephensi*, integrated vector management, standardising sampling methods, rapid genomic surveillance, insecticide resistance characterisation, tailoring responses to specific settings, cross-border and multisectoral collaboration, and promoting data-sharing platforms.
- Country priorities, identified through feedback: focus on surveillance, control, genomics, modelling, and human behaviour. The research prioritisation summary document and the MESA tracker will highlight ongoing *An. stephensi* work, minimise duplication, and establish collaborative efforts.

Using the C Events mobile app audience participation was encouraged via a polling system, in an engaging and interactive manner. Gleaning audience opinions on *Anopheles stephensi* and related topics such as control and research gaps.

**Q&A**

***Question: There's so many countries now trying to increase their surveillance efforts, wondering how we can encourage an integrated surveillance, building it up into a beneficial programme and can help across many other VBDs***

Susanta Ghosh answered: Mosquito (indicator) surveillance is a method for diseases surveillance. In India, there are case where indicator surveillance has helped identify dengue, lymphatic filariasis alongside malaria too.

Sarah Zody answered: *Anopheles stephensi* presents an opportunity to work with active *Aedes* groups, Ethiopia is a great example of that where malaria programme changed to the malaria and other vector borne diseases programme.

***Question: Are we going to wait before we put surveillance is place considering its rapid spread? How can we mobilise to contend the spread of Anopheles stephensi and avoid the next outbreak?***

Sarah Zody answered: In terms of evidence, there's been some studies in Ethiopia, which have found *P. vixax and P. falciparum* sporozoites in adult caught *Anopheles stephensi*, showing they can effectively transmit malaria.

**Entomological monitoring for larval source management against invasive malaria vector, *Anopheles stephensi*, in Ethiopia (Gashu Zegeye, PMI Evolve Project, Abt Associates)**

Ethiopia's primary malaria vector, *Anopheles arabiensis*, was joined by *An. stephensi* in 2016, now identified in 52 urban and peri-urban sites. About 69% of Ethiopia's population is at risk of malaria, necessitating robust control measures.

LSM began in eight urban towns in August 2022. Entomological monitoring aimed to assess the impact of LSM on larval density, habitat indices, and adult mosquito density. Baseline data was collected from July 25 to August 20, 2022, followed by weekly sampling of larvae, pupae, and adult mosquitoes. The mHealth tool guided larvicide dosage during biweekly visits to larval habitats.

Results showed a significant decline in larval density across the eight towns. On average, 87,996 properties were visited per cycle, with 30,046 larval habitats (44% of the total) treated directly and 1,741 habitats (3%) treated by spraying, using 2015 kg of VectoBac. Additionally, 36,191 larval habitats (53%) were source reduced. Pre-LSM enumeration ensured comprehensive coverage and high-quality intervention, facilitating accurate resource estimation and efficient deployment. Most larval habitats were artificial water containers, with slow-flowing river edges also identified as breeding sites.

Each property received an ID number for organised intervention. Artificial water containers like barrels, tanks, and cisterns, easily accessible and identifiable by Community Vector Control Teams (CVCTs), proved effective LSM targets. Larval surveillance indicated that slow-flowing river edges, requiring more frequent VectoBac WG applications, also served as breeding habitats.

High-quality LSM implementation resulted in significant declines in larval and pupal densities, and larval habitat indices compared to baseline data, consistently observed across the eight towns. Since early 2024, these towns have transitioned to community-based interventions. Quarterly meetings and staff training have ensured a successful transition and sustained operational benefits. This community-based approach is expected to maintain reduced mosquito populations and potentially lower malaria transmission rates. These findings underscore the importance of thorough enumeration, targeted intervention in artificial water containers, frequent larvicide application at river edges, and community involvement for effective VC and malaria prevention.

## Task Team 4: Vector control in humanitarian emergencies Co-leads: Joe Lewinski, Julius Kasozi

**Introduction to the Session and Task Team (Joe Lewinski, Consultant/ Julius Kasozi, UNHCR)**

**Current Situation and Challenges**

In 2024, over 114 million people are displaced globally, with nearly two-thirds residing in malaria-endemic regions. Malaria is the second leading cause of morbidity among refugees in these areas. Growing displacement and conflict situations have exacerbated the spread of malaria due to disrupted healthcare systems, overcrowded living conditions, and inadequate sanitation, creating ideal breeding grounds for malaria-carrying mosquitoes. Response efforts are hindered by limited funding, disjointed coordination, and restrictive regulations, resulting in inadequate resources for essential VC tools like ITNS and IRS.

**Climate Change Impact**

Climate change is anticipated to further influence malaria transmission patterns, complicating control efforts. The changing climate could lead to expanded habitats for malaria vectors, thus increasing the disease burden on vulnerable populations.

**Vector Control in Emergency Settings**

A new approach is necessary to enhance vector control in emergency settings. This includes proactive and pre-emptive actions to improve access and use of VC tools, despite the higher costs involved. The emphasis is on integrated VC measures into the emergency response framework, new tools, approaches, and multisectoral actions.

**Updates on the NEW Malaria and Emergencies Handbook**

An updated WHO Malaria and Emergencies Handbook is being developed, incorporating new guidance and aiming to be more actionable for emergency responders. The handbook will include comprehensive information on various vector control strategies such as insecticide-treated nets, indoor residual spraying, and larval source management. Additionally, the expansion of the vector control toolbox includes innovative tools like passive emanators, attractive targeted sugar baits, and insecticide-treated textiles.

**A look to the future, priorities and opportunities**

For 2024, the priorities include advocacy, coordination, expanding the vector control toolbox, and resource mobilization. Key recommendations for donors include improving pre-stocking of malaria commodities and increasing coordination and pooled funding. Countries are advised to create cross-border coordination frameworks and include refugees in health service delivery planning. Humanitarian partners should enhance data coordination to target malaria interventions effectively and work with community-based actors.

**A look to the future, priorities and opportunities Expanding the Vector Control Toolbox for Emergency Settings (Michael Macdonald, Consultant)**

In 2017, a pivotal meeting in Basel with stakeholders such as MSF, UNICEF, WHO, and the Mentoring Initiative led to a mission aimed at reducing suffering from VBDs in humanitarian emergencies. The mission focuses on improving the delivery and uptake of existing VC tools and developing new, evidence-based ones. It serves as a platform for researchers and industry to innovate tools tailored for humanitarian crises.

The presentation highlights five key tools:

- SRs not only repel mosquitoes but also inhibit feeding and increase mortality, offering personal and community protection. Studies in Thailand and Cambodia and field assessments in Northern Nigeria, Syria, and Yemen confirmed their effectiveness in emergency settings. Highly portable and idea for temporary shelters.
- IRS is another crucial tool, with efforts underway to expand its use to temporary and emergency shelters. Successful applications in Pakistan, following floods, showcased its potential. However, not all IRS formulations are equally effective on materials like tarpaulins, necessitating further research for practical guidelines.
- Larval control, though not new, is emphasised for settled camps rather than immediate emergencies. Programs like Goodbye Malaria and PMI are piloting larvicide applications with improved targeting technologies. Despite having 23 pre-qualified larvicides, Africa faces limited availability, which the initiative seeks to address by increasing access and sharing best practices.
- ATSBs are promising tools for environments with reduced vegetation and nectar sources, common in displaced persons' camps. Ongoing Randomised Controlled Trials in Kenya, Mali, and Zambia are assessing ATSB efficacy, aiming for submission to the Vector Control Advisory Group and Prequalification by the end of 2024.
- Etofenprox-treated textiles represent another innovative tool. Compared to permethrin, etofenprox offers superior wash resistance and a better safety profile. Initially developed for military uniforms, this technology is now being considered for blankets and other textiles, providing crucial protection during the initial days of an emergency before more permanent solutions are available.

The presentation concludes by emphasising the importance of an expanded toolbox for VC in humanitarian emergencies, including SRs, IRS, improved larvicide delivery, ATSBs, and etofenprox-treated textiles. Additionally, treated materials and animal treatments can provide further protection for displaced populations and their livestock.

**Improving Coordination and Delivery of Vector Control Commodities in Uganda (Julius Kasozi, UNHCR)**

Discussed integrating refugee health services into Uganda's national health system. Hosting 1.6 million refugees, Uganda is Africa's largest refugee host. The focus was on the high incidence of malaria among refugees and strategies to combat it through the Global Compact on Refugees (GCR) and the Comprehensive Refugee Response Framework (CRRF).

Uganda's Health Sector Integrated Refugee Response Plan (HSIRRP) ensures refugees access health services at the same level as the host population. Integration includes policies, strategies, programmes, and systems to accommodate refugees, who frequently arrive from Sudan, the Democratic Republic of Congo, and Kenya.

Refugees have a higher malaria incidence than the host population due to communal living and exposure during travel. Interventions include distributing LLIN, SBCC, early diagnosis and treatment, surveillance, and chemoprophylaxis for pregnant women.

Vector control coordination involves task forces and the NMCP. Inclusive quantification of commodities, considering refugees in planning, and integrated procurement led by the MoH and supported by

humanitarian partners ensures effective delivery. Logistics are tailored to refugee settlements, with humanitarian responders part of the national response.

Challenges for IRS include unsuitable infrastructure and high mobility of refugee households, but coverage and protection levels are comparable to those of the host population. The distribution of LLINs shows similar coverage between refugees and the host population, indicating effective planning and implementation There has been a reduction in malaria incidence among refugees following integrated vector management (IVM) interventions, with coverage and protection levels similar to those of the host population, indicating the success of integrated health service delivery.

MoH must include refugees in their population strategies and health programmes. LSM and chemoprevention remain challenging and require further support. Strategic information is needed to understand why refugees are more vulnerable to malaria, and research is necessary to address these vulnerabilities.

**Vector Control: learnings from implementing in emergencies (Katie Evans, The MENTOR Initiative)**

Learnings from vector control in emergency and conflict settings, focusing on their operations in various countries were presented. The necessity for ambition and adaptability in these challenging environments.

Displacement due to conflict increases exposure to disease vectors, exacerbated by malnutrition, leading to severe disease and death among displaced populations. Conflicts often last over 30 years, as seen in Sudan, West Africa, and Palestine, causing prolonged suffering and neglect, and leaving neighbouring countries vulnerable.

Significant data challenges were highlighted in conflict zones which complicate operational effectiveness. For example, the IRS campaign in Renk, South Sudan, faced challenges due to unexpected population movements. Located near the Sudanese border, Renk saw an influx of people, requiring flexible planning and funding to scale up operations quickly when the population size was initially underestimated.

Logistical challenges also include tool and water availability. In Cabo Delgado, Mozambique, securing water trucking in conflict zones proved difficult, especially before the rainy season. Technological advancements in tracking and real-time data monitoring improve safety and supervision but are limited by infrastructure constraints in many areas, such as the Central African Republic, where only major towns have network coverage.

Humanitarians face increased risks, becoming targets for physical attacks and disinformation campaigns, which undermine their efforts. Recruiting and training local staff, particularly women, is challenging due to literacy issues and the complexity of data collection required. Despite these hurdles, MENTOR is committed to distributing LLINs and conducting IRS, while advocating for tools better adapted to specific circumstances.

The lack of research funding hampers the ability to build a robust evidence base necessary for effective response and policy changes. This inadequacy impacts global health goals, not only in affected areas but also in neighbouring regions, as disease vectors do not respect borders. Eve emphasised the need for flexible funding and continued innovation to address these ongoing challenges and improve the effectiveness of vector control in emergencies.

**Q&A**

Comment: What we are trying to convince policy makers etc, this is not business as usual once these are emergencies. If we can take lessons from our response to Ebola and Covid in terms of public-private partnerships, in terms of expedited reviews, in terms of emergency use listing. We need to act now.

***Question: Do we need specific data on the efficacy in humanitarian emergencies for WHO to recommend? Or can you implement on basis of existing recs? Thinking if spatial emanators get a policy recommendation for example?***

Katie Evans answered: With a National Control Programme (NCP) that is willing to adopt our ideas, we can sure.. However, I understand that the National Malaria Control Programme (NMCP) may prefer to adhere to WHO guidelines, which is completely understandable. We are working with passive emanators through our research in Aden, in northeast Nigeria, and we have also used them in Syria. We are gradually rolling them out in the Central African Republic. in specific cases where severely acutely malnourished children cannot reach therapeutic feeding units (TFUs).

Comment: We need data on the efficacy in humanitarian populations. However, it is important to understand what indicator we are using. Is it prevalence, incidence, or simply looking at mortality? Mortality in specific populations needs to be understood depending on the emergencies we are focused on.

Katie Evans responded: I was just going to say that regarding mortality data, it depends on the type of emergencies. In some protracted emergencies, many people may die at home and thus not be visible to the system, so another indicator might be more appropriate. We need to remain flexible in our approach.

Comment: It's my understanding that the WHO is updating the emergency use listing not just for vector control products, but also for various drugs, vaccines, and other products. Vector control is part of this emergency use listing revamp within the WHO. We hope to keep it there and ultimately enable products in the vector control pipeline to be used in emergency settings. It's not ready yet.

Comment: I would like to say one last word about the upcoming WHO Manual. There is an annex in the manual on what I call threat assessment. This section is designed for less trained, non-professional entomologists. It provides guidance for workers in complex emergencies on determining if there is disease transmission in the area, identifying the vectors, and performing basic monitoring. We are also exploring citizen science applications that can be used by WASH and sanitation workers to help identify vectors in the area. This falls under the rubric of threat assessment: determining whether there is malaria transmission, identifying the vector, and then proceeding from there. Entomological monitoring for humanitarian emergencies has significant overlap with community-based monitoring in sustained programs.

***Question: Working in places of ongoing conflict?***

Katie Evans answered: It is possible. People are generally receptive to control measures. Having worked in such conditions, from experience, militias are likely to let survivors in (after working with local communities.) to administer VC tools as they understand their need and importance widely.

***Question: MENTOR Initiative does not work in Sudan currently. Why? How to work in countries that are hard to access?***

Katie Evans answered: At MENTOR we are reliant on institutional donors, and we can't work in Sudan due to a lack of funding. However we are working on the borders, in places like Chad, to support.

## Wednesday 17th April 2024

**3 Minute Sponsor Pitches (Envu- Christine Ochieng, Goizper- Iñigo Garmendia, MESTO- Wolfram Wagner, Mitsui- Takeo Maezawa, RAFT- Jo Lines, Syngenta- Rose Peter, Vestergaard- Alexis Kamdjou)**

The sponsors of VCWG-19 are called on stage and give 3-minute pitches:

- ENVU has introduced Fludora Fusion, a combination of clothianidin and deltamethrin. This product is designed to be difficult for insects to develop resistance against, making it an ideal component of insecticide resistance programmes. It is self-protecting and compatible with IRS and PBO products.
- Goizper, a company specialised in various sectors, has focused on field collaboration over the past 15 years. They launched the first non-metallic sprayer that meets WHO standards. Their latest

innovation, the IK Smart Light, includes a laser for measuring spray distance and an app that collects and visualises spraying data. This solution supports IRS programmes by enhancing spray performance and tracking.

- MESTO, a German company, is known for its ergonomic sprayer designs with stainless steel parts, visible measurement marks, and high stability. Their sprayers include a filling strainer, ergonomic shut-off valve, and a support box for team leaders and storekeepers. Spare parts are available for 20 years. They are funded by GF, WAMBO, and UNICEF, and their products feature a laser distance device.
- The Vectron T500 is an IRS product featuring the active ingredient Tenebal in powder form. It is registered for use in 19 countries and is under development in seven more. In 2023, it moved from the development to the implementation phase, supported by IVCC, PMI, the Gates Foundation, and the Global Fund.
- The RAFT programme is a six-year research initiative focused on malaria and arboviruses in Sub-Saharan Africa and Southeast Asia. It addresses short-term threats like resistance management, coverage gaps, and operational issues, as well as long-term threats like emerging mosquito threats and planning for malaria eradication. Research areas include LLIN performance, *Aedes* behaviour, e-DNA surveillance, and the impact of urbanisation on malaria vectors.
- Syngenta has submitted results of a new product for prequalification approval. They have discovered a new binding site that helps overcome resistance, contributing to more effective insecticide solutions.
- Vestergaard has produced over 1 billion bed nets and is investigating the life cycle and usage patterns of LLINs. They aim to understand how households use and maintain bed nets, the triggers for discontinuing their use, and end-of-life management. They are exploring opportunities for recycling and repurposing nets to ensure sustainable usage and disposal.

Corine thanks the sponsors for their contribution and presentations.

**IVCC strategy update (Justin McBeath, IVCC)**

Last year, the CEO underwent a change in leadership, prompting a strategic review focusing on strategy and innovation. Core funding remains essential, with some funding being specifically allocated. Their vision and mission encompass all vector-borne diseases (VBD) and aim to sustain the tools used to combat them. During consultations, key elements of change were assessed to help partners address market gaps and innovation and product needs.

The organisation evaluates technologies within scope and emphasises their strategic message. They consider the time span required for the product development process and have a structured strategy in place. Collaboration with the industry is crucial for the continued use of tools like IRS, ITNs, and spatial emanators. Funding partnerships are sustained to support these initiatives. The organisation provides a visual representation of their strategy and structure, highlighting recruitment opportunities within IVCC.

**PAMCA 2025 conference (Corine Karema, PAMCA)**

PAMCA was created in 2009 and officially established in 2011. Since then, many changes have taken place, prompting a reassessment of how PAMCA can be fit for purpose in the evolving vector control landscape. There is a focus on improving PAMCA, rethinking its approach, and determining how it can best serve its mission.

**Introducing the new Global Elimination Interest Group (Allison Tatarsky, UCSF)**

The Global Elimination Interest Group is currently under the PMI and aims to share ideas and exchange knowledge at a global level. It focuses on the early elimination phase in districts and provinces, primarily facilitating knowledge exchange rather than offering technical advice. The goal is to build on both global and regional experiences.

The group has gathered with NMCPs and has over 125 members to date. For 2024, the work plan includes tackling cross-cutting topics and bringing together thematic areas in malaria elimination. The EIG seeks to find synergies in various topic areas and unite communities. As donor financing shifts, the group is also aiming to become an RBM Working Group and is in the process of submitting an application.

**The role of vector control in malaria eradication: where are we? (Helen Jamet, BMGF)**

***Question: There is a lot of innovation happening, but why isn't LSM getting more attention?***

Helen Jamet: LSM hasn't always been a strategic priority because we aim to bring the most value with our funds. There's already a lot of work being done in this area. However, we managed to secure additional funds this year, thanks to our co-chairs, which allowed us to invest more in this area.

***Question: Can you tell us about the new tools being developed for mosquito species identification?***

Helen Jamet: Yes, the VectorCam app, which we demonstrated at OMCA last year, will be very helpful. It's sensitive to sibling species and can quickly scan and identify the mosquito species present. This combined with other tools will provide much more accurate data.

***Question: In many countries, malaria might soon be history. How are Aedes-borne viruses being targeted?***

Helen Jamet: Securing funding specifically for *Aedes*-borne diseases has been challenging due to issues like outdoor biting at different times of the day. However, we're looking to capitalize on malaria funding to address other diseases. Projects like Oxitec's work in Brazil have shown promising results, generating excitement and success. The investment in the World Mosquito Program, particularly in Wolbachia-infected mosquitoes, shows impact, but scaling up remains difficult. This is a key discussion point for our future strategy.

***Question: How do you make decisions given limited funding and expanding needs?***

Helen Jamet: We are collaborating with multiple partners, including PMI, RBM, and country representatives, to fund joint efforts. We're developing a five-year plan to bring together different communities and identify areas where we need alignment. This plan will help us push forward by the end of the year.

**Question: What is IVCC doing to ensure user acceptance of ITNs? Are there other tools excluded from your strategy, particularly for outdoor transmission?**

Justin McBeath: Our primary focus is on ITNs, but we are also considering additional modes of action. We evaluate chemistry and cost-effectiveness, ensuring we do not compromise user acceptance, which is critical for effectiveness. For outdoor tools, we look at scalable options and exclude certain elements due to regulatory implications. We aim to address the most accessible opportunities first.

## Roundtable discussion and closure

## Climate Change, Climate-Related Emergencies and Vector Control

The WHO has identified climate change as a significant threat. Climate variability, including changes in temperature and rainfall, affects the transmission burden of vector-borne diseases. The inability to migrate exacerbates this issue, leaving populations vulnerable. During a recent panel discussion, experts provided insights on the impacts of climate change on malaria and other vector-borne diseases. A panel of experts discussed pressing issues.

**Abdisalan Noor**

Abdisalan Noor, a lead author of a dedicated chapter in the World Malaria Report, emphasised that there is limited evidence available on the relationship between climate change and malaria. The attempt to quantify

these pathways is ongoing, but it is clear that malaria continues to have a wide geographic extent. Climate change affects the life cycle of mosquitoes and parasite development. Specifically, changes in temperature and rainfall influence larval development, the blood-feeding process, and the overall vectorial capacity of mosquitoes. Non-linear relationships between temperature and vectorial capacity indicators highlight the complex effects of climate change. The Intergovernmental Panel on Climate Change (IPCC) projects various scenarios, with SSP2 being the most likely and SSP5 the worst-case scenario. The frequency and magnitude of extreme weather events have increased globally, directly expanding transmission limits, and increasing the sustainability of malaria transmission.

**Mohammad Mukhtar**

Mohammad Mukhtar from Directorate of Malaria Control Pakistan discussed the severe impact of climate change on his country, which ranked as the 5th most affected by climate change from 2002 to 2020. Pakistan has experienced significant increases in temperature and extreme weather events, particularly over the last two decades. Notably, there has been a 50°C increase in heatwaves and a dramatic rise in rainfall intensity. In 2020, Pakistan saw a 190% increase in rainfall, affecting two provinces with a 340% increase, leading to 2000 deaths and the destruction of 2000 health facilities and 47,000 km of roads. This state of emergency has resulted in a resurgence of malaria cases to the highest levels in the last 50 years. The NMP in Pakistan has responded by distributing insecticide-treated nets (ITNs) and developing guidelines and strategic plans to handle such emergencies, focusing on local production and distribution of vector control products. However, challenges remain, including coordination between partners and quality concerns during emergencies.

**Achim Redding**

Baltazar Candrinho from NMCP Mozambique highlighted the challenges of container shortages and the importance of maintaining flexible supply chains to deliver mosquito nets. Collaborating with partners like the Global Fund, BASF focuses on sustainable agricultural practices, including irrigation systems and rice breeding, to reduce vector pressure. He stressed the importance of local manufacturing and sourcing materials to reduce the carbon footprint and improve sustainability in vector control efforts.

**Kenny Onasanya**

Kenny Onasanya from Unitaid discussed the organisation's climate and health strategy, which aims to reduce carbon emissions by 2030. Unitaid is focusing on understanding the intersections between climate and health to deploy technical solutions effectively. The recently commissioned Megaton Report highlights technical solutions that can be deployed by stakeholders to mitigate the impact of climate change on health.

**Helen Jamet**

Helen Jamet from the BMGF expressed concerns about the potential rollback of progress in malaria control due to climate change. She emphasised the importance of investing in understanding local climate patterns, early warning systems, and resilient health systems. The foundation is working on climate models to adjust seasonal malaria prophylaxis timing and is investing in long-lasting interventions, such as larvicides and insecticides, to manage the impact of climate change on malaria transmission.

**Sarah Zohdy**

Sarah Zohdy from the President’s Malaria Initiative (PMI) discussed the establishment of a climate change council to identify and mitigate climate change impacts on malaria programming. PMI is expanding its vector control toolbox and improving data systems for better response planning. Efforts include ensuring climate data accessibility and providing quick response and contingency planning, such as maintaining ITN reserve stocks.

**Kate Kolaczinski**

Kate Kolaczinski from The Global Fund discussed the organisation's embedded response to the climate emergency within its strategy. The focus is on resilience and flexibility in health systems to respond to rapidly changing conditions. Efforts include stockpiling commodities in climate event-prone areas and integrating climate resilience into grant cycles. The Global Fund aims to ensure that health systems can respond effectively to climate-related emergencies by building resilience and adapting to changing needs and circumstances.

**Conclusion:**

Climate change has a significant impact on malaria and other VBDs. The global response must include proactive measures across multiple domains, including improved data collection, flexible supply chains, resilient health systems, and innovative vector control strategies. Collaborative efforts between public and private sectors, as well as regional and global stakeholders, are essential to mitigate the effects of climate change on vector control and disease transmission.

**Work Stream highlights, next steps**

Corine engages with the audience and goes through the Work Stream highlights, capturing the vast breadth of expansive topics covered. She announced Christen Fornadel of IVCC as the new co-lead for Work Stream 1 who is taking over Allan Were of MSH who's term has come to an end.

W**ay forward in 2024-2025**

Corine states that the VCWG would like a platform on which information can be shared readily, instead of waiting until the next year for the next meeting. There is a continued call for breaking the silos, and encouraging collaboration, with the likes of APMEN and *Aedes* control programmes. She encourages attendees to publish their findings and ideas in the name of RBM/VCWG to further foster platforming. Finally, Corine reminded attendees that the next annual meeting will mark the 20th anniversary of the VCWG and special activities will be planned to celebrate the achievements of the Group.

Corine and Konstantina end the 19th Annual VCWG meeting by thanking the attendees.

## Wednesday 17th April 2024

## Joint meeting Vector Control & Multi-Sectoral Working Groups : The role of multisectoral approaches to vector control

## Co-chairs: Corine Ngufor & El Hadji Amadou Niang (VCWG) & Graham Alabaster & Peter Mbabazi (MSWG)

**Update from RBM VCWG (Corine Ngufor, El Hadji Amadou Niang)**

**Objectives of the VCWG:**

1. Aligning Partners: Ensure all RBM partners follow best practices to maintain universal coverage with effective vector control interventions.

2. Supporting Implementation: Facilitate the application of WHO-generated vector control guidance to help achieve specific malaria elimination targets.

**Membership and Participation:**

- Participants: Includes national programmes, product manufacturers, academia, implementers, policymakers, multi-laterals, and civil society organisations (CSOs).
- Annual Meetings:

- 18th meeting (Feb 2023) in Accra, Ghana: ~339 participants from 49 countries.

- 19th meeting (April 2024) in Kigali: 221 registrants from 43 countries as of April 2024.

**Work streams and Themes:**

**Three Work Streams, each focusing on different themes and tasks:**

1. Enhancing the Impact of Core Interventions: Improving the effectiveness of insecticide-treated nets (ITNs) and indoor residual spraying (IRS).

2. Expanding the Vector Control Toolbox: Innovating new tools and strategies for vector control.

3. Implementing the Global Vector Control Response: Ensuring comprehensive and effective global responses to vector control challenges.

**Key Achievements in 2023**

1. Guidance Documents: Developed documents including the Global Vector Control Response to invasive *Anopheles stephensi* and guidance for evaluating vector control interventions.

2. New Task Teams: Established teams focusing on vector control in humanitarian emergencies.

3. Workshops and Meetings: Participated in workshops to update the RBM strategy and held board meetings to discuss progress and future steps.

**Challenges and Focus Areas**

- *Anopheles stephensi* Invasion: Highlighted the spread of this vector in Africa and the associated increase in urban malaria. Calls for collaborative efforts to combat its spread.
- Vector Control in Humanitarian Emergencies: New initiatives to protect displaced populations from vector-borne diseases, with events and statements to raise awareness.

**Update from RBM MSWG (Graham Alabaster, Peter Mbabazi)**

The MSWG Updates presentation from April 17, 2024, provided an overview of the group's recent activities, achievements, challenges, and future plans within the RBM Partnership to End Malaria. The session was Co-chaired by Graham Alabaster (UN-Habitat) and Peter Mbabazi (Ministry of Health Uganda), and coordinated by Konstantina Boutsika (Swiss TPH).

In 2023, the MSWG made progress with the Malaria Multisectoral Action Framework, emphasizing the importance of actions outside the health sector. The framework and the joint WHO/UN-Habitat Urban Malaria Framework gained traction. The MSWG participated in regional meetings in Nairobi, Harare, Dakar, and Brazzaville, and hosted the 5th RBM MSWG Annual Meeting in Accra, Ghana. This meeting included panels with city mayors and the private sector, focusing on the Healthy Cities Healthy People Initiative and Pathfinder projects. The joint session with the VCWG was successful.

Challenges included securing funding for the Healthy Cities Healthy People and Pathfinder initiatives, recruiting more multisectoral partners into the MSWG, and integrating multisectoral engagement as a global fund priority.

For 2024, the MSWG plans to develop performance indicators for multisectoral engagement through consultations with members, ensuring NMCPs include these objectives in their strategic plans. The CRSPC will recruit consultants to support countries in multisectoral engagement, trained by the MSWG. The group will engage with The Lancet Commission on *Aedes*-borne diseases and include multisectoral engagement progress reporting in annual SRN meetings. Interim feedback sessions to discuss the results of annual MSWG meetings will continue.

The presentation highlighted opportunities from The Yaoundé Ministerial Declaration, which emphasizes local leadership and enhanced coordination mechanisms for malaria control at subnational levels. This strategy involves various sectors and stakeholders to ensure a unified response to malaria, focusing on strong leadership in multisectoral action to provide appropriate tools to at-risk populations, including those in hard-to-reach and conflict areas.

The Lancet Commission on *Aedes*-borne diseases identified major cities at risk from *Aedes*-transmitted diseases. Preventative measures such as environmental modifications, proactive vector control, wide-scale vaccination, and disease and mosquito surveillance are necessary. Collaboration with rapidly growing impoverished communities is essential for developing innovative solutions.

In conclusion, the MSWG continues to focus on multisectoral approaches to malaria control, addressing challenges and leveraging opportunities to enhance coordination and engagement across sectors. The group aims to integrate these strategies into future urban planning and disease control efforts.

**Building a broader approach to mosquito management across the built environment (Seth Irish, WHO GMP)**

The presentation by Seth Irish, a technical officer at the GMP WHO, focuses on expanding mosquito management in urban settings, highlighting the need for a broader approach.

Seth explains that urban areas, with their complex environments, are crucial for intervention compared to rural settings. Urban areas include diverse housing and water systems, and larval sites that support mosquito vectors like *Aedes aegypti*, *Aedes albopictus*, and *Anopheles stephensi*. Cities have better capacities to manage these diseases.

The presentation reviews suitable interventions for urban settings. While IRS and ITNs are used, the additional use of house screening and LSM is emphasised. Space spraying is not recommended due to insufficient evidence of its impact on malaria control.

WHO guidance stresses an integrated response to vector-borne diseases, considering others besides malaria, such as those borne by *Aedes* mosquitoes. Effective management requires community

engagement, urban-specific surveillance, and enhanced cross-sector capacity. Collaboration beyond the health sector, involving urban planning, environmental management, and civil engineering, is crucial.

The need for broader mosquito management is discussed. Many factors contributing to malaria transmission are managed by city governments or private companies, such as sanitation, road construction, drainage, and water supply. Solely focusing on the health sector leads to a limited response. Greater engagement with urban planning, housing construction, and environmental management professionals is needed for effective changes.

In conclusion, it is stressed that urban settings need special attention due to their complexity and management capacity. Expanding malaria prevention beyond the health sector and integrating efforts from various fields is essential for comprehensive mosquito management. This strategy leverages existing guidelines and encourages innovative, collaborative solutions to address malaria transmission in urban settings. Intersectoral communication and cooperation are key to managing all aspects of the built environment contributing to mosquito proliferation.

**Building a broader approach to mosquito management across the built environment (Michael Macdonald, consultant)**

The presentation by Michael Macdonald focuses on expanding mosquito management strategies within urban environments. It emphasises the integration of healthy city initiatives, global frameworks for urban malaria control, and vector management responses, with a strategic partnership with private pest management associations. Key tactical opportunities identified include improved targeting and delivery of LSM, leveraging urban agriculture, utilising space sprays, microcredit for housing improvements, and enhancing surveillance and citizen science initiatives. The presentation advocates for establishing institutional training networks and devolved vector control services supported by intersectoral collaboration.

Technological advancements highlighted include the use of unmanned aerial systems for remote sensing and larvicide delivery, and wide area larviciding, supported by citizen science and information management tools like ZZAPP. The importance of urban agriculture, especially in cities like Accra, is highlighted, linking microfinance and payments to incremental housing improvements.

A significant part of the strategy involves modifying unimproved housing to provide equitable mosquito protection, which can be achieved cost-effectively by closing gaps with treated netting. This method has shown high efficacy against multiple mosquito species and high user acceptance, with the potential to provide protection at a cost comparable to ITNs. The presentation concludes that house screening is a flexible, less disruptive, and a longer-lasting alternative to IRS, with broad acceptance among residents and substantial protective benefits against VBDs.

***Locally focused approaches to financing:* Uganda's experience regarding IRS Financing (Robert Mugerwa, Uganda NMCD)**

Uganda's approach to financing IRS as part of its National Malaria Strategic Plan 2021-2025. The plan targets high-burden districts, with DFID and PMI currently funding sixteen districts, though DFID exited 6 districts in 2022, and GF supports 14 more.

The business case for IRS includes a defined target market, a clear needs assessment, and an IRS marketing strategy. The need for modelling the impact of IRS in target areas is emphasised. Malaria Free Uganda (MFU) leads various resourcing efforts, including in-kind and financial contributions from companies, with a total of $505,000 raised in 2023. Corporate Social Responsibility (CSR) initiatives are highlighted for their community impact and employee morale benefits. Foundations like MFU engage in advocacy activities, including engagements with parliament, private sector advocacy, presidential recognition, cultural and religious engagements, and sports events for resource mobilization.

Copayment mechanism for malaria commodities, particularly QAACTs, aims to increase access, especially in rural areas, by assessing supply chain networks, pricing, and availability. The mechanism involves various markups and subsidies, detailed in the presentation.

Free market principles and pooled procurement are discussed, with pooled procurement noted for quality control, reduced prices, and faster processes, though it may sideline local industries and reduce national control.

Out-of-pocket expenditures and domestic resource mobilization efforts are noted, with policies drafted for workplace malaria strategies in companies. Mechanisms to engage the private sector include private spray associations, schools, hospitals, hotels, military barracks, and manufacturing companies.

Potential private sector purchasers for financing IRS include private companies, mission hospitals, NGOs, Rotary clubs, private philanthropists, and pest control companies, with specific mention of Pilgrim Africa's sprayer model. The presentation concludes with notes on hiring spray teams and regulatory oversight for pest control industries.

**New Routes to Market (David McGuire IVCC)**

Uganda's approach to financing IRS is part of its National Malaria Strategic Plan 2021-2025. The plan targets high-burden districts, with DFID and PMI currently funding 16 districts, though DFID exited 6 districts in 2022, and GF supports 14 more.

The business case for IRS includes a defined target market, a clear needs assessment, and an IRS marketing strategy. The need for modelling the impact of IRS in target areas is emphasised. Malaria Free Uganda (MFU) leads various resourcing efforts, including in-kind and financial contributions from companies, with a total of $505,000 raised in 2023. Corporate Social Responsibility (CSR) initiatives are highlighted for their community impact and employee morale benefits. Foundations like MFU engage in advocacy activities, including engagements with parliament, private sector advocacy, presidential recognition, cultural and religious engagements, and sports events for resource mobilisation.

The copayment mechanism for malaria commodities, particularly QAACTs, aims to increase access, especially in rural areas, by assessing supply chain networks, pricing, and availability. The mechanism involves various markups and subsidies, detailed in the presentation.

Free market principles and pooled procurement are discussed, with pooled procurement noted for quality control, reduced prices, and faster processes, though it may sideline local industries and reduce national control.

Out-of-pocket expenditures and domestic resource mobilisation efforts are noted, with policies drafted for workplace malaria strategies in companies. Mechanisms to engage the private sector include private spray associations, schools, hospitals, hotels, military barracks, and manufacturing companies.

Potential private sector purchasers for financing IRS include private companies, mission hospitals, NGOs, Rotary clubs, private philanthropists, and pest control companies, with specific mention of Pilgrim Africa's sprayer model. The presentation concludes with notes on hiring spray teams and regulatory oversight for pest control industries.

**Malaria Control Program, Benso Oil Palm Plantation (BOPP), PLC (Samuel Asare-Bediako Benso Oil Palm Plantation, Ghana)**

The MCP at Benso Oil Palm Plantation (BOPP) PLC, Ghana was initiated to tackle the high incidence of malaria among its workforce and their dependents. Established in 1976 as a joint venture between the Ghanaian Government and Unilever, BOPP is now managed by Wilmar, covering a 6799-hectare concession with a significant population residing on the estate.

Malaria accounts for 30-45% of outpatient cases at BOPP, leading to significant lost workdays. In response, the company launched its Malaria Control Programme in 2017, aiming to reduce malaria by 50% within five years. Measures include sanitation improvements, distribution of insecticide-treated nets, early testing, treatment, and follow-up.

In 2021, Indoor Residual Spraying (IRS) was introduced, involving training spray operators, orienting beneficiaries, implementing spraying activities, and conducting spray quality and efficacy tests with support from AGAMal Ltd and IVCC. IRS has been consistently carried out from 2021 to 2023.

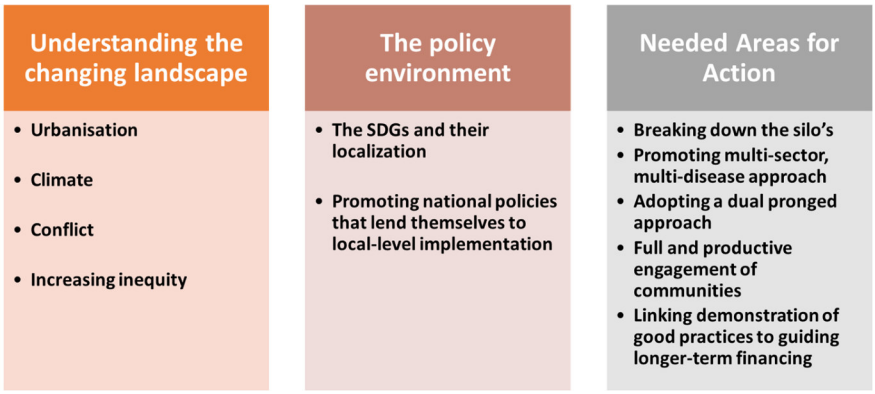
By 2023, malaria cases on the estate had reduced by 13.2%, with a 20% reduction in cases three years post-IRS compared to the three years prior. This has improved workforce confidence in management's commitment to their health, increased malaria awareness, and provided protection for 3805 people on the estate. Additionally, there has been a notable reduction in domestic insects.

The programme's success highlights the need for a multi-pronged approach to combat malaria. BOPP has also built local capacity for IRS, positioning itself to support other entities interested in similar programmes. The ongoing efforts and collaborations underscore BOPP's commitment to the health and well-being of its workers and their dependents.

**Opinion/commentary article (1.5-2 pages) for the broader audience**

**Two-way dialogue, vision and areas where the two WGs are working together in a complementary way**

The attendees are thanked for taking part in the first collaborative meeting between the VCWG and MSWG group. List of outcomes from the joint meeting:




**List of acronyms**

AGA Mal – AngloGold Ashanti Malaria

APMEN - Asia Pacific Malaria Elimination Network

ATSB - Attractive Targeted Sugar Bait

BMGF - Bill & Melinda Gates Foundation

BOPP - Benso Oil Palm Plantation

Bti - *Bacillus thuringiensis israelensis*

Bs – *Bacillus subtilis*

CAF - Climate Adaptation Fund

CFP - Chlorfenapyr

CHAI - Clinton Health Access Initiative

COE - Complex Operating Environment

CRRF - Comprehensive Refugee Response Framework

CSO - Civil Society Organisation

DFID - Department for International Development

EPI – Expanded Programme on Immunization

EMRO - Eastern Mediterranean Region Organisation

ESPT - Entomological Surveillance Planning Tool

FY - Fiscal Year

GF - Global Fund

GMP - Global Malaria Programme

GOR - Government of Rwanda

HSIRRP - Health Sector Integrated Refugee Response Plan

IRS - Indoor Residual Spraying

ITN - Insecticide-Treated Net

IVM - Integrated Vector Management

LLIN - Long-Lasting Insecticidal Net

LSM - Larval Source Management

MINT - Malaria Intervention Tool

MoH - Ministry of Health

MSF - Médecins Sans Frontières (Doctors Without Borders)

MSWG - Multi-Sectoral Working Group

NGO - Non-Governmental Organisation

NMCP - National Malaria Control Programme

NMEP - National Malaria Elimination Programme

PAHO - Pan American Health Organization

PMI - President's Malaria Initiative

PQ - Prequalification

PQR - Prequalification of Medicines Programme

PTP - Push-Pull Technology

PY - Pyrethroid

RBM - Roll Back Malaria

RBC - Rwanda Biomedical Centre

SIT - Sterile Insect Technique

SE – Spatial Emanator

SR - Spatial Repellent

UNHCR - United Nations High Commissioner for Refugees

USAID - United States Agency for International Development

VBD - Vector-Borne Disease

VC - Vector Control

VCAG - Vector Control Advisory Group

VCNAs - Vector Control Needs Assessments

VCWG - Vector Control Working Group

WHO - World Health Organization

WSH - Water, Sanitation, and Hygiene