Contents

Selected Recent Publications 2

Experimental Hut Trials Reveal That CYP6P9a/b P450 Alleles Are Reducing the Efficacy of Pyrethroid-Only Olyset Net against the Malaria Vector Anopheles funestus but PBO-Based Olyset Plus Net Remains Effective 2

Impact of a spatial repellent product on Anopheles and non-Anopheles mosquitoes in Sumba, Indonesia 2

Leveraging mathematical models of disease dynamics and machine learning to improve development of novel malaria interventions 3

Enhancing the Quality of Spray Application in IRS: Evaluation of the Micron Track Sprayer 3

Incremental cost and cost-effectiveness of the addition of indoor residual spraying with pirimiphos-methyl in sub-Saharan Africa versus standard malaria control: results of data collection and analysis in the Next Generation Indoor Residual Sprays (NgenIRS) project, an economic-evaluation 4

Assessing the impact of a novel house design on the incidence of malaria in children in rural Africa: study protocol for a household-cluster randomized controlled superiority trial 4

Modified World Health Organization (WHO) Tunnel Test for Higher Throughput Evaluation of Insecticide-Treated Nets (ITNs) Considering the Effect of Alternative Hosts, Exposure Time, and Mosquito Density 5

Estimating female malaria mosquito age by quantifying Y-linked genes in stored male spermatozoa 5

Efficacy of a spatial repellent for control of Aedes-borne virus transmission: A cluster-randomized trial in Iquitos, Peru 5

A closer look at the WHO cone bioassay: video analysis of the hidden effects of a human host on mosquito behaviour and insecticide contact 6

Inferring the epidemiological benefit of indoor vector control interventions against malaria from mosquito data 6

To spray or target mosquitoes another way: focused entomological intelligence guides the implementation of indoor residual spraying in southern Mozambique 6

Building International Capacity for Citizen Scientist Engagement in Mosquito Surveillance and Mitigation: The GLOBE Program's GLOBE Observer Mosquito Habitat Mapper 7

Back to the Future: Quantifying Wing Wear as a Method to Measure Mosquito Age 7

Comparison of entomological impacts of two methods of intervention designed to control Anopheles gambiae s.l. via swarm killing in Western Burkina Faso 8

Over half of known human pathogenic diseases can be aggravated by climate change 10

Malaria Transmission in Sahelian African Regions, a Witness of Climate Changes 10

Biolarviciding implementation in southern Tanzania: Scalability opportunities and challenges 10

Mass Trapping and Larval Source Management for Mosquito Elimination on Small Maldivian Islands 11

WHO News and Publications 12

Updated WHO guidance for monitoring resistance in mosquito vectors 12

Monitoring resistance in mosquito vectors: Updated guidance from the World Health Organization 12

Malaria surveillance assessment toolkit 13

New vector control PPCs 13

Webinars, websites and other resources 13

Recent Meetings and Webinars 13

Summary of the 8th PAMCA Annual Conference and Exhibition from the MESA Correspondents 13

Ifakara Master Classes in Public Health & Medical Entomology 13

APMEN Webinar YouTube channel 14

Malaria Operational Research and Program Evaluation Priorities as Defined by Sub-Saharan African Countries 14

The Economics of Resistance 14

Massive Open Online Course on The Resistant Mosquito: Staying Ahead of the Game in the Fight against Malaria 15

Greenwood Africa Lecture 2022 with Dr. Corine Ngufor 16
AMCA publishes supplemental training manual on "Mosquito Management During a Public Health Emergency" 16
Highlights from the Kigali Summit on Malaria and NTDs 16
MESA Track has expanded 16
In the news and social media 17
PMI Welcomes New U.S. Global Malaria Coordinator 17
Floods, heat and other climate hazards are turning 218 infectious diseases into bigger threats, study says 17
Why the Interceptor G2 net could be a game changer for malaria eradication 17

Selected Recent Publications

Experimental Hut Trials Reveal That CYP6P9a/b P450 Alleles Are Reducing the Efficacy of Pyrethroid-Only Olyset Net against the Malaria Vector Anopheles funestus but PBO-Based Olyset Plus Net Remains Effective

Pathogens 1 June 2022

Metabolic resistance in major malaria vectors such as *An. funestus* is jeopardizing the effectiveness of long-lasting insecticidal nets (LLINs) to control malaria. Here, we used experimental hut trials (EHTs) to investigate the impact of cytochrome P450-based resistance on the efficacy of PBO-based net (Olyset Plus) compared to a permethrin-only net (Olyset), revealing a greater loss of efficacy for the latter. EHT performed with progenies of F5 crossing between the *An. funestus* pyrethroid-resistant strain FUMOZ and the pyrethroid-susceptible strain FANG revealed that PBO-based nets (Olyset Plus) induced a significantly higher mortality rate (99.1%) than pyrethroid-only nets (Olyset) (56.7%) ($p < 0.0001$). The blood-feeding rate was higher in Olyset compared to Olyset Plus (11.6% vs. 5.6%; $p = 0.013$). Genotyping the *CYP6P9a/b* and the intergenic *6.5 kb structural variant* (SV) resistance alleles showed that, for both nets, homozygote-resistant mosquitoes have a greater ability to blood-feed than the susceptible mosquitoes. Homozygote-resistant genotypes significantly survived more with Olyset after cone assays (e.g., *CYP6P9a* OR = 34.6; $p < 0.0001$) than homozygote-susceptible mosquitoes. A similar but lower correlation was seen with Olyset Plus (OR = 6.4; $p < 0.001$). Genotyping EHT samples confirmed that *CYP6P9a/b* and *6.5 kb_SV* homozygote-resistant mosquitoes survive and blood-feed significantly better than homozygote-susceptible mosquitoes when exposed to Olyset. Our findings highlight the negative impact of P450-based resistance on pyrethroid-only nets, further supporting that PBO nets, such as Olyset Plus, are a better solution in areas of P450-mediated resistance to pyrethroids.

Impact of a spatial repellent product on Anopheles and non-Anopheles mosquitoes in Sumba, Indonesia

Malaria Journal 3 June 2022

This study evaluated the impact of a transfluthrin passive emanator (i.e. "spatial repellent") product on both *Anopheles* and non-*Anopheles* landing rates, among other endpoints, in a field setting over the course of the parent study baseline and intervention period.

Overall, the intervention was documented to have an impact on landing rates in all anthropophagic mosquitoes, with the impact being measured on malaria. These results are encouraging and support the spatial repellent paradigm towards both malaria and other vector borne diseases. This study documented a limited reduction (*Anopheles* HBR indoor: 16.4%; outdoor: 11.3%) in landing mosquitoes exposed to the active treatment compared to the placebo-control. The large variation seen between households and clusters, and the resulting wide confidence intervals resulted in low statistical significance. However**, a statistically significant decrease on malaria infection related to the intervention was detected (60% protective efficacy) in these clusters**. This discrepancy of SR impact on malaria incidence and entomological correlates was also observed in another study, where a 32% reduction of *Anopheles* landing rates yielded a 52% reduction on malaria incidence. The seemingly higher reduction in infections relative to the reduction in landing rates may indicate the accumulation of other SR impacts not limited to the reduction in landing. In addition to an impact on landing (repellency), exposure to the SR active may result in several other phenomena. These include

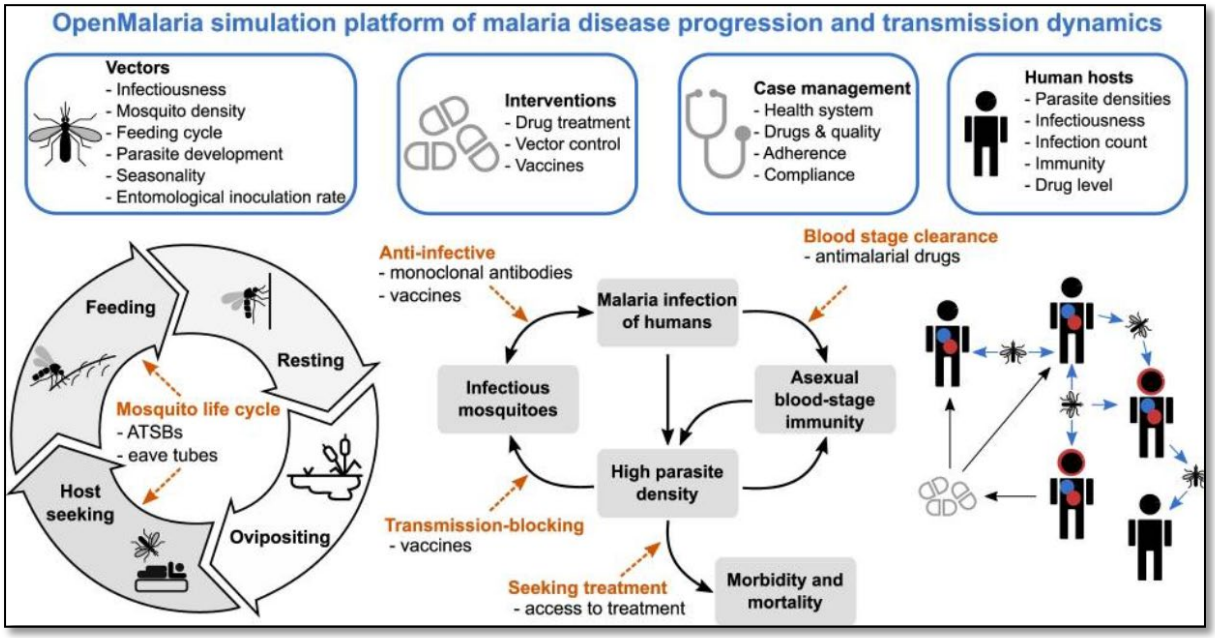
feeding inhibition where a mosquito may land but not feed, as well as knock down with consequent delay in recovery and feeding and possibly death.

Leveraging mathematical models of disease dynamics and machine learning to improve development of novel malaria interventions

Infectious Diseases of Poverty 4 June 2022

Substantial research is underway to develop next-generation interventions that address current malaria control challenges. As there is limited testing in their early development, it is difficult to predefine intervention properties such as efficacy that achieve target health goals, and therefore challenging to prioritize selection of novel candidate interventions. Here, we present a quantitative approach to guide intervention development using mathematical models of malaria dynamics coupled with machine learning. Our analysis identifies requirements of efficacy, coverage, and duration of effect for five novel malaria interventions to achieve targeted reductions in malaria prevalence.

We apply our approach to five malaria interventions under development. Aiming for malaria prevalence reduction, we identify and quantify key determinants of intervention impact along with their minimal properties required to achieve the desired health goals. While coverage is generally identified as the largest driver of impact, higher efficacy, longer protection duration or multiple deployments per year are needed to increase prevalence reduction. We show that interventions on multiple parasite or vector targets, as well as combinations the new interventions with drug treatment, lead to significant burden reductions and lower efficacy or duration requirements.



Enhancing the Quality of Spray Application in IRS: Evaluation of the Micron Track Sprayer

Insects 6 June 2022

Indoor residual spraying (IRS) has changed little since its introduction in the 1940s. Manual spraying is still prone to variation in insecticide dose. To improve the application of IRS in experimental hut trials, an automated track sprayer was developed, which regulates the speed of application and the distance of the nozzle from the wall, two key sources of variation. The automated track sprayer was compared to manual spraying, firstly using fluorescein solution in controlled indoor settings, and secondly in experimental huts in Tanzania using several IRS products. Manual spraying produced greater variation with both fluorescein and insecticide applications. Both manual and automated spray methods under-dosed the actual dose sprayed compared to the target dose. Overall, the track sprayer treats surfaces more consistently, offering a potential improvement over manual spraying for experimental hut evaluation of new IRS formulations.

Incremental cost and cost-effectiveness of the addition of indoor residual spraying with pirimiphos-methyl in sub-Saharan Africa versus standard malaria control: results of data collection and analysis in the Next Generation Indoor Residual Sprays (NgenIRS) project, an economic-evaluation

Malaria Journal 11 June 2022

This study details the results of a multi-country cost and cost-effectiveness analysis of indoor residual spraying (IRS) programmes using Actellic®300CS in sub-Saharan Africa in 2017.

Overall, adding IRS with Actellic®300CS to the local standard intervention package was protective compared to the standard intervention package alone (IRR 0.67, [95% CI 0.50–0.91]). Results indicate that Actellic®300CS is expected to be a cost-effective (> 60% probability of being cost-effective in all settings) or highly cost-effective intervention across a range of transmission settings in sub-Saharan Africa.

Effectiveness estimates from the NgenIRS project

Programme	Years(s)	Incidence rate ratio estimate	Lower 95% CI	Upper 95% CI	Estimated cases averted	Estimated persons targeted[a]
Ghana AIRS/VectorLink	2015–2017	0.60	0.36	1.00	257,162	597,895
Northeastern and Northern Regions						
Mali AIRS/VectorLink	2015–2016	0.68	0.52	0.89	349,688	304,654
Ségou Region						
Uganda Abt bilateral	2016	0.53	0.43	0.66	245,331	1.78 million
Northern and Eastern Regions						
Zambia AIRS/VectorLink	2017	0.88	0.82	0.95	N/A[b]	N/A

Assessing the impact of a novel house design on the incidence of malaria in children in rural Africa: study protocol for a household-cluster randomized controlled superiority trial

Trials 20 June 2022

Background: Traditional rural housing in hot, humid regions of sub-Saharan Africa usually consists of single-level, poorly ventilated dwellings. Houses are mostly poorly screened against malaria mosquitoes and limited airflow discourages the use of bednets resulting in high indoor transmission. This study aims to determine whether living in a novel design house with elevated bedrooms and permeable screened walls reduces malaria, respiratory tract infections, and diarrhoea among children in rural Tanzania.

Methods/study design: This is a household-randomized, controlled study in 60 villages in Mtwara, Tanzania. A total of 550 households are randomly selected, 110 of which are allocated a novel design house and 440 households continue to reside in traditional houses. A dynamic cohort of about 1650 children under 13 years will be enrolled and followed for 3 years, approximately 330 living in novel design houses and 1320 in traditional rural houses. The primary endpoint is the incidence of malaria; secondary endpoints are incidences of acute respiratory tract infections and diarrhoea diseases detected by passive and active surveillance. Exposure to malaria vectors will be assessed using light traps in all study houses. Structural, economic, and social science studies will assess the durability, cost-effectiveness, and acceptability of the new houses compared with traditional housing. Environmental data will be collected indoors and outdoors in study homes to assess the differences between house typologies.

Discussion: This is the first randomized controlled trial to assess the protective efficacy of a new house design targeting malaria in sub-Saharan Africa. The findings of this study could influence the future construction of homes in hot and humid zones of Africa.

Modified World Health Organization (WHO) Tunnel Test for Higher Throughput Evaluation of Insecticide-Treated Nets (ITNs) Considering the Effect of Alternative Hosts, Exposure Time, and Mosquito Density

Insects 21 June 2022

The standard World Health Organization (WHO) tunnel test is a reliable laboratory bioassay used for "free-flying" testing of insecticide-treated nets (ITNs) bio-efficacy where mosquitoes pass through a ITN sample to reach a live animal bait. Multiple parameters (i.e., bait, exposure time, and mosquito density) may affect the outcomes measured in tunnel tests. Therefore, a comparison was conducted of alternative hosts, exposure time, and lower mosquito density against the current gold standard test (100 mosquitoes, animal bait, and 12-h exposure) as outlined in the WHO ITN evaluation guideline. This was done with the aim to make the tunnel test cheaper and with higher throughput to meet the large sample sizes needed for bio-efficacy durability monitoring of chlorfenapyr ITNs that must be evaluated in "free-flying" bioassays.

Figure 1 WHO tunnels for comparison of baits: (A) Conduct of standard WHO Tunnel with the bait chamber to the left of the picture and mosquitoes being placed into the longer end of the chamber; (B) Rabbit—in Experiments 1–4; (C) Hemotek® membrane—in Experiment 1

Conclusion: These results demonstrate that WHO tunnel tests using rabbit bait may be run with 50 mosquitoes to increase sample sizes needed for bio-efficacy durability monitoring of ITNs in "free-flying" bioassays. Using a membrane feeder with 50 mosquitoes is a potential replacement for the WHO tunnel bioassay with animal bait if control blood feeding rates can be improved to 50% because blood feeding impacts mosquito survival after exposure to insecticides.

Estimating female malaria mosquito age by quantifying Y-linked genes in stored male spermatozoa

Scientific Reports 22 June 2022

Vector control strategies are among the most effective measures to combat mosquito-borne diseases, such as malaria. These strategies work by altering the mosquito age structure through increased mortality of the older female mosquitoes that transmit pathogens. However, methods to monitor changes to mosquito age structure are currently inadequate for programmatic implementation. Female mosquitoes generally mate a single time soon after emergence and draw down spermatozoa reserves with each oviposition cycle. Here, we demonstrate that measuring spermatozoa quantity in female *Anopheles* mosquitoes is an effective approach to assess mosquito age. Using multiplexed qPCR targeted at male spermatozoa, we show that Y-linked genes in female mosquitoes are exclusively found in the spermatheca, the organ that houses spermatozoa, and the quantity of these gene sequences significantly declines with age. The method can accurately identify mosquitoes more than 10 days old and thus old enough to potentially transmit pathogens harbored in the salivary glands during blood feeding. Furthermore, mosquito populations that differ by 10% in daily survivorship have a high likelihood of being distinguished using modest sample sizes, making this approach scalable for assessing the efficacy of vector intervention control programs.

More work is needed to build on the overarching results of this proof-of-principle study to determine if the age of wild mosquitoes can be estimated by quantifying spermatozoa. The assay also requires evaluation by comparing it against an established age-grading technique in field.

Efficacy of a spatial repellent for control of Aedes-borne virus transmission: A cluster-randomized trial in Iquitos, Peru

PNAS USA 28 June 2022

A parallel, cluster-randomized controlled trial was conducted in Iquitos, Peru, to quantify the impact of a transfluthrin-based spatial repellent on human *Aedes*-borne virus (ABV) infection. From 2,907 households across 26 clusters (13 per arm), 1,578 participants were assessed for seroconversion (primary endpoint) by survival analysis. Incidence of acute disease was calculated among 16,683 participants (secondary endpoint). Adult mosquito collections were conducted to compare *Ae. aegypti* abundance, blood-fed rate, and parity status through mixed-effect difference-in-difference analyses. **The spatial repellent significantly reduced ABV infection by 34.1%** (one-sided 95% CI lower limit, 6.9%; one-sided *P* value = 0.0236, z = 1.98). *Aedes aegypti* abundance and blood-fed rates were significantly reduced by 28.6 (95% CI 24.1%, ∞); z = −9.11) and 12.4% (95% CI 4.2%, ∞); *z* = −2.43), respectively.
Conclusion. Our trial provides conclusive statistical evidence from an appropriately powered, preplanned cluster-randomized controlled clinical trial of the impact of a chemical intervention, in this case a spatial repellent, to reduce the risk of ABV transmission compared to a placebo.

A closer look at the WHO cone bioassay: video analysis of the hidden effects of a human host on mosquito behaviour and insecticide contact

Malaria Journal 1 July 2022

Background. The WHO cone test is one of three tests currently used to evaluate the efficacy of insecticide-treated bed nets (ITNs). It generates two test outputs, knockdown and 24-h mortality, both indicative of immediate toxicity but that reveal little about the nature of mosquito and ITN interaction or how results translate to real-world settings.
Methods. A human arm held 5 mm behind the net surface acted as a host attractant during cone tests and a smartphone was used to capture mosquito behaviour in the cone. Post-exposure blood feeding and survival for nine days were recorded; ingested blood meal size was determined by measuring excreted haematin.
Conclusions. Simple modifications to the WHO cone test and extension of post-test monitoring beyond the current 24 h enable detailed behavioural characterizations of individual ITNs to be compiled. The effects observed from testing with a host and including blood feeding suggest that more representative estimates of true of ITN efficacy are gained with these modifications than when using the current testing protocol.

Inferring the epidemiological benefit of indoor vector control interventions against malaria from mosquito data

Nature Communications 5 July 2022

The cause of malaria transmission has been known for over a century but it is still unclear whether entomological measures are sufficiently reliable to inform policy decisions in human health. Decision-making on the effectiveness of new insecticide-treated nets (ITNs) and the indoor residual spraying of insecticide (IRS) have been based on epidemiological data, typically collected in cluster-randomised control trials. The number of these trials that can be conducted is limited. Here we use a systematic review to highlight that efficacy estimates of the same intervention may vary substantially between trials. **Analyses indicate that mosquito data collected in experimental hut trials can be used to parameterize mechanistic models for *Plasmodium falciparum* malaria and reliably predict the epidemiological efficacy of quick-acting, neuro-acting ITNs and IRS. Results suggest that for certain types of ITNs and IRS using this framework instead of clinical endpoints could support policy and expedite the widespread use of novel technologies.**

To spray or target mosquitoes another way: focused entomological intelligence guides the implementation of indoor residual spraying in southern Mozambique

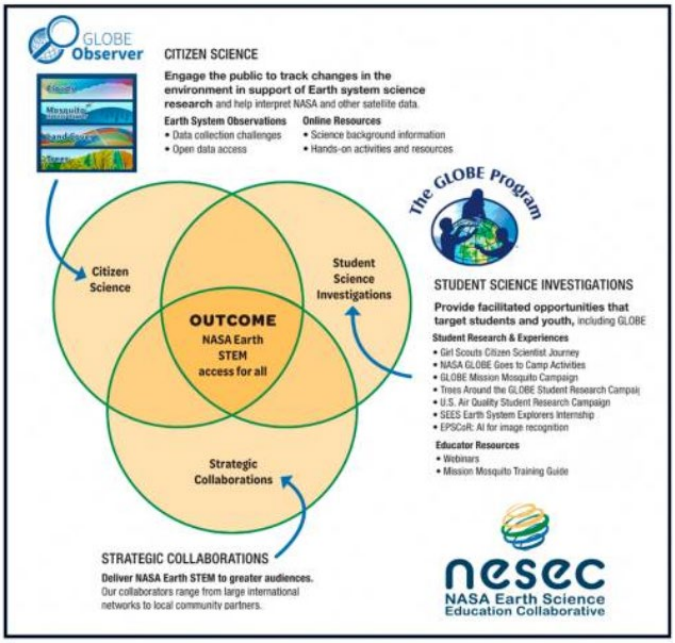
Malaria Journal 10 July 2022

Background: To eliminate malaria in southern Mozambique, the National Malaria Control Programme and its partners are scaling up indoor residual spraying (IRS) activities in two provinces, Gaza and Inhambane. An entomological surveillance planning tool (ESPT) was used to answer the programmatic question of whether IRS would be effective in target geographies, given limited information on local vector bionomics.
Methods: Entomological intelligence was collected in six sentinel sites at the end of the rainy season (April–May 2018) and the beginning of the dry season (June–July 2018). The primary objective was to provide an 'entomological snapshot' by collecting question-based, timely and high-quality data within one single week in each location. Host-seeking behaviour (both indoors and outdoors) was monitored by human-baited tent traps. Indoor resting behaviour was quantified by pyrethrum spray catches and window exit traps.

Conclusion: The targeted approach to entomological surveillance was successful in collecting question-based entomological intelligence to inform decision-making about the use of IRS in specific districts. Endophilic *An. funestus s.s.* was documented as being the most prevalent and primary malaria vector suggesting that IRS can reduce malaria transmission, but the presence of other vector species both indoors and outdoors suggests that alternative vector control interventions that target these gaps in protection may increase the impact of vector control in southern Mozambique.

Building International Capacity for Citizen Scientist Engagement in Mosquito Surveillance and Mitigation: The GLOBE Program's GLOBE Observer Mosquito Habitat Mapper

Insects 13 July 2022



The GLOBE Program's GLOBE Observer Mosquito Habitat Mapper is a no-cost citizen scientist data collection tool compatible with Android and iOS devices. Available in 14 languages and 126 countries, it supports mosquito vector surveillance, mitigation, and education by interested individuals and as part of participatory community surveillance programs. For low-resource communities where mosquito control services are inadequate, the Mosquito Habitat Mapper supports local health action, empowerment, and environmental justice. The tangible benefits to human health supported by the Mosquito Habitat Mapper have encouraged its wide adoption, with more than 32,000 observations submitted from 84 countries. The Mosquito Habitat Mapper surveillance and data collection tool is complemented by an open database, a map visualization interface, data processing and analysis tools, and a supporting education and outreach campaign. The mobile app tool and associated research and education assets can be rapidly deployed in the event of a pandemic or local disease outbreak, contributing to global readiness and resilience in the face of mosquito-borne disease. Here, we describe the app, the Mosquito Habitat Mapper information system, examples of Mosquito Habitat Mapper deployment in scientific research, and the outreach campaign that supports volunteer training and STEM education of students worldwide.

Back to the Future: Quantifying Wing Wear as a Method to Measure Mosquito Age

Am J Trop Med Hyg 18 July 2022

Vector biologists have long sought the ability to accurately quantify the age of wild mosquito populations, a metric used to measure vector control efficiency. This has proven difficult due to the difficulties of working in the field and the biological complexities of wild mosquitoes. Ideal age grading techniques must overcome both challenges while also providing epidemiologically relevant age measurements. Given these requirements, the Detinova parity technique, which estimates age from the mosquito ovary and tracheole skein morphology, has been most often used for mosquito age grading despite significant limitations, including being based solely on the physiology of ovarian development. Here, we have developed a modernized version of the original mosquito aging method that evaluated wing wear, expanding it to estimate mosquito chronological age from wing scale loss. We conducted laboratory experiments using adult Anopheles gambiae held in insectary cages or mesocosms, the latter of which also featured ivermectin bloodmeal treatments to change the population age structure. Mosquitoes were age graded by parity assessments and both human- and computational-based wing evaluations. Although the Detinova technique was not able to detect differences in age population structure between treated and control mesocosms, significant differences were apparent using the wing scale technique. Analysis of wing images using averaged left- and right-wing pixel intensity scores predicted mosquito age at high accuracy (overall test accuracy: 83.4%, average training accuracy: 89.7%). This suggests that this technique could be an accurate and practical tool for mosquito age grading though further evaluation in wild mosquito populations is required.

Comparison of entomological impacts of two methods of intervention designed to control Anopheles gambiae s.l. via swarm killing in Western Burkina Faso

Nature Scientific Reports 20 July 2022

Outdoor biting constitutes a major limitation of current vector control based primarily on long-lasting insecticidal nets and indoor residual spraying, both of which are indoor interventions. Consequently, malaria elimination will not be achieved unless additional tools are found to deal with the residual malaria transmission and the associated vector dynamics. In this study we tested a new vector control approach for rapidly crashing mosquito populations and disrupting malaria transmission in Africa. This method targets the previously neglected swarming and outdoor nocturnal behaviors of both male and female *Anopheles* mosquitoes. It involved accurate identification and targeted spraying of mosquito swarms to suppress adult malaria vector populations and their vectorial capacities. The impact of targeted spraying was compared to broadcast spraying and evaluated simultaneously. The effects of the two interventions were very similar, no significant differences between targeted spraying and broadcast spraying were found for effects on density, insemination or parity rate. However, targeted spraying was found to be significantly more effective than broadcast spraying at reducing the number of bites per person.

Less is more: repellent-treated fabric strips as a substitute for full screening of open eave gaps for indoor and outdoor protection from malaria mosquito bites

Parasites and Vectors 20 July 2022

Screening of house entry points, especially with incorporated insecticides, confers significant protection but remains a costly and labour-intensive application. Use of spatial repellents has shown promise in creating areas of protection in peri-domestic areas.

This study aimed at comparing the protection provided by transfluthrin-treated and untreated complete screens over open eave gaps with incomplete transfluthrin-treated eave strips as a potential replacement for a full screen. Human landing catches were implemented independently inside and outside an experimental hut under controlled semi-field conditions, with insectary-reared *Anopheles arabiensis* mosquitoes.

Fig. 1

a Pictorial presentation of a semi-field system (27 m × 11 m), including an experimental hut made of plywood with a grass thatched roof (6.5 m × 3.5 m). **b** Application of an eave screen secured on the eave gap of the experimental hut using aluminium wires to ensure complete coverage of the eave gap (**c**) and eave strip secured on the eave gaps of the experimental hut using aluminium wires to ensure equal distance (2.5 cm) above and below the eave fabric

Results. The odds of a female mosquito finding a human volunteer indoors and attempting to bite were similar

whether the eaves were completely open or there was an untreated fabric strip fixed around the eaves. However, when the eave gap was completely screened without insecticide, the odds of receiving a bite indoors were reduced by 70% (OR 0.30, 95% CI 0.20–0.47). Adding transfluthrin to the full screen, further increased the protection indoors, with the odds of receiving a bite reduced by 92% (0.08, 95% CI 0.04–0.16) compared to the untreated screen. Importantly, the same protection was conferred when only a narrow transfluthrin-treated fabric strip was loosely fixed around the eave gap (OR 0.07, 95% CI 0.04–0.13). The impact of the transfluthrin treatment on outdoor biting was correlated with evening temperatures during the experiments. At lower evening temperatures, a transfluthrin-treated, complete screen provided moderate and variable protection from bites (OR 0.62, 95% CI 0.37–1.03), whilst at higher evening temperatures the odds of receiving a bite outdoors was over four times lower in the presence of transfluthrin, on either a full screen (OR 0.22 95% 0.12–0.38) or a fabric strip (OR 0.25, 95% 0.15–0.42), than when no treatment was present.
Conclusion. The findings suggest that transfluthrin-treated fabric strips can provide a substitute for complete eave screens. They are a simple, easy-to-handle tool for protecting people from malaria mosquito bites indoors and potentially around the house in climatic areas where evening and night-time temperatures are relatively high.

Laboratory and experimental hut trial evaluation of VECTRON ™ T500 for indoor residual spraying (IRS) against insecticide resistant malaria vectors in Burkina Faso

Gates Open Research 25 July 2022

Background: Malaria cases in some areas could be attributed to vector resistant to the insecticide. World Health Organization recommended insecticides for vector control are limited in number. It is essential to find rotational partners for existing Indoor Residual Spraying (IRS) products. VECTRON ™ T500 is a novel insecticide with broflanilide as active ingredient. It has a mode of action on mosquitoes completely different to usually used. The aim of this study was to determine the optimum effective dose and efficacy of VECTRON ™ T500 against susceptible and resistant strains of *Anopheles* in Burkina Faso.
Results: In the laboratory, VECTRON ™ T500 showed residual efficacy (≥80% mortality) on *An. gambiae* Kisumu up to 12 and 14 months, respectively, on concrete and mud blocks. Similar results were found with 100 and 200 mg/m² using *An. coluzzii* pyrethroid resistant strain. In experimental huts, a total of 19,552 *An. gambiae* s.l. were collected. Deterrence, blood-feeding inhibition and exophily with VECTRON™ treated huts were very low. At 100 and 150 mg/m², mortality of wild *An. gambiae* s.l. ranged between 55% and 73%. Monthly cone bioassay mortality remained >80% up to 9 months.
Conclusions: VECTRON™ T500 shows great potential as IRS formulation for malaria vector control. It can be added to the arsenal of IRS products for use in rotations to control malaria and manage mosquito insecticide resistance.

Malaria elimination does not cost more than malaria control: Sri Lanka a case in point

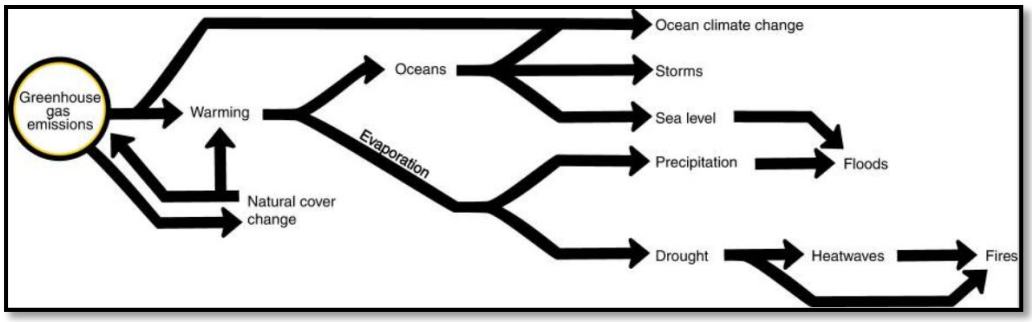
Malaria Journal 1 August 2022

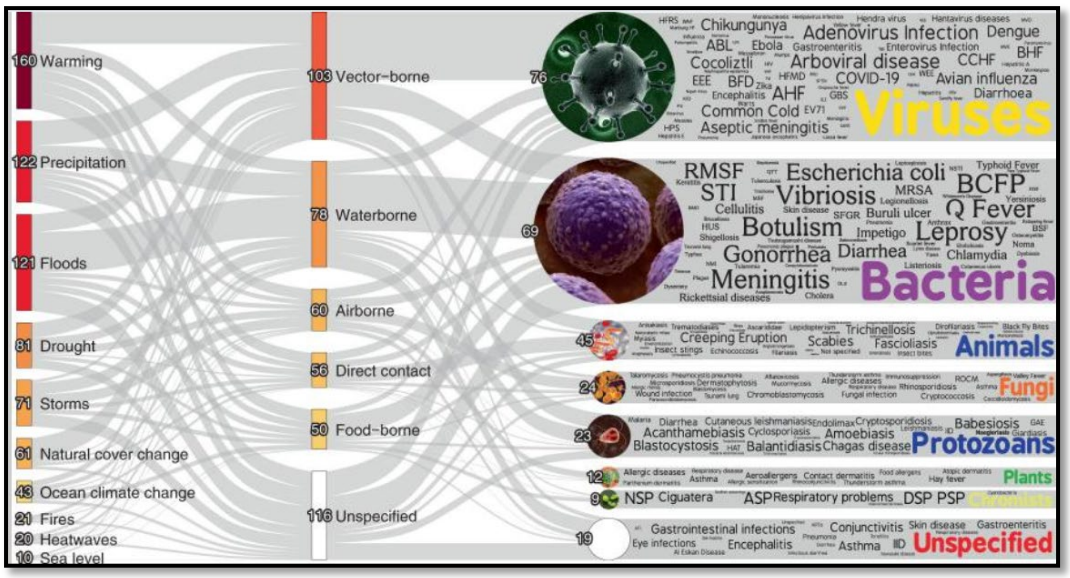
Background. Malaria was endemic in Sri Lanka for centuries and was eliminated in 2012. It is widely assumed that the costs of elimination are generally greater than that of control. The costs of malaria elimination in Sri Lanka with that of malaria control in the past using periods in which starting transmission dynamics were similar were compared.
Results. The expenditure on malaria control and malaria elimination was similar ranging from 21 to 45 million USD per year when adjusted for inflation. In both periods, external funding for the malaria progamme constituted around 24% of the total budget; during the control phase in the 1980s, external funds came from bilateral agencies and were disbursed in accordance with government budget guidelines. In the elimination phase in the 2000s, most of external funding was from the Global Fund and had flexibility of disbursement. In the 1980s, most funds were expended on commodities—insecticides, diagnostics and medicines and their delivery; in the elimination phase, they were spent on programme management, human resources, technical assistance and monitoring and evaluation; monitoring and evaluation was not a budget line in the 1980s. Although the cost per case of malaria was considerably higher during the elimination phase than in the control phase, expenditure was not on individual cases but on general systems strengthening.
Conclusion. Malaria elimination in Southeast Asia may not require more funding than malaria control. But sustained funding for an agile programme with flexibility in fund utilization and improved efficiencies in programme management with stringent monitoring and evaluation appears to be critically important.

Over half of known human pathogenic diseases can be aggravated by climate change

Nature Public Health Emergency Collection 2 August 2022

Here we carried out a systematic search for empirical examples about the impacts of ten climatic hazards sensitive to greenhouse gas (GHG) emissions on each known human pathogenic disease. We found that 58% (that is, 218 out of 375) of infectious diseases confronted by humanity worldwide have been at some point aggravated by climatic hazards; 16% were at times diminished. Empirical cases revealed 1,006 unique pathways in which climatic hazards, via different transmission types, led to pathogenic diseases. The human pathogenic diseases and transmission pathways aggravated by climatic hazards are too numerous for comprehensive societal adaptations, highlighting the urgent need to work at the source of the problem: reducing GHG emissions.





Malaria Transmission in Sahelian African Regions, a Witness of Climate Changes

Int J Environ Res Public Health 19 August 2022

Climate changes in the eastern part of Sahelian regions will induce an increase in rainfalls and extreme climate events. In Africa, temperature increases 1.5 faster than the global temperature. Predictive models confirm an increase of rainfall in the eastern and the central part of the Sahel from Niger to Ethiopia whereas drought will increase after 2030 in the western portion of West Africa from Mali to Mauritania. Due to the intense events and floods, malaria transmission, a climate sensitive disease, is thus slowly extending in time to the drought season and in areas close to the border of the desert. Vectors can as well modify their area of breeding. Control programs must be aware of these changes to adapt their strategies.

Biolarviciding implementation in southern Tanzania: Scalability opportunities and challenges

PLoS One 26 August 2022

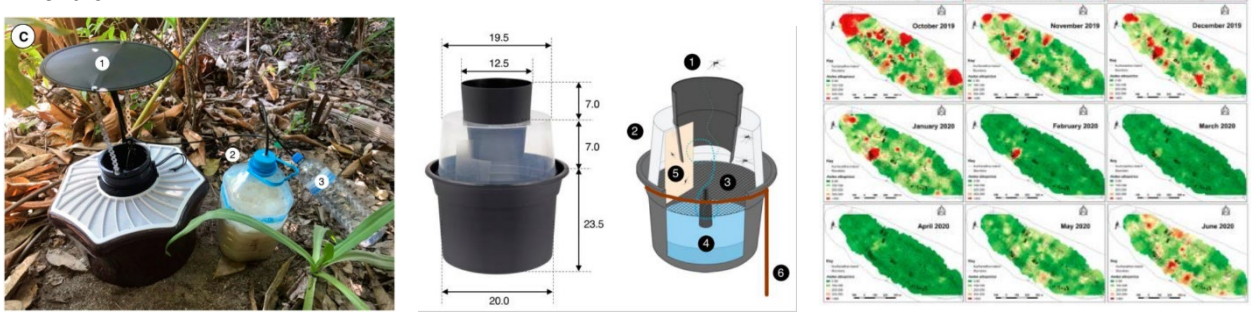
The resistance to insecticides among malaria vectors poses a global challenge in the efforts towards malaria elimination. This calls for an addition of larval control methods such as biolarviciding. However, the implementation of biolarviciding in Tanzania has been very low. Therefore, this study explored factors affecting the implementation of biolarviciding in the councils of Southern Tanzania.

Our results reflect perceptions of both implementers and receiving communities as to the challenges and opportunities associated with scaling of biolarviciding in the region. The main identified challenges facing the implementation were resource scarcity: inadequate funds, inadequately trained personnel, inconsistency in biolarvicide supply, inadequate equipment, and unreliable transport for carrying out biolarviciding activities. Another challenge was inadequate coordination between the councils and the Ministry of Health during the quantification of biolarvicide, resulting in frequent biolarvicide stock-outs. On the other hand, the study found some opportunities for biolarviciding implementation that manifested through the existence of vector control coordinators, the existence of a budget for biolarviciding in some of the councils that were set for the implementation of biolarviciding, the existence of local industry that produces biolarvicide and existence of community members who are willing to take part in the biolarviciding, a potential factor for program achievement and sustainability. Therefore, despite the identified challenges, implementing of biolarviciding in Southern Tanzania was feasible and potentially sustainable when identified challenges are resolved.

Mass Trapping and Larval Source Management for Mosquito Elimination on Small Maldivian Islands

Insects 2 Sept 2022

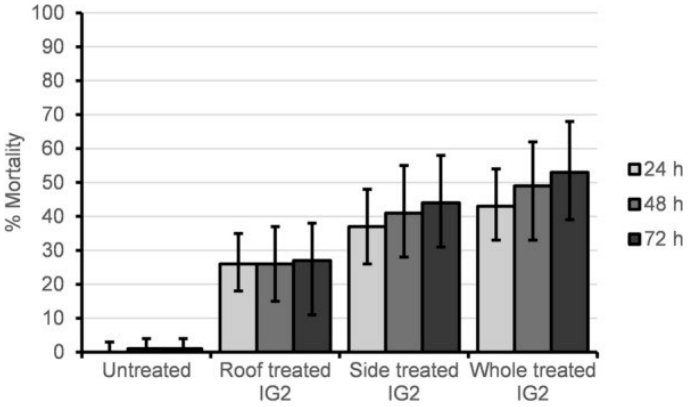
We used, for the first time, a combination of human odor-baited mosquito traps (at 6.0 traps/ha), oviposition traps (7.2 traps/ha) and larval source management (LSM) to practically eliminate populations of the Asian tiger mosquito *Aedes albopictus* (peak suppression 93.0% (95% CI 91.7–94.4)) and the Southern house mosquito *Culex quinquefasciatus* (peak suppression 98.3% (95% CI 97.0–99.5)) from a Maldivian island (size: 41.4 ha) within a year and thereafter observed a similar collapse of populations on a second island (size 49.0 ha; trap densities 4.1/ha and 8.2/ha for both trap types, respectively). On a third island (1.6 ha in size), we increased the human odor-baited trap density to 6.3/ha and then to 18.8/ha (combined with LSM but without oviposition traps), after which the *Aedes* mosquito population was eliminated within 2 months.



Efficacy of bednets with dual insecticide-treated netting (Interceptor® G2) on side and roof panels against Anopheles arabiensis in north-eastern Tanzania

Parasites & Vectors 15 September 2022

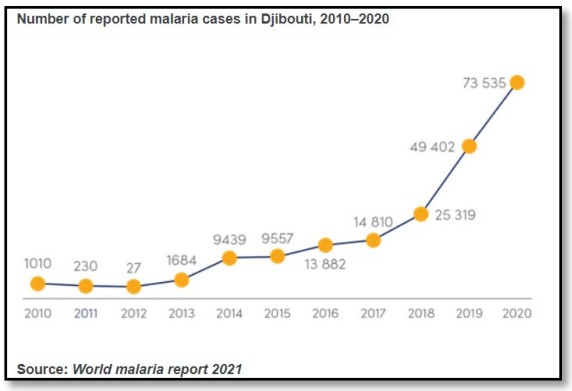
Background. Optimising insecticide use and managing insecticide resistance are important to sustain gains against malaria using long-lasting insecticidal nets (LLINs). Restricting insecticides to where mosquitoes are most likely to make multiple contacts could reduce the quantity of insecticide needed to treat the nets. Previous studies have shown that nets partially treated with a pyrethroid insecticide had equivalent mortality compared to a fully treated net. This study compared the efficacy of: (i) whole Interceptor® G2 nets (IG2; a dual-active LLIN containing alpha-cypermethrin and chlorfenapyr), (ii) nets with roof panels made of IG2 netting, (iii) nets with side panels made of IG2 netting and (iv) whole untreated nets as test nets.

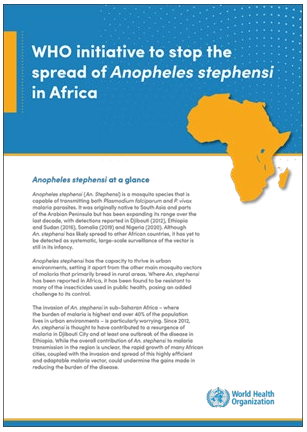


WHO News and Publications

A new WHO initiative takes aim at *Anopheles stephensi*, an invasive malarial mosquito species that thrives in cities and is expanding across Africa

- Brochure *WHO initiative to stop the spread of Anopheles stephensi in Africa*
- Feature story *Mosquito on the move (who.int)*
- News release *WHO launches new initiative to stop the spread of invasive malaria vector in Africa*





Updated *WHO Guidelines for malaria*

3 June 2022

In June 2022, WHO released consolidated, updated malaria recommendations covering prevention, case management, elimination and prevention of re-establishment, and surveillance. The guidelines include updated recommendations for use of pyrethroid-piperonyl butoxide (PBO) insecticide-treated nets in areas of pyrethroid resistance, use of insecticide-treated nets and indoor residual spraying in areas affected by humanitarian emergencies and house screening. For each, practical considerations are provided, and areas where evidence is lacking are highlighted. The guidelines are currently accessible online on the WHO website (*https://www.who.int/publications/i/item/guidelines-for-malaria*) and via the online platform, MAGICapp (*https://app.magicapp.org/#/guideline/6287*). Conditional recommendations allow for more nuanced consideration of contextual factors, in line with the malaria community's shift away from a "one size fits all" approach.

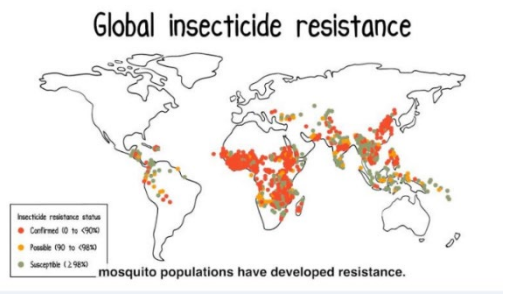
Updated WHO guidance for monitoring resistance in mosquito vectors

22 June 2022

A new manual from WHO provides updated and integrated guidance on monitoring insecticide resistance in *Anopheles*, *Aedes* and *Culex* mosquito vectors. See, also, the related video.

Monitoring resistance in mosquito vectors: Updated guidance from the World Health Organization

Watch this new WHO video (4 minutes long) providing a short summary of the new WHO guidance and tools for monitoring insecticide resistance in mosquito vectors.



Malaria surveillance assessment toolkit

3 August 2022

GMP, with support from CHAI and other partners, has developed a malaria surveillance assessment toolkit which provides a standardized but adaptable package of tools to assess surveillance systems across all transmission settings. Standardized outputs allow results to be compared between countries, between regions within a country, or over time.
The complete toolkit includes an implementation reference guide which provides a step-by-step guide on how to carry out a malaria surveillance assessment. Digital tools are currently under development and will be available through a web portal later this year.

New vector control PPCs

21 June 2022

Preferred product characteristics (PPCs) are key tools to incentivize and guide the development of urgently needed health products. WHO recently published two PPCs in the area of vector control: *PPCs on indoor residual surface treatments* (formerly called "indoor residual spraying") and on *endectocide and ectocide products for malaria transmission control*.
Of note to the IRS community, the WHO is evolving from using the term "indoor residual spraying" (IRS) for the intervention class to using the term "indoor residual surface treatment" (IRST). The latter term captures the current use pattern of IRS for malaria vector control and conceptually allows for the inclusion of other delivery approaches, such as insecticidal paints or wall linings, or for the partial or selective treatment of walls.

Webinars, websites and other resources

Recent Meetings and Webinars

Summary of the 8th PAMCA Annual Conference and Exhibition from the MESA Correspondents

26 - 28 September 2022

In case you missed the recent PAMCA meeting, the MESA team has shared a thorough summary of the event.

Ifakara Master Classes in Public Health & Medical Entomology

Hosted by Fredros Okumu (Ifakara Health Institute) and Sheila Ogoma (Clinton Health Access Initiative), the recorded Q and A sessions with experts in the field on various topics are available on YouTube and well worth viewing. Recent topics include:

- 4 August - ***The Next Malaria Vaccine***: A MasterClass with Prof. Adrian Hill
- 12 August - ***Malaria Strategies***: A MasterClass with Prof. Marcel Tanner

APMEN Webinar YouTube channel

APMEN organizes a webinar series to provide a platform for discussing a variety of topics of interest and sharing information related to malaria elimination. Recorded sessions are available on their YouTube channel. Recent topics include:

- 15 June - *All about Bednets, Cradle to Grave*
- 7 September - *The IVCC Indo-Pacific Initiative: Expanding the Vector Control Toolbox*

Malaria Operational Research and Program Evaluation Priorities as Defined by Sub-Saharan African Countries

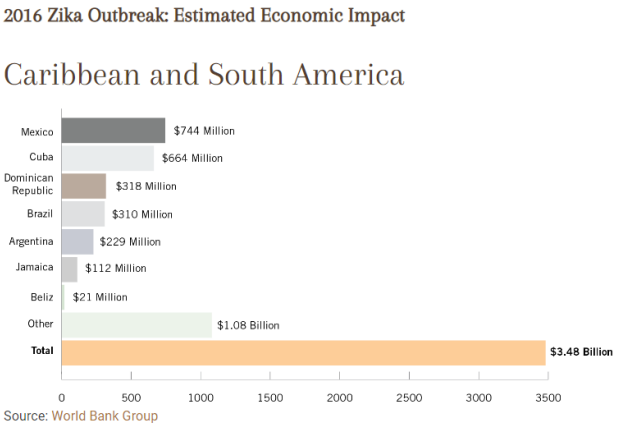
On June 16, 2022, the PMI Insights Project hosted a webinar to share details about the research prioritization process, the prioritized list of operational research (OR) and program evaluation topics (PE) topics, and the vision for addressing the identified research priorities.

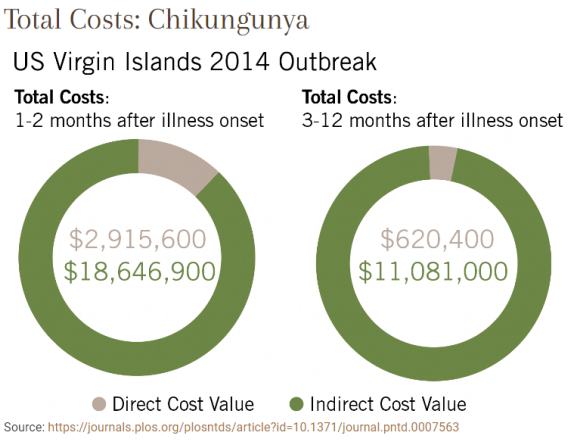
If you were unable to join or would like to revisit the session material, here are the links to the webinar recording and slide deck.

The Economics of Resistance

Valent BioSciences' *Public Health Landscape* August 2022

This article reviews the topic of economic impact of insecticide resistance and cites some statistics on estimated cots of various mosquito bor ne diseases. Worth a read.





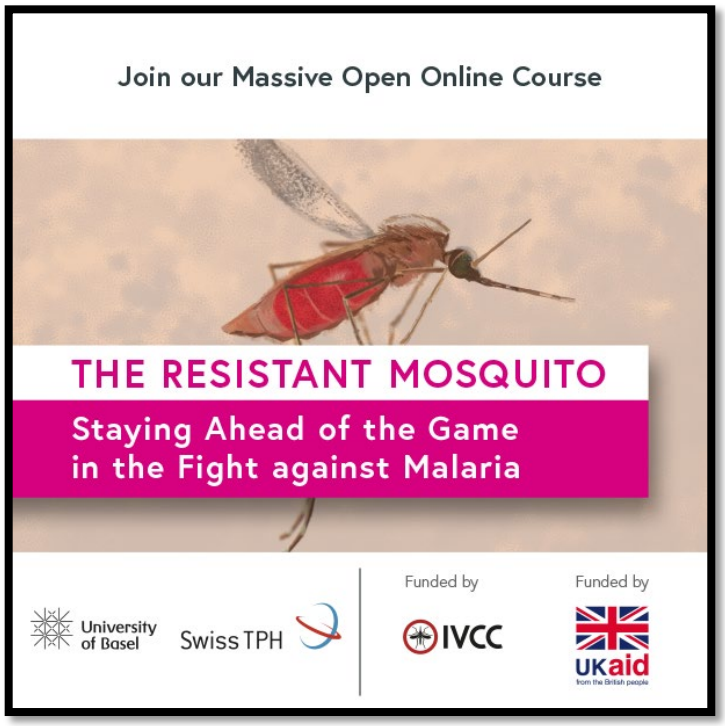
The *APMEN-Kasetsart Online Course in Vector Surveillance* has now launched.

From the APMEN Vector Control Working Group- *Vector Control rests squarely on effective Vector Surveillance. However, published reports have shown that globally there is a strong need for capacity-strengthening in vector surveillance, and National Malaria Control Programmes have indicated a desire to receive training support to bolster the shortfalls in skills.*

To help meet this demand, APMEN has partnered with Kasetsart University in Bangkok to produce a 5-module series of trainings under the heading of "***APMEN-Kasetsart Online Course in Vector Surveillance*".** We are excited and proud to release Module 1, which has multiple tutorials covering the different methods for collection and processing of malaria vectors. We will release the additional Modules covering mosquito identification, insecticide resistance assays, insectary management, biting behaviour, and others, at roughly monthly intervals, and trust that the course material will assist in alleviating the current shortfall in vector surveillance skills.

Massive Open Online Course on The Resistant Mosquito: Staying Ahead of the Game in the Fight against Malaria

The VCWG, in collaboration with the University of Basel, the Swiss TPH, and many other organisations and institutions, has developed a Massive Open Online Course to help address the challenges of insecticide resistance in the mosquito vectors of disease.
Free (limited) access to the course is available through 25 Oct 2022. Paid options also available.



By the end of the course, you'll be able to...

Explore the concept of insecticide resistance (IR), and how it develops in a mosquito population
Evaluate the impact of insecticide resistance on malaria vector control and the importance of managing it
Investigate the principles of applied Insecticide Resistance Management (IRM)
Identify IRM as an essential and integral component of vector control activities to reduce the burden of, eliminate, and eventually eradicate malaria

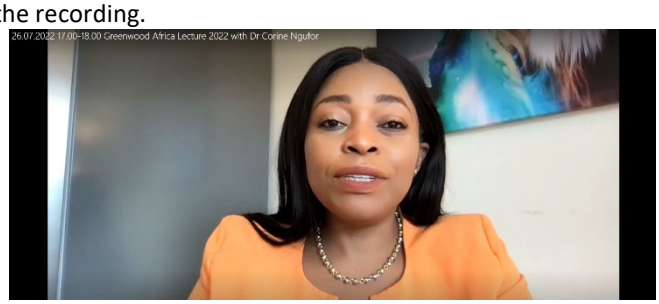
This course is intended for those with any involvement in mosquito vector control as well as students and scholars of Public Health, One Health, Entomology, Epidemiology or Evolutionary Biology. It will also appeal to

the general public interested in malaria elimination, vector-borne diseases and mosquito control. It lasts for three weeks with two to three hours of weekly study and is free to access!

Greenwood Africa Lecture 2022 with Dr. Corine Ngufor

26 July 2022

If you did not see Dr. Ngufor's lecture live, here is the recording.



AMCA publishes supplemental training manual on "Mosquito Management During a Public Health Emergency"

The American Mosquito Control Association (AMCA) published a supplemental to their *Best Practices for Integrated Mosquito Management* manual on "*Mosquito Management During a Public Health Emergency*"

Although these publications are focused on U.S. control programs, they offer a good template that could help guide programs in other regions. The supplemental resource includes information regarding mosquito control in response to a water-related natural disaster or during increased risk of mosquito-transmitted disease.

Highlights from the Kigali Summit on Malaria and NTDs

The Kigali Summit on Malaria and NTDs featured commitments totalling more than USD 4.5 billion including funding from governments, international organisations, philanthropists, and private sector support to fight these diseases. Countries also called on other global leaders to join them and demonstrate their support by endorsing and committing resources to the Kigali Declaration on NTDs and mobilising at least USD 18 billion for the malaria response at the Global Fund's Seventh Replenishment Conference in September.

MESA Track has expanded

MESA Track is being updated to include country portfolios where you will find:

- A map of the country and its malaria burden
- The determinants of malaria transmission, transmission intensity, seasonality, parasites, vectors and % population at risk
- Hyperlinks to the MESA Track portfolios of institutions that carry out malaria activities in the country
- A landscape of projects ongoing in that country, who's funding them, the timelines, and most importantly, the research priorities as outlined by the country's national malaria program.

Also from MESA, check out the recently published ***Anopheles stephensi Deep Dive***

In the news and social media

PMI Welcomes New U.S. Global Malaria Coordinator

15 August 2022

Dr. David Walton has been appointed as the new U.S. Global Malaria Coordinator. He was appointed by President Biden on August 15th, 2022 and brings over two decades of experience working in global health, including working on the ground in Haiti to fight the 2010 cholera outbreak and on the front lines of the 2014 Ebola outbreak in Sierra Leone. Dr. Walton has a proven track record of building local partnerships to expand access to care, and providing primary health services to the hardest to reach populations. Dr. Walton takes the helm of PMI after serving as the Senior Director of Global Health at the Butterfly Network, Inc., co-founding Build Health International, and 15 years with Partners In Health. Dr. Walton was previously an Associate Physician in the Division of Global Health Equity at Brigham and Women's Hospital and Instructor in Medicine at Harvard Medical School.

He holds an MD from Harvard Medical School, an MPH from the Harvard School of Public Health, and trained in Internal Medicine at Brigham and Women's Hospital as the first Doris and Howard Hiatt Global Health Equity resident.

Floods, heat and other climate hazards are turning 218 infectious diseases into bigger threats, study says

NBC news 8 August 2022

Patients rest on beds in a makeshift dengue ward in a hospital in Lahore, Pakistan

People walk through the fumes after a worker sprays pesticide to kill mosquitoes at a public park in Dhaka, Bangladesh, on July 14, 2021

See the original publication here ***Over half of known human pathogenic diseases can be aggravated by climate change***
Nature Public Health Emergency Collection 2 August 2022

Why the Interceptor G2 net could be a game changer for malaria eradication

Helen Jamet, Deputy Director, Vector Control, Bill & Melinda Gates Foundation 18 August 2022

Upcoming: *Future of Malaria Research Symposium*
A hybrid symposium highlighting early career and emerging malaria researchers

- Date: 28 October 2022
- Time: 8:30 AM - 3.00 PM EDT
- Registration deadline for in-person participation: 7 October 2022
- ***Register here***

Registration deadline for in-person participation, at the Bloomberg School of Public Health, is October 7th. Registration for virtual participation will remain open.

Note this issue covers the period from 1 June through 15 September 2022.

Disclaimer: Given the breadth of vector control related literature, we are unable to include all relevant work. This update is intended to focus primarily *Anopheles* vectors and a subset of control topics with global relevance. Any views expressed in this update do not necessarily reflect the views or opinions of IVCC. In many cases we directly quote abstracts and other sections of published work. Mention of trade names or commercial products in this publication is solely for the purpose of providing specific information and does not imply recommendation or endorsement by IVCC or its funders. Readers may view copyrighted publications shared here provided that the information is only for their personal, non-commercial use.