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Selected Recent Publications

[Permethrin-treated baby wraps for the prevention of malaria: results of a randomized controlled pilot study in rural Uganda](#)

Malaria Journal 23 Feb 2022

In the spirit of exploring novel interventions this group reports on the safety, acceptability and feasibility of permethrin-treated baby wraps in Uganda. Conclusions. Permethrin-treated baby wraps were well-tolerated and broadly acceptable. Adverse events were infrequent and mild. These findings support future trials seeking to determine the efficacy of treated wraps to prevent *P. falciparum* malaria infection in young children as a complementary tool to existing household-based interventions.



Related to this topic of permethrin (or other insecticide) treatment of textiles, here is a paper worth a revisit. Insecticide treatment of various textiles could provide significant protection to displaced persons and mobile populations not protected by LLINs or IRS.

[Bio-efficacy and wash-fastness of a lambda-cyhalothrin long-lasting insecticide treatment kit \(ICON® Maxx\) against mosquitoes on various polymer materials](#)

Malaria Journal 28 Sept 2021

The binder technology tested by this group “raises the prospect of making insecticide-binder kits into an effective approach for turning untreated nets, curtains, military clothing, blankets—and tents and tarpaulins as used in disasters and humanitarian emergencies—into effective malaria prevention products. It may provide a solution to the problem of reduced LLIN coverage between campaigns by converting commercially sourced untreated nets into LLINs through community or home treatment. It may also open the door to binding of non-pyrethroid insecticides to nets and textiles for control of pyrethroid resistant vectors.”

[Climate Change and Vector-Borne Diseases in China: A Review of Evidence and Implications for Risk Management](#)

Biology (Basel) 25 February 2022

The purpose of this paper is to review all relevant studies concerning weather, climate, and vector-borne diseases to identify the most sensitive climate-related vector-borne diseases in China. In addition, we investigated how these meteorological factors impact vector-borne diseases and regional differences in their relationships. We also analyze the limitations of the current studies and put forward some suggestions for future research.

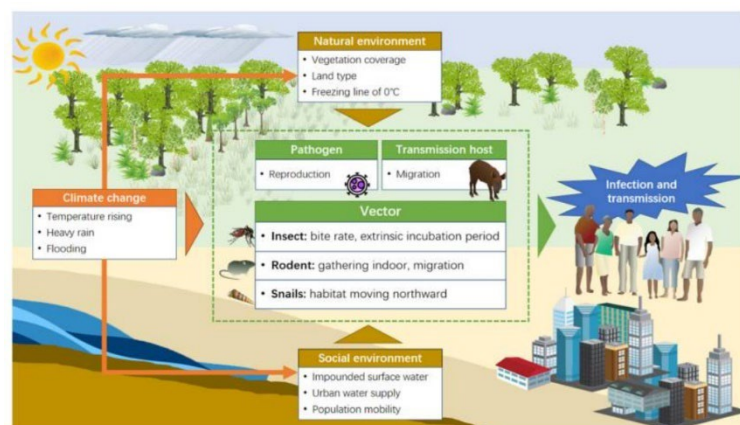


Figure 3. The main pathway of climate change impact on the risk of vector-borne diseases.

[High-content phenotypic screening identifies novel chemistries that disrupt mosquito activity and development](#)

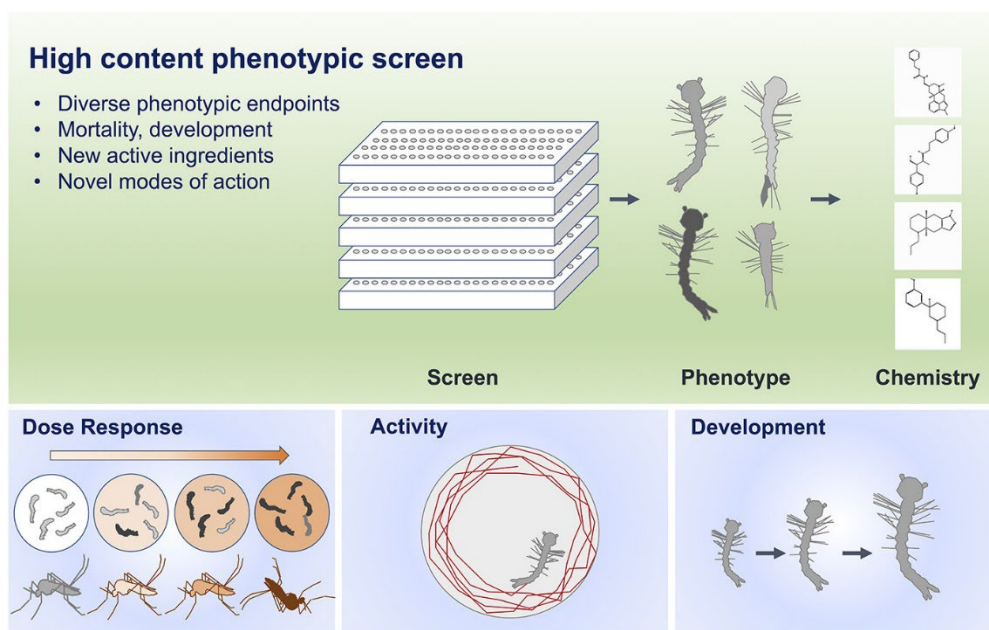
Pesticide Biochemistry and Physiology March 2022

Advances in image-based screening offer an opportunity to identify chemistries that operate via novel biochemical modes and investigate the range of phenotypes exhibited by mosquitoes following exposure to lethal and sub-lethal chemical dose. An automated, high throughput phenotypic screen (HTS) employing high-

content imaging of first instar (L1) *Aedes aegypti* larvae was developed to identify chemistries associated with mortality and atypical morphological phenotypes. A pilot screen of the Library of Pharmacologically Active Compounds (LOPAC₁₂₈₀) identified 92 chemistries that disrupted larval activity and development, including conventional insecticides and chemistries known to modulate G protein-coupled receptors (GPCRs) and other molecular targets in mammalian systems.

Highlights

- An automated phenotypic screen was employed to find new mosquito-active chemistries.
- High-content imaging detected larval movement and novel phenotypic endpoints.
- Pilot screen uncovered chemistries that disrupted mosquito activity, development.
- Assays confirmed insecticidal activity of GPCR modulators and other chemistries.
- Screening regime revealed diverse chemistries and possible novel modes of action.



[Resurgent and delayed malaria](#)

Malaria Journal 9 March 2022

Repeated exposure to *Plasmodium falciparum* leads to the acquisition of some protective immunity to this infection. Consequently, when a highly effective malaria control intervention is introduced into a population for a limited period of time and then withdrawn, there is a risk that in the subsequent period the population which received the intervention may be at greater risk from malaria than if they had not received the intervention. This phenomenon is commonly termed 'rebound malaria'. In this paper, it is suggested that it may be helpful to differentiate two related but different epidemiological situations often considered under this heading.

Characteristics of 'resurgent malaria' and 'delayed malaria'

	Resurgent malaria	Delayed malaria
Population exposed to the intervention	Usually the whole population	Usually young children
Malaria immune status on cessation of the intervention	Varied	Low
Impact of withdrawal of the intervention	An increase in incidence of malaria in the whole at risk population	An increase in incidence of malaria in older children

[Evaluating malaria prevalence and land cover across varying transmission intensity in Tanzania using a cross-sectional survey of school-aged children](#)

Malaria Journal 9 March 2022

Background: Transmission of malaria in sub-Saharan Africa has become increasingly stratified following decades of malaria control interventions. The extent to which environmental and land cover risk factors for malaria may differ across distinct strata of transmission intensity is not well known and could provide actionable targets to maximize the success of malaria control efforts.

Conclusions: Greater cropland cover was positively associated with increased malaria prevalence in areas with low transmission intensity and presents an actionable target for environmental vector control interventions to complement current malaria control activities. As areas are nearing malaria elimination, it is important to re-evaluate environmental risk factors and employ appropriate interventions to effectively address low-level malaria transmission.

[Sub-national tailoring of malaria interventions in Mainland Tanzania: simulation of the impact of strata-specific intervention combinations using modelling](#)

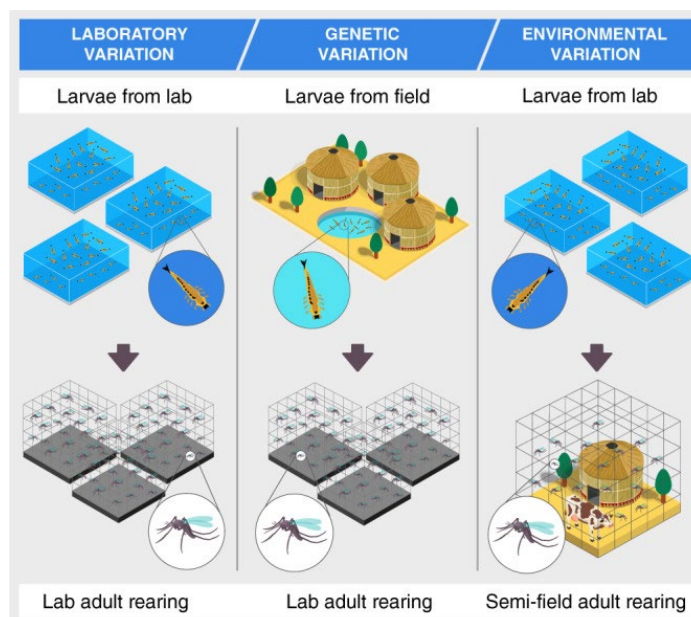
Malaria Journal 17 March 2022

To accelerate progress against malaria in high burden countries, a strategic reorientation of resources at the sub-national level is needed. This paper describes how mathematical modelling was used in mainland Tanzania to support the strategic revision that followed the mid-term review of the 2015–2020 national malaria strategic plan (NMSPP) and the epidemiological risk stratification at the council level in 2018. Intervention mixes, selected by the National Malaria Control Programme, were simulated for each malaria risk strata per council. Intervention mixes included combinations of insecticide-treated bed nets (ITN), indoor residual spraying, larval source management, and intermittent preventive therapies for school children (IPTsc). The application of modelling for exploring alternative intervention scenarios is likely to increase confidence in the selection of intervention mixes when developing a new national malaria control strategy. Continuous model updates and improvements in the approach will be crucial when scaling up the application of modelling for strategic planning processes in countries.

[Rapid age-grading and species identification of natural mosquitoes for malaria surveillance](#)

Nature Communications 21 March 2022

The malaria parasite, which is transmitted by several *Anopheles* mosquito species, requires more time to reach its human-transmissible stage than the average lifespan of mosquito vectors. Monitoring the species-specific age structure of mosquito populations is critical to evaluating the impact of vector control interventions on malaria risk. We present a rapid, cost-effective surveillance method based on deep learning of mid-infrared spectra of mosquito cuticle that simultaneously identifies the species and age class of three main malaria vectors in natural populations. Using spectra from over 40,000 ecologically and genetically diverse *An. gambiae*, *An. arabiensis*, and *An. coluzzii* females, we develop a deep transfer learning model that learns and predicts the age of new wild populations in Tanzania and Burkina Faso with minimal sampling effort.



Experimental setup for capturing variation in MIRS caused by the laboratory of origin, individual genetic differences and natural environment.

Additionally, the model is able to detect the impact of simulated control interventions on mosquito populations, measured as a shift in their age structures. In the future, we anticipate our method can be applied to other arthropod vector-borne diseases.

[*A Practical Insecticide Resistance Monitoring Bioassay for Orally Ingested Dinotefuran in Anopheles Malaria Vectors*](#)

Insects 22 March 2022

Attractive Toxic Sugar Baits (ATSB) deployed outdoors are likely to be particularly effective against outdoor biting mosquitoes and, if they contain insecticides with a different mode of action, mosquitoes resistant to pyrethroids. One such ATSB based on the neonicotinoid dinotefuran is currently under evaluation in Africa. As with any insecticide-based intervention, it will be important to monitor for the possible emergence of vector resistance. While methods for detecting resistance to insecticides via tarsal contact are recommended by the World Health Organization (WHO), these may not be applicable for orally ingested insecticides. Here, a new ingestion assay, appropriate for a controlled laboratory setting, is described using fluorescein sodium salt (uranine) as a feeding marker. Conventional topical application bioassays, more appropriate for routine deployment, have also been used to apply dinotefuran to the thorax of adult *Anopheles* mosquitoes with an organic carrier to bypass lipid cuticle barriers. The two methods were compared by establishing lethal doses (LD) in several *Anopheles* strains. The similarity of the ratios of susceptibility to dinotefuran between pairs of pyrethroid susceptible and resistant strains validates topical application as a suitable, more practical and field applicable method for monitoring for the emergence of resistance to orally ingested dinotefuran. A discriminating dose is proposed, which will be further validated against field populations and used to routinely monitor for the emergence of resistance alongside ATSB trials.

[*An evidence synthesis approach for combining different data sources illustrated using entomological efficacy of insecticides for indoor residual spraying*](#)

PLoS One 24 March 2022

Abstract

Background Prospective malaria public health interventions are initially tested for entomological impact using standardised experimental hut trials. In some cases, data are collated as aggregated counts of potential outcomes from mosquito feeding attempts given the presence of an insecticidal intervention. Comprehensive data i.e. full breakdowns of probable outcomes of mosquito feeding attempts, are more rarely available. Bayesian evidence synthesis is a framework that explicitly combines data sources to enable the joint estimation of parameters and their uncertainties. The aggregated and comprehensive data can be combined using an evidence synthesis approach to enhance our inference about the potential impact of vector control products across different settings over time.

Methods Aggregated and comprehensive data from a meta-analysis of the impact of Pirimiphos-methyl, an indoor residual spray (IRS) product active ingredient, used on wall surfaces to kill mosquitoes and reduce malaria transmission, were analysed using a series of statistical models to understand the benefits and limitations of each.

Conclusions We developed an approach to combine sources from trials to maximise the inference that can be made from such data and that is applicable to other systems. Bayesian evidence synthesis enables inference from multiple datasets simultaneously to give a more informative result and highlight conflicts between sources. Advantages and limitations of these models are discussed.

[*Modelling new insecticide-treated bed nets for malaria-vector control: how to strategically manage resistance?*](#)

Malaria Journal 24 March 2022

Previous insecticides have been deployed one-at-a-time until their utility was compromised, without the strategic management of resistance. Recent investment has led to the near-synchronous development of new insecticides, and with it the current opportunity to build resistance management into mosquito-control methods to maximize the chance of eradicating malaria. Here, building on the parameter framework of an existing mathematical model, resistance-management strategies using multiple insecticides are compared to

suggest how to deploy combinations of available and new insecticides on bed nets to achieve maximum impact. Substantially building on previous works, alternative solutions for the resistance management of new insecticides to be used in bed nets for malaria vector control are found. The results support a mixture product concept as the most robust way to deploy new insecticides, even if they are mixed with a pyrethroid that has lower effectiveness due to pre-existing resistance. This can help deciding on deployment strategies and policies around the sustainable use of these new anti-malaria tools.

[*Effectiveness and cost-effectiveness against malaria of three types of dual-active-ingredient long-lasting insecticidal nets \(LLINs\) compared with pyrethroid-only LLINs in Tanzania: a four-arm, cluster-randomised trial*](#)

The Lancet 26 March 2022

The paper reports the results of a four-arm, cluster-randomised trial in Misungwi, Tanzania evaluating four types of LLIN treated with the following: α -cypermethrin only (pyrethroid-only [reference] group); pyriproxyfen and α -cypermethrin (pyriproxyfen group); chlorfenapyr and α -cypermethrin (chlorfenapyr group); or the synergist piperonyl butoxide and permethrin (piperonyl butoxide group). This study is the first to assess the effectiveness and cost-effectiveness of the three classes of dual-activeingredient LLINs currently available for malaria control. After 2 years, chlorfenapyr LLINs provided significantly better protection than pyrethroid-only LLINs against malaria in an area with pyrethroid-resistant mosquitoes, and the additional cost of these nets would be considerably below plausible cost-effectiveness thresholds.

Implications of all the available evidence

This study has several major implications. First, LLINs treated with both chlorfenapyr and a pyrethroid should be deployed in areas of insecticide resistance, with careful consideration of strategies for resistance management. Second, further investigation of the role of cross-resistance in pyriproxyfen LLINs is warranted to understand the utility of these nets for malaria control in different ecological and epidemiological settings. Finally, funders, national malaria control programmes, and stakeholders should urgently advocate and set up incentive structures to promote better textile and active ingredient durability on LLINs and implementers should enhance behaviour change and education efforts to promote proper care of nets which could help increase their time in use.

[*Use of novel lab assays to examine the effect of pyrethroid-treated bed nets on blood-feeding success and longevity of highly insecticide-resistant *Anopheles gambiae* s.l. mosquitoes*](#)

Parasites and Vectors 28 March 2022

Standard WHO insecticide resistance monitoring assays are designed for resistance surveillance and do not necessarily provide insight into how different frequencies, mechanisms or intensities of resistance affect the ability of ITNs to reduce malaria transmission. The current study presents some novel laboratory-based assays that attempt to better simulate realistic exposure of mosquitoes to ITNs and to quantify impact of exposure not only on instantaneous mortality, but also on blood-feeding and longevity, two traits that are central to transmission. The study revealed that the standard ITN induced negligible instantaneous mortality against the resistant mosquitoes, whereas the resistance-breaking net caused high mortality and a reduction in blood-feeding. However, both ITNs still impacted long-term survival relative to the UTN. The impact on longevity depended on feeding status, with blood-fed mosquitoes living longer than unfed mosquitoes following ITN exposure. Exposure to both ITNs also reduced the blood-feeding success, the time spent on the net and blood-feeding duration, relative to the untreated net.

Conclusion - Although a standard ITN did not have as substantial instantaneous impact as the resistance-breaking net, it still had significant impacts on traits important for transmission. These

results highlight the benefit of improved bioefficacy assays that allow for realistic exposure and consider sub- or pre-lethal effects to help assess the functional significance of insecticide resistance.

[*Evaluation of the protective efficacy of a spatial repellent to reduce malaria incidence in children in western Kenya compared to placebo: study protocol for a cluster-randomized double-blinded control trial \(the AEGIS program\)*](#)

[*Evaluation of the protective efficacy of a spatial repellent to reduce malaria incidence in children in Mali compared to placebo: study protocol for a cluster-randomized double-blinded control trial \(the AEGIS program\)*](#)

Trials 5 April 2022

These papers detail the trials in Kenya and Mali designed to demonstrate and quantify the protective efficacy (PE) of the Mosquito Shield™, a transfluthrin-based SR product, in reducing the incidence of malaria infection in humans.

[*Primate malaria: An emerging challenge of zoonotic malaria in Indonesia*](#)

One Health 8 April 2022

Abstract

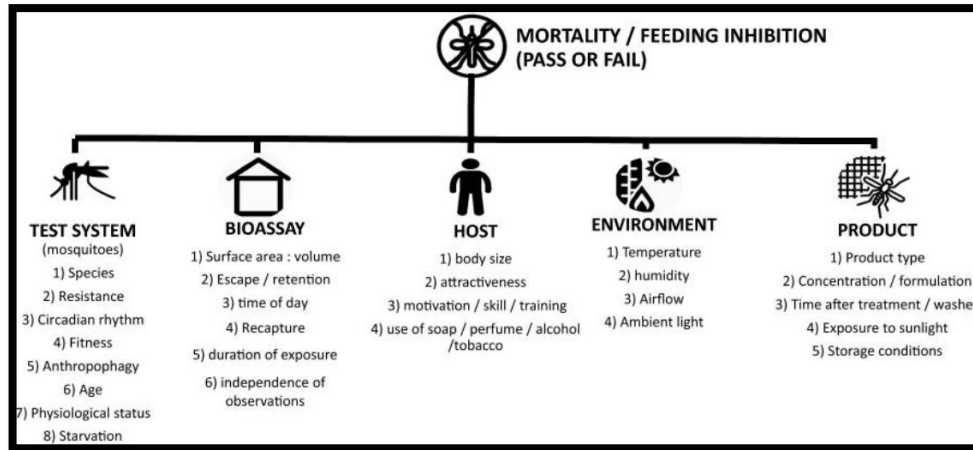
The emergence of zoonotic malaria in different parts of the world, including Indonesia poses a challenge to the current malaria control and elimination program that target global malaria elimination at 2030. The reported cases in human include *Plasmodium knowlesi*, *P. cynomolgi* and *P. inui*, in South and Southeast Asian region and *P. brazilianum* and *P. simium* in Latin America. All are naturally found in the Old and New-world monkeys, macaques spp. This review focuses on the currently available data that may represent primate malaria as an emerging challenge of zoonotic malaria in Indonesia, the distribution of non-human primates and the malaria parasites it carries, changes in land use and deforestation that impact the habitat and intensifies interaction between the non-human primate and the human which facilitate spill-over of the pathogens. Although available data in Indonesia is very limited, a growing body of evidence indicate that the challenge of zoonotic malaria is immense and alerts to the need to conduct mitigation efforts through multidisciplinary approach involving environmental management, non-human primates conservation, disease management and vector control.

[*Influence of testing modality on bioefficacy for the evaluation of Interceptor® G2 mosquito nets to combat malaria mosquitoes in Tanzania*](#)

Parasites and Vectors 11 April 2022

This study evaluated the performance of Interceptor® G2 compared to Interceptor® against local strains of mosquitoes in Tanzania using four bioassay types: (1) World Health Organisation (WHO) cone test (cone), (2) WHO tunnel test (tunnel), (3) Ifakara ambient chamber test (I-ACT) and (4) the WHO gold standard experimental hut test (hut). Results depend on the type of bioassay used, highlighting the importance of choosing a bioassay appropriate for the product and biological system being evaluated. Against resistant strains,

superiority of Interceptor® G2 over Interceptor® was observed in all “free-flying bioassays”. In cone tests (which restrict mosquito flight), superiority of Interceptor® over Interceptor® G2 was rerecorded.
Factors determining bioassay results beyond product characteristics



[Assessing the Impact of Insecticide Resistance on Vector Competence: A Review](#)

Insects 12 April 2022

It is unknown if insecticide resistance (IR) could impact insects’ other characteristics, such as their ability to infect, maintain infection, or transmit pathogens, a trait known as vector competence (VC). In this review, we analyze the literature that involves the study of VC and IR or insecticide exposure in three main approaches; studies conducted in the field versus laboratory-designed experiments, the impact of insecticide exposure on pathogen transmission, and studies performed on vectors of crop pathogens. The evidence points out three different patterns where enhancement, impairment, or neutral effects are seen between IR and VC. Although current information is scarce and obtained under highly heterogeneous experimental designs, evidence indicates that insecticide exposure and resistance increase the risk of pathogen transmission. It is of great concern that IR could enhance VC since it increases the risk of epidemics. More detailed and standardized studies are needed to confirm this relationship. Finally, results from this investigation could help create evidence-based vector control programs.

[Effectiveness of autocidal gravid trapping and chemical control in altering abundance and age structure of *Aedes albopictus*](#)

Pest Mgmt Science 13 April 2022

Although this paper focuses on *Aedes albopictus*, it is relevant to those of you struggling to control other urban and “container breeding” mosquitoes such as *Anopheles stephensi*.

This group investigated whether adding Gravid *Aedes* Traps (GATs), Autocidal Gravid Ovitrap (AGOs) or In2Care traps would extend the effectiveness of chemical control methods by combining barrier sprays and larval habitat management (LHM) with each trap type at suburban households. Barrier sprays and LHM alone or combined with any supplemental autocidal ovitrap significantly reduced female *Ae. albopictus* through Week 3 post-treatment. GATs significantly extended chemical control effectiveness for the duration of the study. Compared to the untreated control, the AGO and GAT treatment groups had significant overall female *Ae. albopictus* reductions of 74% and 80.4%, respectively, with populations aging significantly slower at houses treated with AGOs.

[Pirikool® 300 CS, a new long-lasting capsule suspension formulation of the organophosphate insecticide pirimiphos-methyl for indoor residual spraying against pyrethroid-resistant malaria vectors](#)

Clinical Trials 18 April 2022

Indoor residual spraying (IRS) using a capsule suspension formulation of the organophosphate insecticide, pirimiphos-methyl, has provided substantial malaria control in many communities in Africa. However, only one brand of this product has been recommended by the World Health Organisation for IRS. To help increase the diversity of the portfolio of IRS insecticides and offer suitable options to procurers and malaria vector control programmes, additional product brands of this highly effective and long-lasting insecticide formulation for IRS will be needed. We evaluated the efficacy of Pirikool® 300CS, a new capsule suspension formulation of pirimiphos-methyl developed by Tianjin Yorkool, International Trading, Co., Ltd in standard WHO laboratory bioassays and experimental hut studies. Pirikool® 300CS induced high mortality against wild free-flying pyrethroid-resistant *An gambiae* s.l. (85%) over 12 months in experimental huts in Benin. The insecticide also provided prolonged residual vector control which lasted for 10–12 months on both mud and cement experimental hut wall substrates. IRS with Pirikool® 300CS, therefore, has the potential to provide significant control of malaria transmitted by pyrethroid-resistant malaria vectors. Its addition to the current portfolio of IRS insecticides will provide an extra choice of microencapsulated pirimiphos-methyl for IRS.

[The potential impact of *Anopheles stephensi* establishment on the transmission of *Plasmodium falciparum* in Ethiopia and prospective control measures](#)

BMC Med 20 April 2022

In this paper the authors quantify the potential impact of *An. stephensi* invasion in Djibouti on malaria transmission in order to make projections about what could happen in Ethiopia, where the species has been found at numerous sites and is spreading. Translating the invasion of *An. stephensi* to its public health impact is difficult due to uncertainty in its vectorial capacity and how public health entities and governments will respond. Different illustrative scenarios are investigated, exploring the public health impact of different vector control interventions.

They estimate that annual *P. falciparum* malaria cases could increase by 50% (95% CI 14–90) if no additional interventions are implemented. The implementation of sufficient control measures to reduce malaria transmission to pre-*stephensi* levels will cost hundreds of millions of USD.

[Household modifications after the indoor residual spraying \(IRS\) campaign in Mozambique reduce the actual spray coverage and efficacy](#)

PLoS Global Public Health 20 April 2022

Household owners continually modified insecticide-treated walls and added rooms onto compounds. Household surveys in southern Mozambique showed frequent modification of indoor walls (0–17.2% of households modified rooms monthly) and/or added rooms (0–16.2% of households added rooms monthly). Actual IRS coverage reduced from an assumed 97% to just 39% in Matutuine, but only from 96% to 91% in Boane, translating to 43% and 5.8% estimated increases in relative daily mosquito bites per person.

[Exposure of *Anopheles gambiae* larvae to a sub-lethal dose of an agrochemical mixture induces tolerance to adulticides used in vector control management](#)

Aquatic Toxicology 26 April 2022

The heavy use of pesticides in agricultural areas often leads to the contamination of nearby mosquito larvae breeding sites. Exposure to complex mixtures of agrochemicals can affect the insecticide sensitivity of mosquito larvae. Our study objective was to determine whether agrochemical residues in Anopheline larval breeding sites can affect the tolerance of adults to commonly used adulticides. *An. gambiae* larvae were exposed to a sub-lethal dose of a mixture of agrochemical pesticides used in a highly active agricultural area on the Ivory Coast.

Highlights

- Exposure to agrochemicals can affect the tolerance of mosquitoes larvae to insecticides.
- The potential carry-over of such effect to the adult stage has been far less documented.
- Exposure of *An. gambiae* larvae to agrochemicals increase tolerance to Fludora® fusion in adults.
- Fludora® fusion efficacy for vector control may be locally affected by the ecological context.

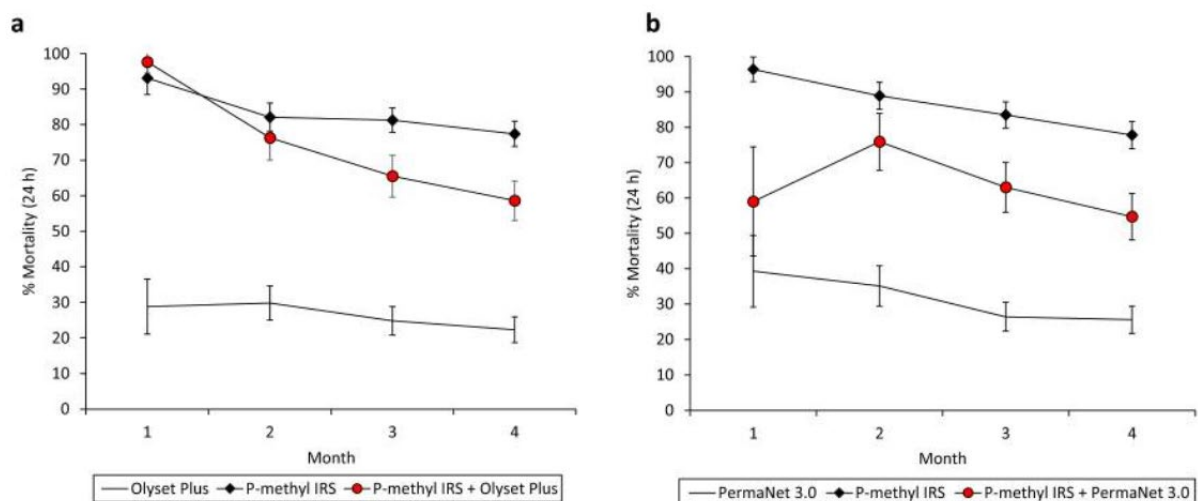
[Pyrethroid-piperonyl butoxide \(PBO\) nets reduce the efficacy of indoor residual spraying with pirimiphos-methyl against pyrethroid-resistant malaria vectors](#)

Scientific Reports 27 April 2022

Abstract

Pirimiphos-methyl is a pro-insecticide requiring activation by mosquito cytochrome P450 enzymes to induce toxicity while PBO blocks activation of these enzymes in pyrethroid-resistant vector mosquitoes. PBO may thus antagonise the toxicity of pirimiphos-methyl IRS when combined with pyrethroid-PBO ITNs. The impact of combining Olyset Plus and PermaNet 3.0 with Actellic 300CS IRS was evaluated against pyrethroid-resistant *Anopheles gambiae* s.l. in two parallel experimental hut trials in southern Benin. The vector population was resistant to pyrethroids and PBO pre-exposure partially restored deltamethrin toxicity but not permethrin. Mosquito mortality in experimental huts was significantly improved in the combinations of bendiocarb IRS with pyrethroid-PBO ITNs (33–38%) compared to bendiocarb IRS alone (14–16%, $p < 0.001$), demonstrating an additive effect. Conversely, mortality was significantly reduced in the combinations of pirimiphos-methyl IRS with pyrethroid-PBO ITNs (55–59%) compared to pirimiphos-methyl IRS alone (77–78%, $p < 0.001$), demonstrating evidence of an antagonistic effect when both interventions are applied in the same household. Mosquito mortality in the combination was significantly higher compared to the pyrethroid-PBO ITNs alone (55–59% vs. 22–26% $p < 0.001$) showing potential of pirimiphos-methyl IRS to enhance vector control when deployed to complement pyrethroid-PBO ITNs in an area where PBO fails to fully restore susceptibility to pyrethroids.

Pyrethroid-PBO ITNs plus Pirimiphos-methyl IRS



Monthly mortality rates of wild, pyrethroid-resistant *Anopheles gambiae* sensu lato entering experimental huts with pyrethroid-PBO ITNs and pirimiphos-methyl IRS, applied alone and in combination in Covè, southern Benin. Panel (a) presents results from the trial with Olyset Plus and panel (b) presents results from the trial with PermaNet 3.0. Error bars represent 95% CIs. Monthly mortality rates are cumulated with increasing time elapsed from the onset of the trial.

[Strain Characterisation for Measuring Bioefficacy of ITNs Treated with Two Active Ingredients \(Dual-AI ITNs\): Developing a Robust Protocol by Building Consensus](#)

Insects 6 May 2022

Durability monitoring of insecticide-treated nets (ITNs) containing a pyrethroid in combination with a second active ingredient (AI) must be adapted so that the insecticidal bioefficacy of each AI can be monitored independently. An effective way to do this is to measure rapid knock down of a pyrethroid-susceptible strain of mosquitoes to assess the bioefficacy of the pyrethroid component and to use a pyrethroid-resistant strain to measure the bioefficacy of the second ingredient. To allow robust comparison of results across tests within and between test facilities, and over time, protocols

for bioefficacy testing must include either characterisation of the resistant strain, standardisation of the mosquitoes used for bioassays, or a combination of the two. Through a series of virtual meetings, key stakeholders and practitioners explored different approaches to achieving these goals. Via an iterative process we decided on the preferred approach and produced a protocol consisting of characterising mosquitoes used for bioefficacy testing before and after a round of bioassays, for example at each time point in a durability monitoring study. We present the final protocol and justify our approach to establishing a standard methodology for durability monitoring of ITNs containing pyrethroid and a second AI.

[Dengue vectors in Africa: A review](#)

Heliyon 17 May 2022

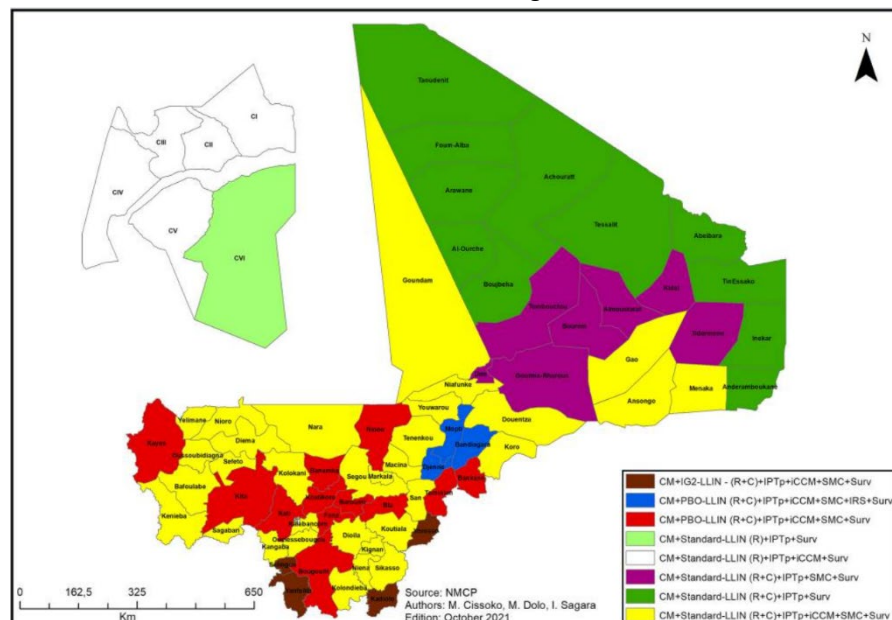
Abstract

Dengue fever is a mosquito-borne-disease of growing public health importance in Africa. The continuous increase of number and frequency of outbreaks of dengue fever, especially in urban area in Africa underline the need to review the current data available on vectors involved in dengue virus transmission in Africa. Here, we summarized the available data on vectors involved in the transmission of dengue virus in the sylvatic and urban environments, vertical transmission, vector competence studies, and vector control strategies used in Africa. The virus was isolated mainly from *Aedes furcifer*, *Ae. luteocephalus*, and *Ae. taylori* in the sylvatic environment and from *Ae. aegypti* and *Ae. albopictus* in the urban areas. Prospective and urgently needed studies on vectors biology, behavior, and alternative control strategies are suggested.

[Stratification at the health district level for targeting malaria control interventions in Mali](#)

Scientific Reports 18 May 2022

This group performed a malaria risk stratification at the health district level in Mali with a view to proposing targeted control interventions. Risk stratification identified 12 health districts in very low transmission areas, 19 in low transmission areas, 20 in moderate transmission areas, and 24 in high transmission areas. Low health facility usage and increased vector resistance were observed in high transmission areas. Eight intervention combinations were selected for implementation. Our work provides an updated risk stratification using advanced statistical methods to inform the targeting of malaria control interventions in Mali. This stratification can serve as a template for continuous malaria risk stratifications in Mali and other countries.

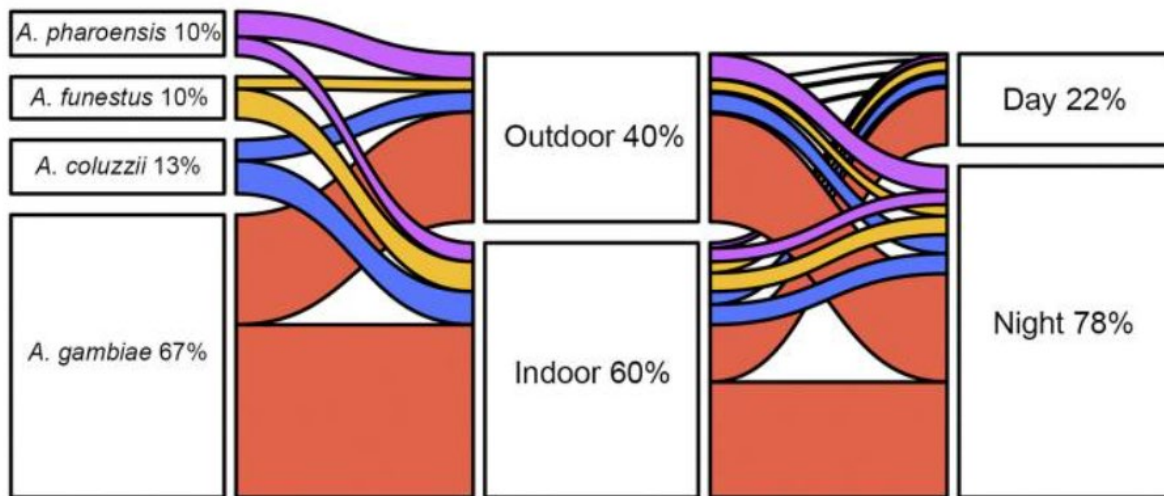


Intervention combinations at the health district level in Mali. CM: Malaria case management; IG2-LLIN: Interceptor G2 Net; R: Routine distribution; C: Universal campaign; IPTp: Intermittent preventive treatment in pregnancy; iCCM: Integrated community case management; SMC: Seasonal malaria chemoprevention; Surv: Weekly and monthly epidemiological surveillance; PBO-LLIN: Long-lasting piperonyl butoxide-treated insecticidal net; IRS: Indoor residual spraying; Standard LLIN: Standard long-lasting insecticidal net.

[Diurnal biting of malaria mosquitoes in the Central African Republic indicates residual transmission may be "out of control"](#)

Proc Natl Acad Sci USA 24 May 2022

By performing mosquito collections 48-h around the clock, both indoors and outdoors, and by modeling biting events using circular statistics, we evaluated the full daily rhythmicity of biting in urban Bangui, Central African Republic. While the bulk of biting by *Anopheles gambiae*, *Anopheles coluzzii*, *Anopheles funestus*, and *Anopheles pharoensis* occurred from sunset to sunrise outdoors, unexpectedly ~20 to 30% of indoor biting occurred during daytime. It is not known whether these populations of biting events correspond to spatiotemporal heterogeneities or also to distinct mosquito genotypes/phenotypes belonging consistently to each compartment. Prevalence of *Plasmodium falciparum* in nighttime- and daytime-biting mosquitoes was the same. As >50% of biting occurs in Bangui when people are unprotected, malaria control interventions outside the domiciliary environment should be envisaged.



Summary of the observed proportion of mosquito bites by species according to location and period of the day: *A. gambiae* (red), *A. coluzzii* (blue), *A. funestus* (yellow), and *A. pharoensis* (violet)

[Wolbachia 16S rRNA haplotypes detected in wild Anopheles stephensi in eastern Ethiopia](#)

Parasites and Vectors 24 May 2022

This study aimed to identify the presence and diversity of *Wolbachia* in *An. stephensi* across eastern Ethiopia. Twenty out of the 184 mosquitoes screened were positive for *Wolbachia*, with multiple haplotypes detected. These findings provide the first evidence of natural *Wolbachia* populations in wild *An. stephensi* in the Africa. They also identify the need for further research to confirm the endosymbiotic relationship between *Wolbachia* and *An. stephensi* and to investigate its utility for malaria control.

[Reflections on the 2021 World Malaria Report and the future of malaria control](#)

Malaria Journal 27 May 2022

This article presents key insights from the 2021 World Malaria Report and reflections on the future trajectories: it was informed by an in-depth discussion with leading malaria experts from the World Health Organization (WHO), the Bill & Melinda Gates Foundation, and the U.S. President’s Malaria Initiative (PMI). The discussion took place during the 34th edition of the Ifakara Master Classes, held virtually on December 15th, 2021.

A key quote from this editorial is,

“The malaria situation cannot be effectively tackled using current practices, highlighting the need for a more transformational approach, tailored to different epidemiological contexts. A drastic change in mindset is needed around the disease and its complexities.”

[Enhancing the Quality of Spray Application in IRS: Evaluation of the Micron Track Sprayer](#)

Insects 31 May 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.



A schematic overview of the sprayer adapted from the Micron product manual is shown on the (left). A photo showing the set-up of track sprayer in the lab (centre left) and in an experimental hut (centre right) is shown, and a schematic overview of the filter paper positions on plywood panels, with values in centimetres, is shown on the (right).

[Anopheles stephensi in Africa requires a more integrated response](#)

Malaria Journal 31 May 2022

Abstract

There are increasing reports of the Asian malaria mosquito, *Anopheles stephensi* invading and spreading in Eastern Africa. We discuss the importance of these invasions in the context of broader challenges facing malaria control in Africa and argue against addressing it as an isolated problem. *Anopheles stephensi* is only one of multiple biological threats facing malaria control in the region—and is itself an indication of wide-ranging weaknesses in vector surveillance and control programs. Expanded investigations are needed in both urban and rural areas, especially in countries serviced by the Indian Ocean trade routes, to establish the full extent and future trajectories of the problem. More importantly, instead of tackling this vector species as a stand-alone threat, affected countries should adopt more integrated and multi-sectorial initiatives that can sustainably drive and keep out malaria.

[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, a 3GIRS product with pirimiphos-methyl, in sub-Saharan Africa in 2017 added to standard malaria control interventions including insecticide-treated bed nets versus standard malaria control interventions alone. An economic evaluation of 3GIRS using Actellic®300CS in a broad range of sub-Saharan African settings was conducted using a variety of primary data collection and evidence synthesis methods. Overall, IRRs from each country indicated that 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. The optimal combination of 3GIRS delivery with other malaria control interventions will be highly context specific. 3GIRS using Actellic®300CS is expected to deliver acceptable value for money in a broad range of sub-Saharan African malaria transmission settings.

WHO News and Publications

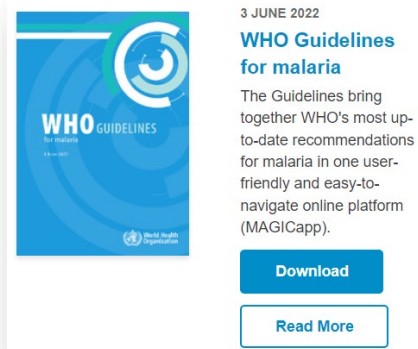
[WHO Guidelines for Malaria](#)

Updated 3 June 2022

WHO regularly convenes the world's leading malaria experts to review available evidence and advise on recommendations to control and eliminate malaria. The consolidated Guidelines for malaria, launched in February 2021, bring together – for the first time – all of the Organization's current recommendations for malaria in one user-friendly online resource. Through the [MAGIcapp platform](#) you will find:

All WHO evidence-based recommendations for malaria prevention (vector control and preventive chemotherapies) and case management (diagnosis and treatment); recommendations for elimination settings are in development.

Links to other resources, such as guidance and information on the strategic use of information to drive impact; surveillance, monitoring and evaluation; operational manuals, handbooks, and frameworks; and a glossary of terms and definitions.



[16th meeting of the Vector Control Advisory Group \(VCAG\)](#)

28 – 30 March 2022

The Vector Control Advisory Group (VCAG) met for its 16th session on 28–30 March 2022. The meeting report details the proceedings and outcomes of the meeting, including advice provided to applicants working on interventions in the following intervention classes: bait stations, reduction of pathogen transmission induced by gene drive, house screening, and eave tubes..

Note the new VCAG website <https://www.who.int/groups/vector-control-advisory-group>

[Vector control: the WHO evaluation process for new interventions](#)

21 February 2022

This recent video provides a high-level overview of the WHO vector control evaluation process jointly managed by the Global Malaria Programme (GMP), the Department of Control of Neglected Tropical Diseases (NTD) and Regulation and Pre-qualification (RPQ). The process evaluates new tools, strategies and approaches that combat vector-borne diseases, and the evidence that underpins an intervention's safety, quality, entomological efficacy and public health value. The video describes how a new tool enters the process, what pathway(s) the intervention must take as part of its evaluation, and the anticipated outcome of the respective pathways as described in the publication "[Norms, standards and processes underpinning development of WHO recommendations on vector control.](#)"

[Malaria Policy Advisory Group \(MPAG\) meeting \(March 2022\)](#)

20 April 2022 | Meeting report

On 23–24 March 2022, the WHO Malaria Policy Advisory Group (MPAG) convened virtually to review updates and progress, and to provide guidance on thematic areas of work by the Global Malaria Programme. The meeting focused on 8 topics:

- 1) an update on the RTS,S malaria vaccine and the draft framework for vaccine allocation;
- 2) the operational manual for subnational tailoring of malaria interventions;
- 3) *Plasmodium knowlesi* disease burden and transmission: implications for WHO certification of malaria elimination;
- 4) the report of the technical consultation to review the classification of glucose-6-phosphate dehydrogenase (G6PD);
- 5) an update on the *WHO Guidelines for malaria*;
- 6) an update on “Rethinking Malaria” and preparations for the Africa regional meeting;
- 7) an update on the framework for response to malaria in urban areas; and
- 8) an update on the development of a strategy to respond to antimalarial drug resistance in Africa.

[PQT/VCP Webinar Wednesdays](#)

PQT/VCP is initiating a series of open online discussions **every other Wednesday from 1300–1400 CET**. These informal webinars are an opportunity for the vector control community to submit questions to PQT/VCP and engage in real-time discussions on the VCP prequalification process. All interested stakeholders are welcome to join by registering for the webinar series and joining at the scheduled time.

The webinars will be presented using Zoom. All prospective attendees must register in advance in order to access the webinar. The one-time registration will ensure you have access to the whole webinar series, meaning you can join based on your availability.

[Webinar Wednesday Registration Link](#)

Webinars, websites and other resources

[Ifakara Master Classes in Public Health & Medical Entomology](#)

Hosted by Fredros Okumu and Sheila Ogoma, the recorded Q and A sessions around various topics are available on YouTube. Recent topics include:

- 14 April 2022 - [The Big Malaria Questions](#) with Prof. Kevin Marsh
- 12 May 2022 - [New Nets & New Sprays for Malaria Control](#) with Natacha Protopopoff, Corine Ngufor, Joe Wagman, Seth Irish, Manuel Lluberas, Abraham Mnzava
- 26 May 2022 - [The Mosquitoes Must Surrender](#) with IVCC & Partners

[APMEN Webinar archive](#)

If you missed the latest APMEN TechTalks you can access the recorded events [here](#).

Recent topics include:

- 15 June - [All about Bednets, Cradle to Grave](#)
- 29 April - [Data Quality for Malaria Elimination](#)
- 30 March - [Larval Source Management: Historical successes, current challenges, and future potential](#)
- 9 Feb - [More discussions on mosquito repellents and attractants](#)

[17th annual meeting of the Vector Control Working Group](#)

We are pleased to announce that the documentation and recordings from the recent VCWG-17 annual meeting (5 sessions) are now uploaded on the [RBM VCWG webpage](#).

[Vector Learning Xchange](#)

Welcome to the *Vector LearningXchange*, Roll Back Malaria’s collaborative site where vector control stakeholders from around the world can learn from one another on the most effective ways to prevent malaria. We aim to provide best practices, tools, trainings and lessons learned on vector control operations,

entomological monitoring and surveillance, environmental compliance, monitoring and evaluation, community mobilization and social behavior change, capacity building, and gender inclusion. We also provide you with the latest data on insecticide resistance (IR) and resistance management.

[Webinars](#) and other technical resources are available at the site.

[MESA Track](#)

Archives may gather dust but a living database like [MESA Track](#) is always buzzing with new content. To help the malaria research community stay up-to-date with ongoing and past malaria projects, we are excited to introduce a new section to our monthly newsletter – Featuring from MESA Track. Starting this month, we will highlight malaria projects from MESA Track that have been recently added to the database. We will also try to extend visibility to those projects that might otherwise go unnoticed. To spread the word about your malaria project or connect with teams working on similar topics, [submit your project](#) to MESA Track today or write to us at mesa@isglobal.org.



In the news and social media

[EPA approves EUP amendment for Oxitec genetically engineered mosquitoes](#)

7 March 2022

The U.S. EPA has approved an experimental use permit (EUP) amendment for Oxitec Ltd. that expands and extends the testing of genetically engineered *Aedes aegypti* (OX5034) mosquitoes to reduce mosquito populations. The original 2020 EUP allowed Oxitec to field test the use of OX5034 mosquitoes in Florida and Texas through 2022. Results from the Florida study were presented on 6 April but have yet to be published. The [Florida Keys Mosquito Control District and Oxitec webinar presenting the results can be viewed here](#).

The EUP amendment extends the EUP until 2024, in Monroe County, Florida; expands the EUP to 4 counties in California, and removes Harris County, Texas. To view the EUP amendment, updated risk assessment, and supporting materials, visit docket [EPA-HQ-OPP-2019-0274](#). To learn more about the initial EUP, view [EPA's webinar recording](#), available with English or Spanish subtitles.



[Tanzanian president visits SC Johnson in Racine to discuss mosquito repellents that could curb malaria](#)

19 April 2022

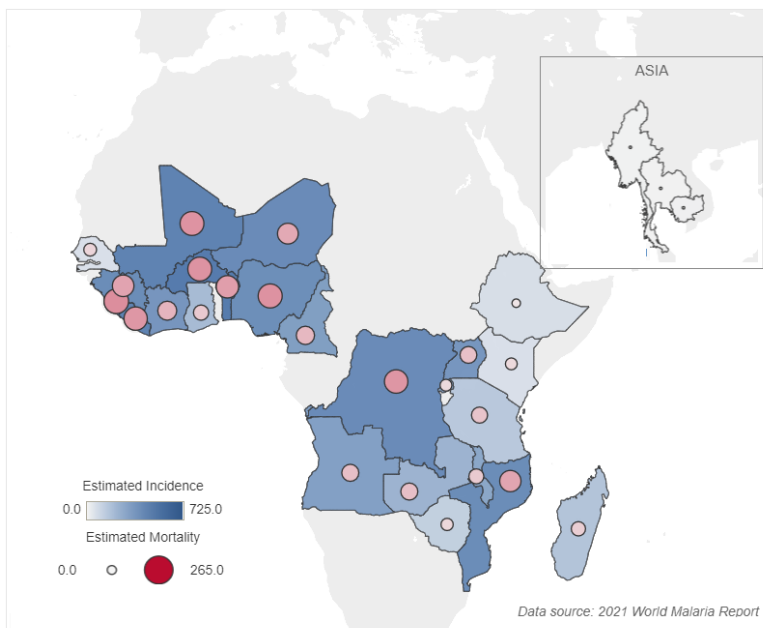
Tanzania president, Samia Suluhu Hassan, left, talks with Tom Mascari, SC Johnson medical entomologist during a tour of the SC Johnson Center for Insect Science at the company's global headquarters in Racine on Tuesday, April 19, 2022. Hassan's visit was a follow up to a visit the company's chairman and CEO H. Fisk Johnson paid to her two weeks ago in Tanzania, to discuss the company's work to develop a technology that seeks to eradicate malaria. Researchers at SC Johnson's Center for Insect Science and Family Health



hosted the President, walking her through the company's efforts to develop new mosquito repellent products that may help curb the spread of malaria and other mosquito-borne diseases. The two products, which are still under development, can be hung in homes, spreading mosquito-repelling chemicals for up to 10 months without the need for electricity or a flame. They are being developed by a team within the company that focuses specifically on supporting global public health efforts. SC Johnson entomologists said the new products, called Mosquito Shield and Guardian, would provide people with mosquito protection that complements other commonly-used tools in countries where malaria is an issue, like mosquito nets that hang over beds and more widespread pesticide spraying efforts by public health officials. See [above report](#) of the trials of the Mosquito Shield product. The Mosquito Shield lasts one month and costs \$0.30 and the Guardian lasts 10 months and costs \$3.00.

[PMI Annual Report](#)

New this year: An [interactive Tableau dashboard](#) that allows you to explore the report's data. In our first decade and a half of fighting malaria and saving lives, we delivered 500 million mosquito nets, 610 million rapid malaria tests, and 715 million fast-acting medicines; protected 23 million children and 42 million pregnant women from malaria through preventive medicines and 310 million people through home spraying; and funded 2 million trainings for health workers.



ABOUT MALARIA

Malaria is one of the world's oldest and deadliest diseases. Malaria was eliminated in the United States in the early 1950s. However, nearly half of the world's population is currently at risk and it remains a major global health security and economic threat. Malaria parasites are spread by infected female *Anopheles* mosquitoes when they bite. Early symptoms, such as fever, headache, and chills, may be mild and difficult to recognize. If not treated, malaria can rapidly progress to severe illness and death. The World Health Organization (WHO) estimated 241 million malaria cases and 627,000 malaria deaths worldwide in 2020. More than two-thirds of these deaths were children under five years old; over 90 percent of all deaths occurred in sub-Saharan Africa. WHO estimated \$6.8 billion was needed to fight malaria in 2020; current global funding for malaria is estimated at \$3.3 billion and the funding gap has widened dramatically over recent years, putting progress against malaria at risk.



Note: This issue covers the period from late February through through end of May 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.