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## Selected Scientific Publications (between 1 Nov 2023 and 31 Jan 2024)

### LLINs

#### [Video augmentation of the WHO cone assay to quantify mosquito behavioural responses to insecticide-treated nets](#)

Parasites & Vectors 15 Nov 2023

The World Health Organization (WHO) cone test was designed to assess the rapid toxicity effects of pyrethroid exposure on mosquito vectors but has yielded no insights beyond 60-min knockdown and 24-h mortality. As dual-active-ingredient (AI) ITNs become more widespread, bioassays that can provide realistic assessment of single- and dual-treated ITNs (i.e. nets with more than one active ingredient) are urgently needed. We present an augmentation of the cone test that enables accurate quantification of vector behavioural responses (specifically movement, spatial and temporal occupancy) to ITNs using video recording and bespoke software that uses background segmentation methods to detect spatial changes in the movement of mosquitoes within the cone.

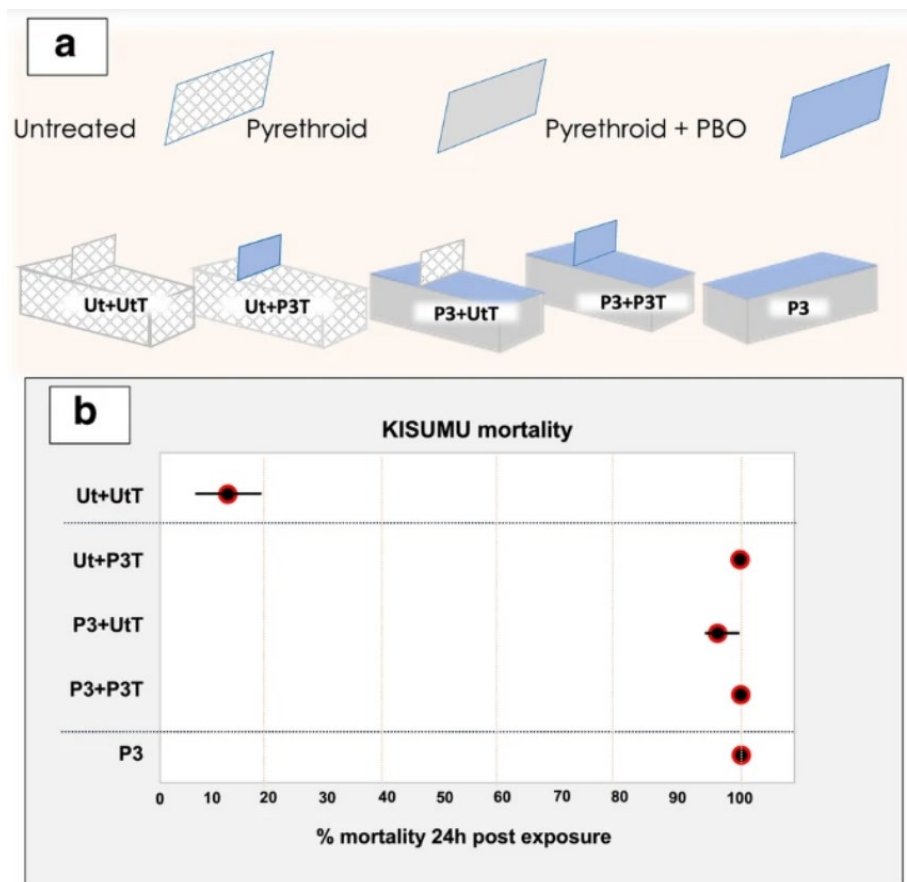
The additional mosquito behaviour data obtained by using this modification to the WHO cone test provides unique insight into the innate responses of different mosquito strains on untreated nets and the entomological mode of action of ITNs, important evidence when evaluating ITN characteristics.



## *Insecticidal roof barriers mounted on untreated bed nets can be as effective against *Anopheles gambiae* as regular insecticide-treated bed nets*

Nature Sci Reports 12 Dec 2023

Barrier bednets (BBnets), regular bednets with a vertical insecticidal panel to target mosquitoes above the bednet roof, where they are most active, have the potential to improve existing Insecticidal Treated Bednets (ITNs), by reducing the quantity of insecticide required per net, reducing the toxic risks to those using the net, potentially increasing insecticide choice. We evaluated the performance of 2PermaNet 3.0 (P3) and untreated (Ut) bed nets with and without pyrethroid and piperonyl butoxide roof barriers in killing pyrethroid-resistant and susceptible *Anopheles gambiae*, simultaneously video-recording mosquito flight tracks. The results of these tests, although not fully conclusive, demonstrate the potential of simple roof mounted bednet barriers for malaria vector control. The bioassays clearly demonstrate that treated longitudinal barriers are likely to greatly improve the performance of the bednet beneath them. This ability could extend as far as ‘converting’ an untreated net into an effective ITN or ‘restoring’ an intact aged net simply by the addition of a treated barrier.



## *Physical durability: are bed nets getting any stronger?*

Malaria Journal 13 Jan 2024

For at least a decade, concerns have been raised about the physical durability of insecticide-treated nets (ITNs) and their ability to remain in good condition for at least three years. To discover if the resistance to damage (RD) of ITNs has improved or not, the RD scores of ITNs sampled in 2013 and 2020 were compared. The RD scores and disaggregated textile performance data for nine ITNs recommended by the WHO pesticide evaluation scheme (WHOPES) measured in 2013 were compared with WHO-prequalified ITNs sampled in 2020. This included assessment of newer ITNs not available in 2013, to determine the extent to which product development has led to performance improvements across all available ITNs in the intervening years. **The resistance to damage of ITNs has not generally improved from 2013 to 2020, and in some cases performance is worse.** The average RD score of comparable ITNs brands decreased from 40 in 2013 to 36 in 2020. **Of the nets available in 2020, only two of the twenty-four ITN products tested achieved an RD score of > 50, while six ITNs had very low RD scores of < 30, highlighting a serious inherent, and literal weakness in many WHO-prequalified ITNs.**

**Conclusions** - The long-term physical durability of ITN products cannot be expected to improve while their resistance to damage remains so low, and major upgrades to the performance standards of textile materials used to make ITNs, as well as incentives to develop stronger ones are urgently required.

[Community benefits of mass distribution of three types of dual-active-ingredient long-lasting insecticidal nets against malaria prevalence in Tanzania: evidence from a 3-year cluster-randomized controlled trial](#)

This article is a preprint and has not been peer-reviewed. Posted 25 Jan 2024

Understanding the minimum community usage at which these novel nets generate an effect that also benefits non-net users against malaria infection is vital for planning net distribution strategies and mobilization campaigns.

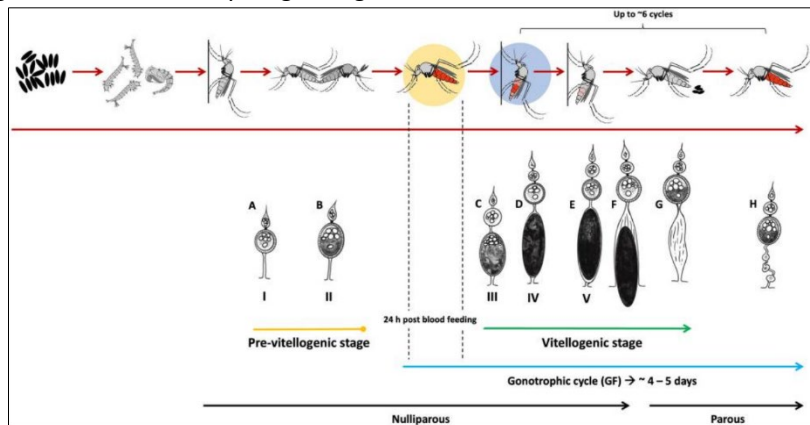
**Conclusion** Our study demonstrated that at a community usage of 40% or more of dual-AI LLINs, non-net users benefited from the presence of these nets. Noticeably, even when usage was  $\leq 40\%$  in the chlorfenapyr-PY arm, non-users were better protected than non-users in the higher coverage PY-only arm. The greater difference in malaria risk observed between users and non-users across all study arms indicates that nets play a crucial role in providing personal protection against malaria infection for the people using the net and that net usage needs to be maximized to realize the full potential of all nets.

**IRS**

[Targeted indoor residual insecticide applications shift \*Aedes aegypti\* age structure and arbovirus transmission potential](#)

Sci Reports 2 Dec 2023

While residual insecticide applications have the potential to decrease pathogen transmission by reducing the density of vectors and shifting the age structure of the adult mosquito population towards younger stages of development, this double entomological impact has not been documented for *Aedes aegypti*. *Aedes* collected from households enrolled in a cluster-randomized trial evaluating the epidemiological impact of targeted indoor residual spraying (TIRS) in Merida, Mexico, were dissected and their age structure characterized by the Polovodova combined with Christopher’s ovariole growth methods. In total, 813 females were dissected to characterize age structure at 1, 3, 6, and 9 months post-TIRS. Significant differences in the proportion of nulliparous *Ae. aegypti* females between the treatment groups was found at one-month post-TIRS (control: 35% vs. intervention: 59%), three months (20% vs. 49%) but not at six or nine months post-TIRS. TIRS significantly shifted *Ae. aegypti* age structure towards younger stages and led to a non-linear reduction in survivorship compared to the control arm. Reduced survivorship also reduced the number of arbovirus transmitting females (those who survived the extrinsic incubation period). **Our findings provide strong evidence of the full entomological impact of TIRS, with important implications for quantifying the epidemiological impact of vector control methods.**



[Impact of population based indoor residual spraying in combination with mass drug administration on malaria incidence and test positivity in a high transmission setting in north eastern Uganda](#)

Malaria Journal 13 Dec 2023

Mass drug administration (MDA) and indoor residual spraying (IRS) are potent malaria burden reduction tools. The impact of combining MDA and IRS is not well documented. We evaluated the impact of MDA + IRS compared to IRS alone at a high transmission site in Eastern Uganda.

In the MDA + IRS arm, malaria incidence dropped by 83% (IRR: 0.17 (0.16–0.18);  $p < 0.001$ ) in children under 5 year and by 78% (IRR: 0.22 (0.22–0.23);  $p < 0.001$ ) in persons aged  $\geq 5$  years from the pre-intervention to the

intervention period. In the IRS arm malaria incidence dropped by 47% (IRR: 0.53 (0.51, 0.56);  $p < 0.001$ ) in children under 5 years and by 71% 0.29 (0.28, 0.30);  $p < 0.001$ ) in persons aged  $\geq 5$  years. A drastic drop occurred immediately after the intervention after which cases slowly increased in both arms. Malaria test positivity rate (TPR) dropped at a rate of 21 ( $p = 0.003$ ) percentage points per 1000 persons in the MDA + IRS arm compared to the IRS arm. There was a mean decrease of 60 ( $p$ -value, 0.040) malaria cases among children under five years and a mean decrease in TPR of 16.16 ( $p$ -value, 0.001) in the MDA + IRS arm compared to IRS arm.

Interpretation

MDA significantly reduced malaria burden among children  $< 5$  years however the duration of this impact needs to be further investigated.

### [Reducing Malaria Transmission through Reactive Indoor Residual Spraying: A Systematic Review](#)

AJTMH 20 Dec 2023

In the final stages of malaria elimination, interventions to reduce malaria transmission are often centered around a confirmed case of malaria, as cases tend to cluster together at very low levels of transmission. The WHO commissioned a systematic review of the literature and synthesis of evidence for reactive indoor residual spraying (IRS) to develop official recommendations for countries.

This review found that reactive IRS reduces malaria prevalence, probably reduces the incidence of clinical malaria, and probably results in little to no difference in adverse events compared with no reactive IRS. This review suggests that in comparison to proactive, focal IRS, reactive IRS probably results in little to no difference in the incidence of clinical malaria, suggesting that it is as equally effective as proactive, focal IRS.

**The evidence indicates that reactive IRS may be a cost-effective tool for the prevention of malaria in elimination settings.**

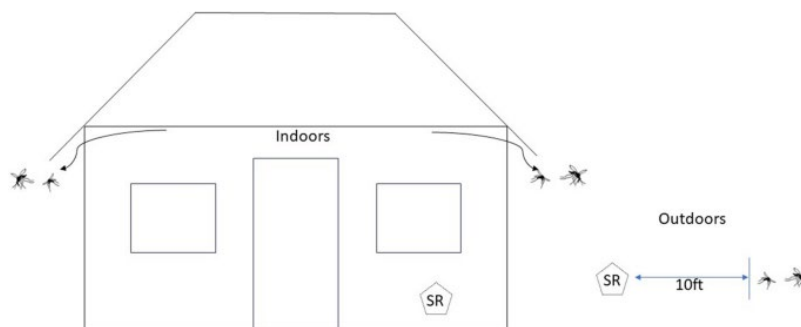
### Spatial emanators

### [Experimental hut and field evaluation of a metofluthrin-based spatial repellent against pyrethroid-resistant Anopheles funestus in Siaya County, western Kenya](#)

Parasites & Vectors 4 Jan 2024

Here we assessed the efficacy of a metofluthrin-based SR in reducing exposure to pyrethroid-resistant *Anopheles funestus* in Siaya County, western Kenya. Metofluthrin was vaporized using an emanator configured to a liquid petroleum gas (LPG) canister, placed inside experimental huts (phase 1) or outdoors (phase 2), and evaluated for reductions in human landing rate, density, knockdown and mortality rates of *An. funestus*, which are present in high density in the area. **Huts with metofluthrin vaporized with LPG**

**combustion had lower indoor density of *An. funestus* (99.3% less than controls), with knockdown and mortality rates of 95.5 and 87.7%, respectively, in the mosquitoes collected in the treated huts.** In the outdoor study (phase 2), the outdoor landing rate was significantly lower at 5 and 10 feet than at 20 feet from the emanator.

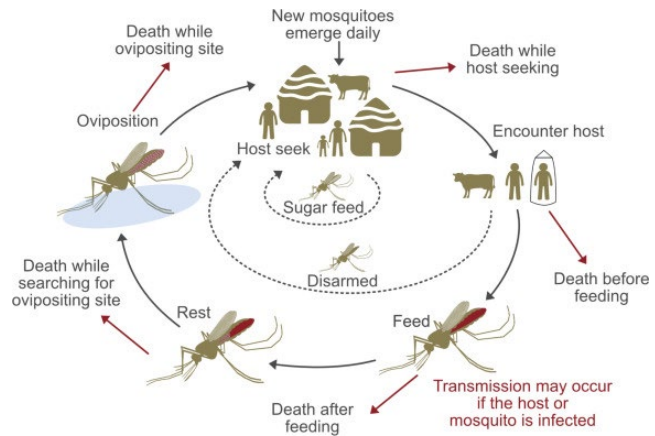


### [Inference for entomological semi-field experiments: Fitting a mathematical model assessing personal and community protection of vector-control interventions](#)

Computers in Biology and Medicine Jan 2024



The effectiveness of vector-control tools is often assessed by experiments as a reduction in mosquito landings using human landing catches (HLCs). However, HLCs alone only quantify a single characteristic and therefore do not provide information on the overall impacts of the intervention product. Using data from a recent semi-field study which used time-stratified HLCs, aspiration of non-landing mosquitoes, and blood feeding, we suggest a Bayesian inference approach for fitting such data to a stochastic model. This model considers both personal protection, through a reduction in biting, and community protection, from mosquito mortality and disarming (prolonged inhibition of blood feeding). Parameter estimates are then used to predict the reduction of vectorial capacity induced by etofenprox-treated clothing, picaridin topical repellents, transfluthrin spatial repellents and metofluthrin spatial repellents, as well as combined interventions for *Plasmodium falciparum* malaria in *Anopheles minimus*. Overall, all interventions had both personal and community effects, preventing biting and killing or disarming mosquitoes. This led to large estimated reductions in the vectorial capacity, with substantial impact even at low coverage. As the interventions aged, fewer mosquitoes were killed; however, the impact of some interventions changed from killing to disarming mosquitoes. Overall, this inference method allows for additional modes of action, rather than just reduction in biting, to be parameterised and highlights the tools assessed as promising malaria interventions.



### [Effects of transfluthrin-treated jute and cotton clothing against resistant and susceptible \*Aedes aegypti\* \(Diptera: Culicidae\) in a semifield system](#)

J Med Ent 12 Jan 2024

Volatile pyrethroids exert a range of both lethal and behavioral effects on mosquitoes through the passive release of insecticides into the atmosphere. We investigated the protective efficacy (PE) of transfluthrin-treated jute (TI-jute) and cotton (TI-cotton) fabrics, worn at the back of a protective black vest, against laboratory-reared pyrethroid susceptible and resistant strains of *Aedes aegypti* (L.) in a semifield system (SFS). Results showed that in the morning, the PE of TI-jute (49.4%) was higher than that of TI-cotton (36.8%). TI-jute demonstrated a lower PE of 9.6% against the transfluthrin-resistant strain. Remarkably, a significantly higher number of eggs were laid by the transfluthrin-resistant mosquitoes that survived the intervention (36.5 eggs/female) compared to the control group (11.8 eggs/female). These are critical challenges that warrant attention in vector control strategies. Investigating this phenomenon in mosquito reproduction necessitates future research at a molecular level.

### [Impact of a spatial repellent intervention on \*Anopheles kdr\* insecticide resistance allele in Sumba, Indonesia](#)

Malaria Journal 22 Jan 2024

This study evaluates the pyrethroid knockdown resistance (*kdr*) allele before and after implementing a transfluthrin-based spatial repellent (SR) intervention in placebo-treated clusters.

*Anopheles* increasing frequency of *kdr* mutant alleles during the 3 year SR deployment was observed in both SR-treated and placebo areas, a statistically significant increase occurred in each arm. However, it is unclear how significant SR is in causing the increase in mutant alleles.

The presence of fully susceptible phenotypes over time, along with an increase in the frequency distribution of the L1014F/S mutations post-intervention, suggest drivers of resistance external to the study, including pyrethroid use in agriculture and long-lasting insecticidal nets (LLINs). However, this does not negate possible SR impacts that support resistance. More studies that enable the comprehension of possible SR-based drivers of resistance in mosquitoes need to be conducted.



[Field evaluation of a volatile pyrethroid spatial repellent and etofenprox-treated clothing for outdoor protection against forest malaria vectors in Cambodia](#)

BioRxiv preprint This article is a preprint and has not been certified by peer review

In this field study the authors evaluated the outdoor application of one passive, transfluthrin-based spatial repellents (VPSR), four etofenprox treated clothing (ITC) paired with a picaridin topical repellent, and a combination of spatial repellents and ITC against wild *Anopheles* landing in Cambodia. Mathematical modeling was also used to predict the reduction of vectorial capacity of these interventions.

A 7x7 Latin-square (6 interventions and one control) was conducted over 49 collection nights in seven temporary, open structures in a forest in Mondulakiri Province, Cambodia. Pairs of participants conducted human landing catches (HLCs).

**All six interventions reduced *Anopheles* landing substantially; protective efficacies ranged between 61%** (95% confidence interval (CI): 48 – 71%) (etofenprox-ITC, washed) **and 95%** (95% CI: 93 – 96%) (combined VPSR and unwashed etofenprox-ITC). Finally, the modelling assessment demonstrates significant reductions in vectorial capacity, with the highest impact observed for the combined ITC and VPSR as well as the VPSR used alone, although effectiveness decreases with intervention aging, and variability exists in the magnitude of predicted reductions due to differences in experimental conditions.

These transfluthrin-based VPSR and etofenprox ITC interventions have the potential to reduce outdoor and daytime *Anopheles* biting by providing substantial protection against *Anopheles* landing.



[Vaporous essential oils and isolates restore pyrethroid-treated netting efficacy to \*Aedes aegypti\* \(Diptera: Culicidae\)](#)

BioRxiv preprint This article is a preprint and has not been certified by peer review

This study tested essential oils previously identified to affect pyrethroid efficacy, as well as their main isolates, to assess if they can restore the efficacy of pyrethroid-treated LLIN against the PR strain. This study provides a selection of promising synergists used as vaporous emanations to restore pyrethroid efficacy and counteract field-evolved resistance in mosquitoes.

**Larval control**

[Geospatial modelling of dry season habitats of the malaria vector, \*Anopheles funestus\*, in south-eastern Tanzania](#)

Parasites and Vectors 29 Jan 2024

*Anopheles funestus* is a major malaria vector in Eastern and Southern Africa and is currently the dominant malaria-transmitting vector in many parts of Tanzania. Previous research has identified its preference for specific aquatic habitats, especially those that persist in dry months. This observation suggests the potential for targeted control through precise habitat mapping and characterization. In this study, we investigated the influence of habitat characteristics, land cover and human population densities on *An. funestus* distribution during dry seasons. Based on the results, we developed a habitat suitability model for this vector species in south-eastern Tanzania.

**The final model had an 83% accuracy in predicting positive *An. funestus* habitats**, with the most important characteristics being permanent waters, clear waters

with or without vegetation or movement and shading over the habitats. Such spatially explicit predictions could enable more precise interventions, particularly larval source management, to accelerate malaria control.



Example of surveyed aquatic habitats that were found to harbour *Anopheles funestus* larvae

## New vector control tools and approaches

### Demonstration of RNAi Yeast Insecticide Activity in Semi-Field Larvicide and Attractive Targeted Sugar Bait Trials Conducted on Aedes and Culex Mosquitoes

Insects 15 Dec 2023

Eco-friendly new mosquito control innovations are critical for the ongoing success of global mosquito control programs. In this study, Sh.463\_56.10R, a robust RNA interference (RNAi) yeast insecticide strain that is suitable for scaled fermentation, was evaluated under semi-field conditions. Inactivated and dried Sh.463\_56.10R yeast induced significant mortality of field strain *Aedes aegypti*, *Aedes albopictus*, and *Culex quinquefasciatus* larvae in semi-field larvicide trials conducted outdoors in St. Augustine, Trinidad, where 100% of the larvae were dead within 24 h. The yeast was also stably suspended in commercial bait and deployed as an active ingredient in miniature attractive targeted sugar bait (ATSB) station sachets. The yeast ATSB induced high levels of *Aedes* and *Culex* mosquito morbidity in semi-field trials conducted in Trinidad, West Indies, as well as in Bangkok, Thailand, in which the consumption of the yeast resulted in adult female mosquito death within 48 h, faster than what was observed in laboratory trials. These findings support the pursuit of large-scale field trials to further evaluate the Sh.463\_56.10R insecticide, a member of a promising new class of species-specific RNAi insecticides that could help combat insecticide resistance and support effective mosquito control programs worldwide.

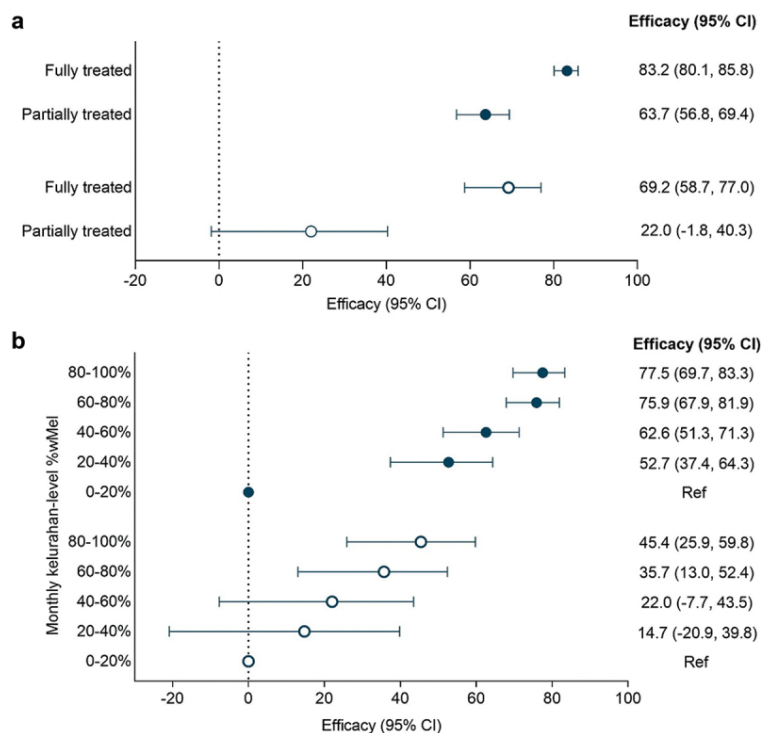
### Impact of randomised wMel Wolbachia deployments on notified dengue cases and insecticide fogging for dengue control in Yogyakarta City

Glob Health Action 31 Dec 2023

Releases of *Wolbachia* (wMel)-infected *Aedes aegypti* mosquitoes significantly reduced the incidence of virologically confirmed dengue in a previous cluster randomised trial in Yogyakarta City, Indonesia. Following the trial, wMel releases were extended to the untreated control areas, to achieve city-wide coverage of *Wolbachia*.

**Notified DHF incidence was 83% lower in fully treated vs untreated periods (IRR 0.17 [95% CI 0.14, 0.20]).** These results show that the *Wolbachia* intervention effect demonstrated previously in a cluster randomised trial was also measurable from routine surveillance data.

Figure 3 Efficacy of the wMel *Wolbachia* intervention against incidence of notified dengue hemorrhagic fever (closed circles) and dengue fever (open circles) by (a) wMel treatment status and (b) quintile of wMel. Point estimates (circles) and 95% confidence intervals (CI) (horizontal bars) from controlled interrupted time series analysis of monthly dengue case notifications to the Yogyakarta District Health Office. Efficacy was defined as 1-IRR (incidence rate ratio).



### Sugar and blood: the nutritional priorities of the dengue vector, Aedes aegypti

Parasites & Vectors 21 Jan 2024

Sugar-feeding behaviour is essential for mosquito survival and reproduction, and has been exploited to develop new control strategies, such as the attractive targeted sugar baits (ATSB). This study examined the

sugar-feeding habits of the dengue vector, *Aedes aegypti*, in semi-field conditions to determine the optimal timing (age) of sugar meals and whether the availability of sugar sources could affect blood-feeding by these mosquitoes.

Newly emerged females of *Ae. aegypti* mosquitoes were equally likely to choose a sugar meal or a blood meal. However, after the first gonotrophic cycle, they had a greater preference for blood over sugar. Additionally, nulliparous female mosquitoes were less likely to blood-feed when both sugar and blood sources were available. These findings provide insights into the sugar-feeding behaviour of *Ae. aegypti* and can inform the development and optimization of new control strategies such as using ATSB.

## *Anopheles stephensi*

### [First detection of \*Anopheles stephensi\* in Ghana using molecular surveillance](#)

BioRxiv Preprint 1 Dec 2013

The invasive *Anopheles stephensi* mosquito has been rapidly expanding in range in Africa over the last decade, spreading from the Indian sub-continent to several East African countries (Djibouti, Ethiopia, Sudan, Somalia and Kenya) and now in West Africa, Nigeria. The rapid expansion of this invasive vector poses a major threat to current malaria control and elimination efforts. In line with the WHO's strategy to stop the spread of this invasive species by enhancing surveillance and control measures in Africa, we incorporated morphological and molecular surveillance of *An. stephensi* into routine entomological surveillance of malaria vectors in the city of Accra, Ghana. Here, we report on the first detection of *An. stephensi* in Ghana. *An. stephensi* mosquitoes were confirmed using PCR and sequencing of the ITS2 regions. These findings highlight the urgent need for increased surveillance and response strategies to mitigate the spread of *An. stephensi* in Ghana.

### [Detection of \*Anopheles stephensi\* Mosquitoes by Molecular Surveillance, Kenya](#)

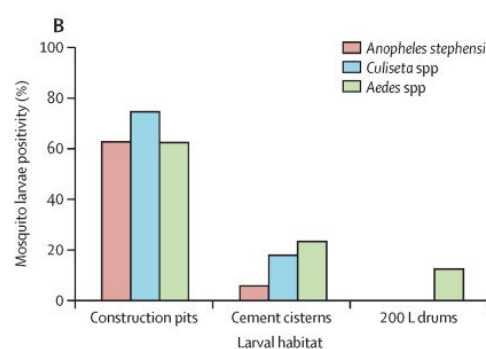
Emerging Inf Dis December 2023

We report the detection and confirmation of *An. stephensi* mosquitoes in Marsabit and Turkana Counties by using endpoint PCR and morphological and sequence identification. We demonstrate the urgent need for intensified entomological surveillance in all areas at risk for *An. stephensi* mosquito invasion, to clarify its occurrence and distribution and develop tailored approaches to prevent further spread.

### [Building the vector in: construction practices and the invasion and persistence of \*Anopheles stephensi\* in Jigjiga, Ethiopia](#)

The LANCET Planetary Health Dec 2023

Here, we provide evidence from the peak of the dry season in the city of Jigjiga in Ethiopia, and report *An stephensi* immature stages infesting predominantly in water reservoirs made to support construction operations (ie, in construction sites or associated with brick-manufacturing businesses). Political and economic changes in Ethiopia (particularly the Somali Region) have fuelled an unprecedented construction boom since 2018 that, in our opinion, has been instrumental in the establishment, persistence, and propagation of *An stephensi* via the year-round availability of perennial larval habitats associated with construction. **We argue that larval source management during the dry season might provide a unique opportunity for focused control of *An stephensi* in Jigjiga and similar areas.**





## Odds & Ends

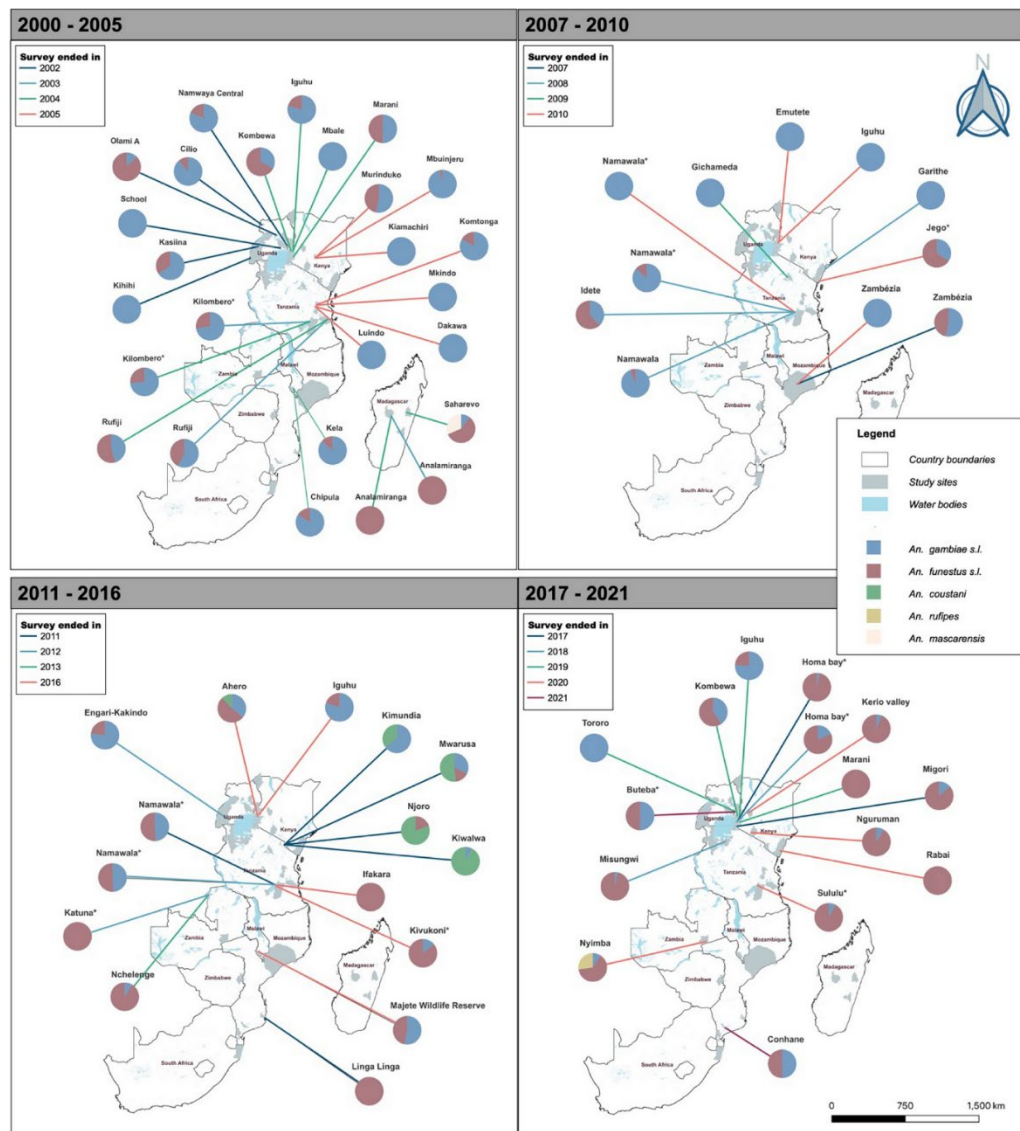
### Changes in contributions of different *Anopheles* vector species to malaria transmission in east and southern Africa from 2000 to 2022

Parasites & Vectors 7 Nov 2023

Malaria transmission in Africa is facilitated by multiple species of *Anopheles* mosquitoes. These vectors have different behaviors and vectorial capacities and are affected differently by vector control interventions, such as insecticide-treated nets and indoor residual spraying. This review aimed to assess changes in the contribution of different vector species to malaria transmission in east and southern Africa over 20 years of widespread insecticide-based vector control.

#### Conclusion

The contribution of different vector species in malaria transmission has changed over the past 20 years. As the role of *An. gambiae* has declined, *An. funestus* now appears to be dominant in most settings in east and southern Africa. Other secondary vector species may play minor roles in specific localities. To improve malaria control in the region, vector control should be optimized to match these entomological trends, considering the different ecologies and behaviors of the dominant vector species.



### Key considerations, target product profiles, and research gaps in the application of infrared spectroscopy and artificial intelligence for malaria surveillance and diagnosis

Malaria Journal 10 Nov 2023

This paper reviews current applications of IR spectroscopy and ML approaches for investigating malaria indicators in both field surveys and laboratory settings, and identifies key research gaps relevant to these

applications. Additionally, the article suggests initial target product profiles (TPPs) that should be considered when developing or testing these technologies for use in low-income settings.

### *Scaling malaria interventions: bottlenecks to malaria elimination*

BMJ Global Health 10 Nov 2023

- Despite rapid progress since 2000s, malaria remains a significant global health challenge, disproportionately affecting low- and middle-income countries (LMICs) and the ambition to eradicate malaria has been met with considerable challenges such as drug resistance, limited access to healthcare in remote and vulnerable populations and climate change.
- Multiple barriers persists along the end-to-end scale up pathway of malaria interventions including underinvestment in malaria research and development, unpredictable or unclear regulatory and policy pathways, lack of engagement with LMICs stakeholders and private sector, and the fragmentation of malaria programs.
- Further efforts are needed to enhance coordination and multi-sector collaboration, empower national stakeholders, leverage incentives and effective market shaping strategies, optimize regulatory and guideline processes, increase effort to integrate malaria services into the broader primary healthcare system, and generate evidence to inform policy design and implementation on improving access to malaria interventions.

### *Late morning biting behaviour of Anopheles funestus is a risk factor for transmission in schools in Siaya, western Kenya*

Malaria Journal 30 Nov 2023

Background-Children in Kenya spend a substantial amount of time at school, including at dawn and dusk when mosquitoes are active. With changing vector behaviour towards early morning biting, it is important to determine whether there is an additional risk of transmission in schools. This study sought to understand whether late morning biting by *Anopheles funestus*, previously documented in households in western Kenya, was replicated in schools.

Results-*Anopheles funestus* was the predominant species collected, forming 93.2% (N = 727) of the entire collection, with **peak landing between 06:00 and 07:00 h and continuing until 11:00 h**. More than half of the collected *An. funestus* were either fed or gravid, potentially indicative of multiple bloodmeals within each gonotrophic cycle, and had a sporozoite rate of 2.05%.

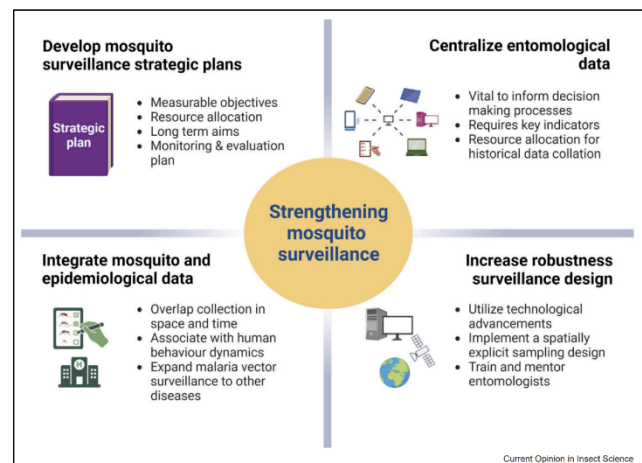
**Conclusion-School children spend up to 10 h of their daytime in schools, reporting between 06:00 and 07:00 h and staying in school until as late as 17:00 h, meaning that they receive potentially infectious mosquito bites during the morning hours in these settings.** There is a need to consider vector control approaches targeting schools and other peridomestic spaces in the morning hours when *An. funestus* is active.



### *Strengthening adult mosquito surveillance in Africa for disease control: learning from the present*

Curr Opin Insect Sci Dec 2023

Mosquito surveillance is essential to successfully control and eliminate mosquito-borne diseases. Yet, it is often done by numerous organizations with little collaboration, incomplete understanding of existing gaps, and limited long-term vision. There is a clear disconnect between entomological and epidemiological indices, with entomological data informing control efforts inadequately. Here, we discuss current mosquito surveillance practises across the heterogeneous disease landscape in Africa. We advocate for the development of mosquito surveillance strategic plans to increase the impact and functionality of mosquito surveillance. We urge for a proactive approach to set up centralized mosquito data systems under the custodian of national governments, focus on



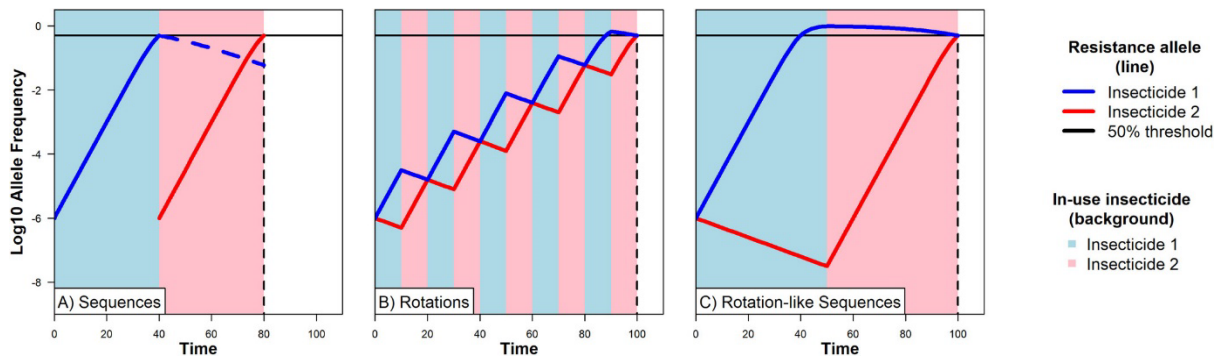
epidemiologically relevant mosquito data, and increase the robustness of mosquito surveillance using a more spatially explicit sampling design.

### *What is the value of rotations to insecticide resistance management?*

Pest Mgmt Science 3 Jan 2024

Rotations have been the cornerstone of insecticide resistance management for many decades. In recent years, there has been a resurgence of interest in the use of insecticide mixtures, particularly based on new theoretical models. Here, we present a perspective on the value of rotations to insecticide resistance management, focusing on the interpretation of influential theoretical models.

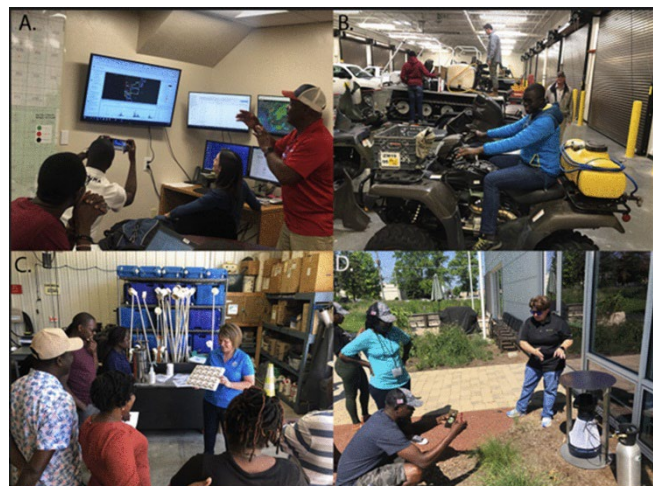
Three explanations have been offered for how rotations delay resistance evolution: counterselection from resistance cost, the relaxation of selection and intergenerational redundant kill. We show that all three explanations can make sense of the comparison of rotations with another resistance-management strategy but have failed to elucidate the principle at work. Overall, we argue that rotations work by moderation, delaying resistance to insecticides through the use of each insecticide less over time. We suggest that the principles of resistance management are recast as moderation, saturation and redundancy. When rotations and mixtures are not conceptualised as competing methods of multiple attack, these strategies can more obviously work together through the complementary principles of moderation and redundancy. Whether solo products or a mixture of products are used, rotations are an effective method of risk management, preserving the arsenal of all effective insecticides for longer.



### *Mosquito control by abatement programmes in the United States: perspectives and lessons for countries in sub-Saharan Africa*

Malaria Journal 4 Jan 2024

The authors detail experiences and learnings gathered by the delegation of African vector control professionals that participated in a formal exchange programme initiated by the Pan-African Mosquito Control Association (PAMCA), the University of Notre Dame, and members of the American Mosquito Control Association (AMCA), in the United States between the year 2021 and 2022. The authors highlight the key components of mosquito control operations in the United States and compare them to mosquito control programmes in SSA countries endemic for vector-borne diseases, deriving important lessons that could be useful for vector control in SSA.



### *Do it yourself: 3D-printed miniature CDC trap for adult mosquito (Diptera: Culicidae) surveillance*

PLoS Negl Trop Dis 10 Jan 2024



The miniature CDC trap is a widely distributed, compact trap type that is best used when baited with carbon dioxide, such as through dry ice or pressurized gas. Even if the miniature CDC trap is among the more accessible variants of host-seeking mosquito traps, there can still be barriers to entry for small/local programs needing to trap, learn about, and make management decisions against their local mosquito species. To facilitate this, the Salt Lake City Mosquito Abatement District (SLCMAD) developed a blueprint for 3D printing your own mini-CDC trap and validated its use against commercial equivalents. If a 3D printer is already available through a nearby institution (University, research institute, WHO centers, etc.), then the total cost without the dry ice is ~\$4 USD (at the time of writing) to print this trap, as compared to commercially supplied models being ~\$200 USD or more. The SLCMAD will continue to improve on the design specifications to require fewer materials and design plans are available publicly without cost at [Thingiverse under the SLCMAD page](#).

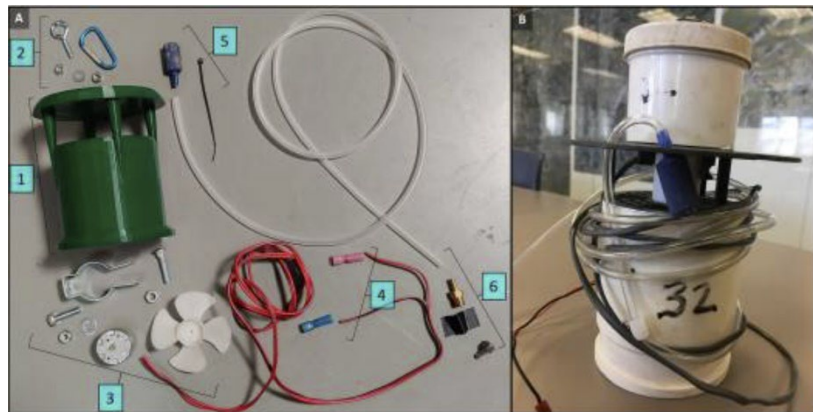


Figure 1 A) Parts layout for the Salt Lake City (SLC) trap: [1]; eye-screws and clips [2]; #2 conduit hanger and a 6-v variable speed motor and 7.5-cm (3 in) propeller; 18-gauge copper wire and battery clips [4]; 0.48 cm (3/16 in) tubing with airstone for CO<sub>2</sub>; and push-to-connect fitting to attach to a CO<sub>2</sub> source of choice. B) Commercial ABC trap, distributed by Clarke Mosquito Control (St. Charles, IL).

### [House Screening Reduces Exposure to Indoor Host-Seeking and Biting Malaria Vectors: Evidence from Rural South-East Zambia](#)

Trop. Med. Infect. Dis 15 Jan 2024

This study evaluated the impact of combining house screens with long-lasting insecticidal nets (LLINs) on mosquito host-seeking, resting, and biting behavior. Intervention houses received house screens and LLINs, while control houses received only LLINs. The protective efficacy of screens and LLINs was estimated through entomological inoculation rates (EIRs). There were 68% fewer indoor host-seeking *Anopheles funestus* (RR = 0.32, 95% CI 0.20–0.51,  $p < 0.05$ ) and 63% fewer *An. arabiensis* (RR = 0.37, 95% CI 0.22–0.61,  $p < 0.05$ ) in screened houses than unscreened houses. There was a significantly higher indoor biting rate for unscreened houses (6.75 bites/person/h [b/p/h]) than for screened houses (0 b/p/h) ( $\chi^2 = 6.67$ ,  $df = 1$ ,  $p < 0.05$ ). The estimated indoor EIR in unscreened houses was 2.91 infectious bites/person/six months, higher than that in screened houses (1.88 infectious bites/person/six months). Closing eaves and screening doors and windows has the potential to reduce indoor densities of malaria vectors and malaria transmission.

### [Chemical Ecology and Management of Dengue Vectors](#)

Annual Review of Entomology 25 January 2024

Advances in chemical ecology, functional genomics, and behavioral analyses have improved our understanding of the underlying neural mechanisms and reveal novel and specific olfactory semiochemicals that dengue vector species use to locate and discriminate among resources in their environment. Physiological status; learning; and host- and habitat-associated factors, including microbial infection and abundance, shape olfactory responses of these vectors. Some of these semiochemicals can be integrated into the toolbox for dengue surveillance and control.



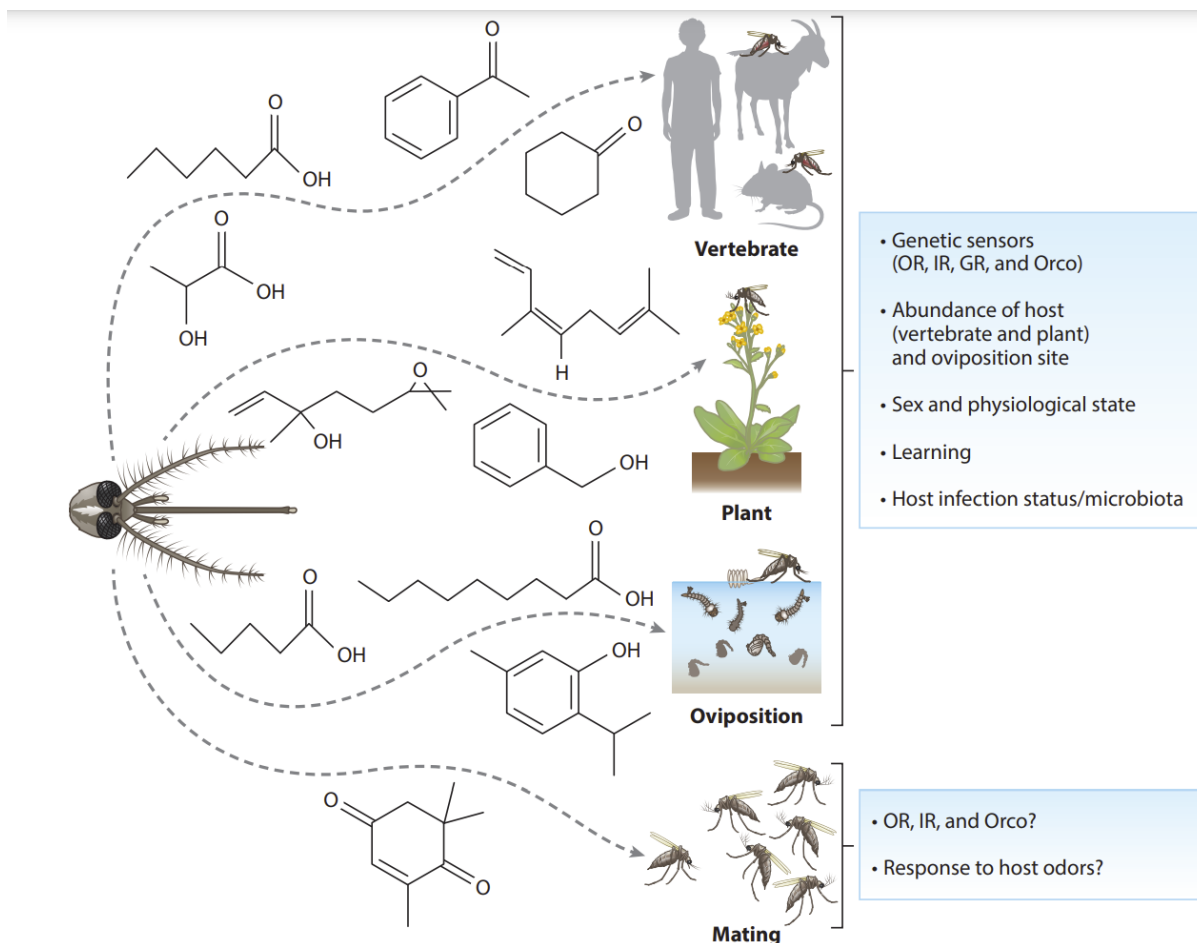


Figure 2. A representation of the key behaviors mediated by semiochemicals and the factors influencing their response. Question marks indicate roles in specific behaviors not yet defined. Abbreviations: GR, gustatory receptor; IR, ionotropic receptor; OR, olfactory receptor; Orco, olfactory receptor coreceptor.

### Predicting malaria risk considering vector control interventions under climate change scenarios

Sci Reports 29 Jan 2024

We aimed to predict the risk of malaria with climate change considering the influence of rainfall, humidity, temperatures, vegetation, and vector control interventions (indoor residual spraying (IRS) and long-lasting insecticidal nets (LLIN)).

The results showed upward trends in the annual malaria cases by 25% to 30% by 2050s in the absence of intervention but there was great variability in the predictions.

**The combination of IRS and LLIN, IRS alone, and LLIN alone would contribute to reducing the malaria burden by 76%, 63% and 35% respectively.** The results highlight the need for maintaining vector control interventions for malaria prevention and control in the context of climate change given the potential public health and economic implications of increasing malaria in Uganda.

### Vector Biology and Integrated Management of Malaria Vectors in China

Annual Review of Entomology January 2024

In 2021, malaria was eliminated in China after more than 70 years of efforts implementing an integrated mosquito management strategy. This strategy comprised indoor residual spray, insecticide-treated bed nets, irrigation management, and rice–fish coculture based on an understanding of taxonomic status and ecological behaviors of vector species, in conjunction with mass drug administration and promotion of public education. However, China still faces post elimination challenges, including the importation of approximately 2,000–4,000 cases of malaria into the country each year, as well as widespread resistance to pyrethroid insecticides in *An.*

*sinensis*; these challenges require long-term vector surveillance to understand the distribution, population density, and development of resistance in vector mosquitoes to prevent local epidemics caused by imported malaria cases.

### SUMMARY POINTS

1. Vectors of malaria in China include *Anopheles sinensis*, *Anopheles lesteri*, *Anopheles minimus*, and *Anopheles dirus*.
2. The important behaviors, including distribution, breeding, blood feeding, and resting, and population dynamics of these main vector species have been studied.
3. Integrated mosquito management has played a vital role in the elimination of malaria in China.
4. Irrigation management, consisting of wet irrigation, rotation of rice fields and dry land, and rice–fish coculture, has been effective for vector control.
5. Indoor residual spraying and insecticide-treated bed nets have been used to control adult mosquitoes, resulting in reductions in vector densities and malaria incidence.



## WHO News and Publications

### [Disease Outbreak News Dengue - Global situation](#)

WHO 21 Dec 2023

#### **Current situation**

After a slight decline of cases between the year 2020-2022 due to the COVID-19 pandemic and lower reporting rate, in 2023, an upsurge in dengue cases have been observed globally, characterized by a significant increase in the number, scale, and simultaneous occurrence of multiple outbreaks, spreading into regions previously unaffected by dengue. Recent data from 2023 emphasize escalated dengue outbreaks in several countries, particularly Bangladesh, Brazil, Burkina Faso, Fiji, Pakistan, the Philippines, and Viet Nam.

The global incidence of dengue has markedly increased over the past two decades, posing a substantial public health challenge. From 2000 to 2019, the World Health Organization (WHO) documented a ten-fold surge in reported cases worldwide increasing from 500 000 to 5.2 million. The year 2019 marked an unprecedented peak, with reported instances spreading across 129 countries.

### [WHO certifies Cabo Verde as malaria-free, marking a historic milestone in the fight against malaria](#)

12 Jan 2024

The World Health Organization (WHO) has certified Cabo Verde as a malaria-free country, marking a significant achievement in global health. With this announcement, Cabo Verde joins the ranks of 43 countries and 1 territory that WHO has awarded this certification.

Cabo Verde is the third country to be certified in the WHO African region, joining Mauritius and Algeria which were certified in 1973 and 2019 respectively. Malaria burden is the highest on the African continent, which accounted for approximately 95% of global malaria cases and 96% of related deaths in 2021.

### [Next meeting of the Malaria Policy Advisory Group](#)

The 25th meeting of the Malaria Policy Advisory Group (MPAG) will be held in Yaoundé, Cameroon on 4–5 March 2024. Technical partners, UN agencies, and other members of the global malaria community are welcome to register for online participation only.

[Register for online participation to the meeting](#)

## Recent WHO publications of interest

### [World malaria report 2023](#)

30 November 2023

Each year, WHO's *World malaria report* provides a comprehensive and up-to-date assessment of trends in malaria control and elimination across the globe. This year's report includes, for the first time, a dedicated chapter focused on the intersection between climate change and malaria.

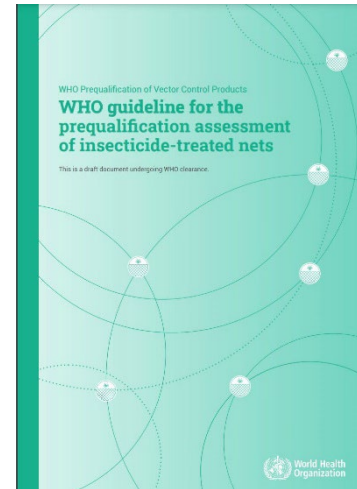
As described in the report, climate change is one of many threats to the global response to malaria. Millions of people continue to miss out on the services they need to prevent, detect, and treat the disease. Conflict and humanitarian crises, resource constraints and biological challenges such as drug and insecticide resistance also continue to hamper progress.

Taken together, these threats are undermining gains in the global fight against malaria. In 2022, the global tally of malaria cases reached 249 million – well above the estimated number of cases before the COVID-19 pandemic, and an increase of five million over 2021.



### [WHO Guideline for the prequalification assessment of insecticide-treated nets](#)

The World Health Organisation Prequalification VCP team has released new implementation guidelines for the prequalification assessment of insecticide-treated nets. These guidelines cover multiple aspects such as regeneration time studies, wash resistance studies, and more, using various tests and experiments (cone tests, tunnel tests, semi-field experimental hut trials etc).



### [Reactive strategies for reducing malaria transmission in elimination settings](#)

8 January 2024 | [video](#)



In addition to "mass" strategies applied to entire populations and "targeted" strategies for high-risk groups, the new WHO recommendations include three "reactive" strategies, to be triggered in response to confirmed malaria cases.

### [Nineteenth meeting of the WHO Vector Control Advisory Group \(27–28 September 2023\)](#)

WHO 25 January 2024 | Meeting report

Experts from the WHO Vector Control Advisory Group (VCAG) met with product developers, innovators and researchers from 27–28 September 2023 for the 19th VCAG meeting. This report details the proceedings and outcomes of the meeting, including an update from the New Nets Project addressing the potential epidemiological benefit of dual active ingredient nets. The report also includes summaries for applications for interventions in the following intervention types:

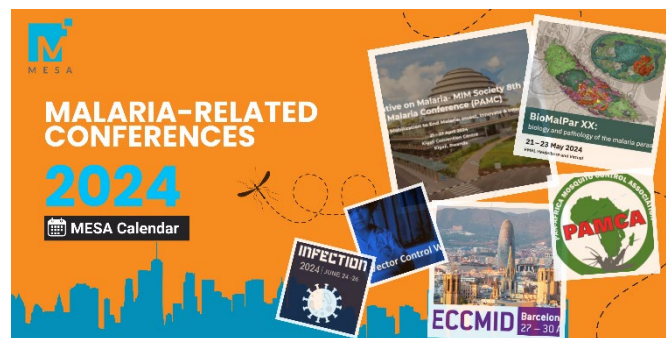
- eave tubes,
- sterilization of male mosquitoes and
- systemic endectocide treatment for Lyme disease.



## Webinars, websites and other resources

### [Malaria-related Conferences in 2024](#)

Bookmark this compilation as a go-to resource, especially relevant to malaria researchers planning on attending conferences this year. Complete with important dates, deadlines and other information, this list will help you plan your year ahead and make sure to not miss any deadlines.



### **19th Annual Meeting Vector Control in Kigali, Rwanda Save the dates!**

The annual meeting is scheduled on April 15–17, 2024 in Kigali, Rwanda.

The 6th Annual Meeting Multi-Sectoral Working Group will take place back to back on April 18-20, 2024 in Kigali, Rwanda.

More information about the registration and details of the venue will be published soon on the [VCWG webpage](#).

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### [APMEN Webinar YouTube channel](#)

APMEN hosts 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 and upcoming topics include:

- ❑ 2 October 2023 – [Climate, Malaria Prediction, and Implications for Elimination](#)  
Speakers/Panellists
  - Dr Shreejana Bhattarai, Independent Researcher, Nepal
  - Prof Michael Wimberly, Professor, University of Oklahoma, USA
  - Dr Kaushik Sarkar, Institute for Health Modeling and Climate Solutions, Malaria No More, India
  - Prof Jiming Liu, Hong Kong Baptist University
  
- ❑ 13 November 2023 – [Bednets: How do we ensure sustainability of our most effective malaria control tool](#)  
Speakers/Panellists
  - Dr Kate Kolaczinski, Manager, Malaria Disease Team, The Global Fund
  - Dr Nora Schmit, MRC Centre for Global Infectious Disease Analysis, Imperial College London
  - Dr Hannah Koenker, Technical Director, Tropical Health LLP

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

Hosted by the Ifakara Health Institute, the University of Glasgow, and the MESA Alliance, 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:

- ❑ 14 Dec 2023 – [Leading global experts to discuss climate, spread of diseases](#)

This event brought together global experts from Stanford University, Harvard University, Virginia Tech University, the University of Glasgow, the University of Florida, the Wellcome Trust, and the University of Washington.

## In the news and social media

### [Cameroon starts world-first malaria mass vaccine rollout](#)

BBC News

The world's first routine vaccine programme against malaria has started in Cameroon, in a move projected to save thousands of children's lives across Africa.

Cameroon is offering the RTS,S vaccine free of charge to all infants up to the age of six months old. Patients require a total of four doses. Health officials say these will be given at the same time as other routine childhood vaccines to make it easier for parents.

### [Rio de Janeiro: Dengue spike prompts health emergency ahead of Carnival](#)

BBC News

**The authorities in the Brazilian city of Rio de Janeiro have declared a health emergency** as they try to contain the spread of dengue fever.

The incidents of the mosquito-borne disease quadrupled in Brazil in January compared to the same month last year.

Rio has registered 10,000 cases so far this year, compared to 23,000 for the whole of 2023.

A dengue vaccine developed by the Japanese company Takeda was approved by Brazil's health regulator last year, but has not yet been widely distributed.

### [PMI 17th Annual Report to Congress](#)

PMI has also published its [2024 Malaria Operational Plans](#) (MOPs).

The Malaria Operational Plans below are detailed 1-year implementation plans for PMI partner countries. Each plan reviews the current status of malaria control and prevention policies and interventions, identifies challenges and unmet needs to achieve PMI goals, and provides a description of planned PMI-funded activities.



This year they have added three new partner countries: Togo, the Gambia, and Burundi.

### [Regulatory Guidance on the Vector Expedited Review Voucher Program](#)

The Vector Expedited Review Voucher (VERV) Program offers registrants of vector control tools a financial incentive, a voucher, in reward for registration of novel public health insecticides that can combat vectors of malaria and other diseases.

In a major step forward for vector-borne disease control, the US Environmental Protection Agency (EPA) announced the establishment of the regulation for a Vector Expedited Review Voucher Program. [The notice](#), issued on Thursday 18<sup>th</sup> of December 2023, includes the eligibility criteria and processes regarding how to apply and qualify for a voucher under the VERV Program.

Disclaimer: Given the breadth of vector control related literature, we are unable to include all relevant work. This update is intended to focus primarily on *Anopheles* vectors and a subset of mosquito control topics relevant to IVCC and its partners. 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.