Contents

Selected Recent Publications

Highlights of Medical Entomology, 2020

J Med Entomology 3 Aug 2021

This past year will be remembered as the year in which the SARS-CoV-2 COVID-19 pandemic affected every part of our lives and professional activities and impacted (sometimes in good ways) our ability to collaborate and detect or respond to invasions. This incredible year is the backdrop for the 2020 Highlights in Medical Entomology. This article highlights the broad scope of approaches and disciplines represented in the 2020 published literature, ranging from sensory and chemical ecology, population genetics, impacts of human-mediated environmental change on vector ecology, life history and the evolution of vector behaviors, to the latest developments in vector surveillance and control. Of note for those working on ATSBs, one study included in this review discusses seasonal difference in sugar-feeding behavior in *Ae. aegypti* and raises the question of possible seasonal variation in malaria vector sugar feeding behavior.

The need for practical insecticide-resistance guidelines to effectively inform mosquito-borne disease control programs

Elife 6 Aug 2021

This paper is part review and part opinion piece in which the authors discuss the challenges associated with measuring resistance levels of wild mosquito populations to the insecticides they are exposed to in the field and the difficulty in obtaining operationally relevant data for decision making. Their arguments address some important and complex issues related to insecticide resistance, how resistance is defined, the terms used to describe "resistance" and methods used to estimate it. The paper raises as many questions as it attempts to address and has stirred some useful debate among colleagues working in the field.

Costs and Cost-Effectiveness of Malaria Control Interventions: A Systematic Literature Review

Value Health. Aug 2021

We identified 103 costing studies. The majority of studies focused on individual rather than combined interventions, notably insecticide-treated bednets and treatments and commonly took a provider perspective. A third of all studies took place in 3 countries. The median provider economic cost of protecting 1 person per year ranged from $1.18 to $5.70 with vector control and from $0.53 to $5.97 with chemoprevention. The median provider economic cost per case diagnosed with rapid diagnostic tests was $6.06 and per case treated $9.31 or $89.93 depending on clinical severity. Other interventions did not share enough similarities to be summarized. Cost drivers were rarely reported. Cost-effectiveness of malaria control was reiterated but care in methodological and reporting standards is required to enhance data transferability.

Investment case for malaria elimination in South Africa: a financing model for resource mobilization to accelerate regional malaria elimination

Malaria Journal 16 August 2021

The government of South Africa has reiterated its commitment to eliminate malaria within its borders. To support the achievement of this goal, this study presents a cost–benefit analysis of malaria elimination in

South Africa through simulating different scenarios aimed at achieving malaria elimination within a 10-year period. Based on three primary simulated scenarios (Business as Usual, Accelerate and Source Reduction), the total economic burden was estimated. Using the Business as Usual scenario, the total economic burden of malaria in South Africa was R 3.69 billion (USD 223.3 million) over an 11-year period (2018–2029). The economic burden of malaria was estimated at R4.88 billion (USD 295.5 million) and R6.34 billion (~ USD 384 million) for the Accelerate and Source Reduction scenarios, respectively. Costs and benefits are presented in mid-year 2020 values. Malaria elimination was predicted to occur in all three provinces if the Source Reduction strategy was adopted to help reduce malaria rates in southern Mozambique. This could be achieved by limiting annual local incidence in South Africa to less than 1 indigenous case with a prediction of this goal being achieved by the year 2026.

Entomological baseline data collection and power analyses in preparation of a mosquito swarm-killing intervention in south-western Burkina Faso

Malaria Journal 23 August 2021

Adult mosquito swarming and other nocturnal behaviours exhibit spatial and temporal patterns that suggest potential vulnerability to targeted space-spraying with effective insecticides. Indeed, targeted space-spraying against adult mosquito swarms has been used to crash mosquito populations and disrupt malaria transmission. Prior to impact assessment of swarm killing, a baseline data collection was conducted from June to November 2016 in 10 villages divided into two areas in western Burkina Faso. The data considered both ecological and demographic characteristics to monitor the key entomological parameters. The distribution of the potential swarm markers and swarms in villages suggested that swarms are clustered across space, making intervention easier. Power simulations showed that the direct sampling of swarms provides the highest statistical power, thereby reducing the number of villages needed for a trial.
This baseline assessment was followed by a trial to test the effectiveness of targeted space-spraying of adult mosquito swarms to reduce populations of malaria vectors in a community. Results of that evaluation will be published in a follow-on paper.

High efficacy of microbial larvicides for malaria vectors control in the city of Yaounde Cameroon following a cluster randomized trial

Scientific Reports 24 August 2021

Generating evidence of the efficacy of larviciding in different epidemiological context could improve malaria control across Africa. In the course of the present study, a cluster randomised trial including 26 clusters of 2 to 4 km^2 each divided into 2 groups, 13 in the intervention area and 13 in the non-intervention area was conducted to assess the impact of larviciding on malaria transmission in the city of Yaoundé. The authors conclude that the larvicide approach tested was effective. The microbial larvicide VectoMax combining *Bacillus thuringiensis var israelensis (Bti)* and *Bacillus sphaericus* in a single granule was applied every 2 weeks in all standing water collection points. The anopheline density collected using CDC light traps was used as the primary outcome; secondary outcomes included the entomological inoculation rate, breeding habitats with anopheline larvae, and larval density. Baseline entomological data collection was conducted for 17 months from March 2017 to July 2018 and the intervention lasted 26 months from September 2018 to November 2020. **The intervention was associated with a reduction of 68% of adult anopheline biting density and of 79% of the entomological inoculation rate** (OR 0.21; 95% CI 0.14-0.30, P < 0.0001). **A reduction of 68.27% was recorded for indoor biting anophelines and 57.74% for outdoor biting anophelines**. A reduction of over 35% of adult Culex biting densities was recorded. **The study indicated high efficacy of larviciding for reducing malaria transmission intensity in the city of Yaoundé**.

Transfluthrin eave-positioned targeted insecticide (EPTI) reduces human landing rate (HLR) of pyrethroid resistant and susceptible malaria vectors in a semi-field simulated peridomestic space

Malaria Journal 30 August 2021

Volatile pyrethroids (VPs) such as transfluthrin are proven to reduce human–vector contact. It is necessary to know whether the efficacy of VPs may be compromised by pyrethroid resistance and, therefore, if VPs can be used in areas with existing pyrethroid-resistant mosquito populations. Structural differences between transfluthrin and non-volatile pyrethroids indicate that cross-resistance may not occur. The objectives of this study were to determine (1) the efficacy of transfluthrin applied as "eave ribbons"/EPTI to reduce the human landing rate (HLR) of multiple strains of Afrotropical malaria vectors with varying levels of pyrethroid resistance and (2) delayed mortality induced by EPTI exposure. The results suggest that *kdr* target site mutations do not reduce the efficacy of transfluthrin. Compared to the control, transfluthrin EPTI can reduce landings of resistant mosquitoes. However, the differences in effect observed in different mosquito species highlight the fact that resistance in mosquitoes may be detrimental to the efficacy of transfluthrin. Although this study suggests that EPTI reduces HLR for both mosquito populations tested, additional evidence is needed to determine whether transfluthrin is effective against resistant mosquitoes and other species, such as *An. funestus*, where it is the dominant vector.

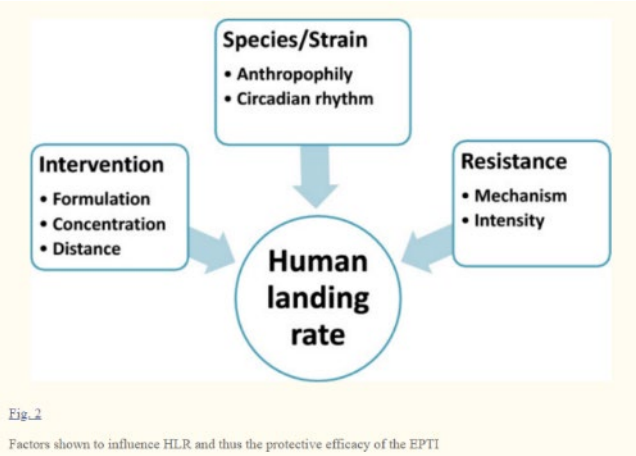


Fig. 2

Factors shown to influence HLR and thus the protective efficacy of the EPTI

Mosquito transgenesis for malaria control

Trends in Parasitology 2 Sept 2021

This is a good review of the development of mosquito transgenesis and its application for malaria control, as it highlights the transgenic expression of antiparasitic effector genes, inactivation of host factor genes, and manipulation of miRNAs and lncRNAs. The paper has a useful summary of the prospects and concerns related to mosquito transgenesis (see Box 1) and a nice figure on the life cycle of the malaria parasite and its bottleneck in mosquitoes (figure 1, below). The authors discuss how mosquito transgenesis is not envisioned as a stand-alone approach; rather, its use is proposed as a complement to existing vector-control strategies.

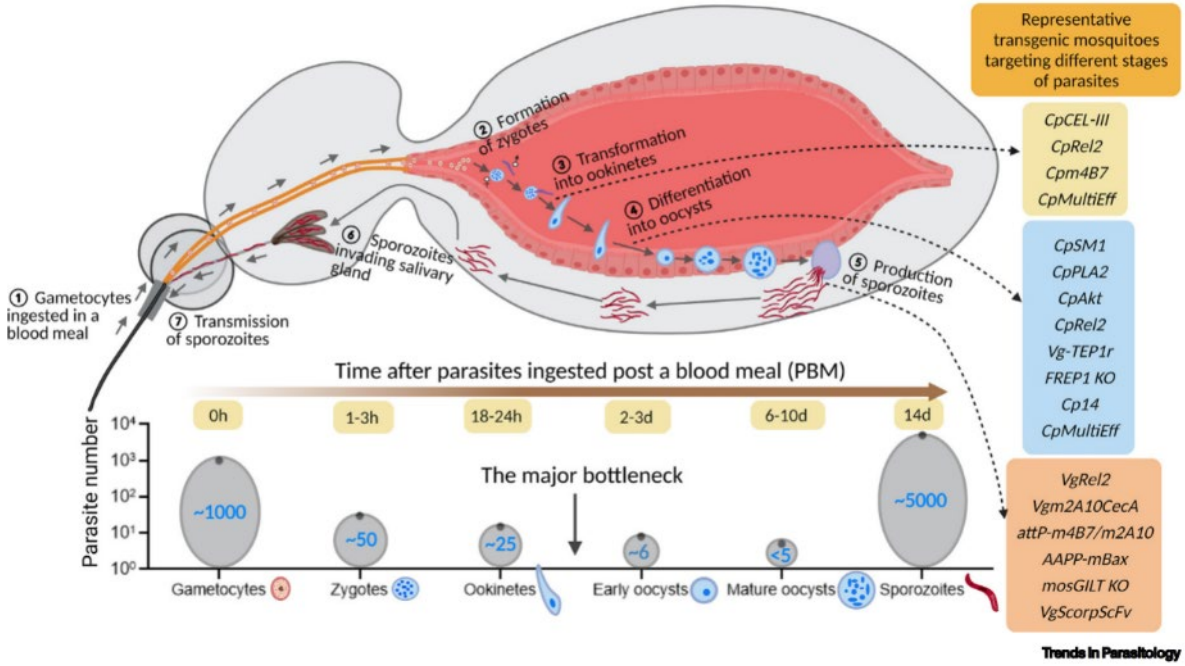


Figure 1. The life cycle of the malaria parasite and its bottleneck in mosquitoes. *Plasmodium* gametocytes are ingested through a blood meal (step ①). The male

Insecticide resistance and behavioural adaptation as a response to long-lasting insecticidal net deployment in malaria vectors in the Cascades region of Burkina Faso

Scientific Reports 2 Sept 2021

The decline in malaria across Africa has been largely attributed to vector control using long-lasting insecticidal nets (LLINs). However, this intervention has prompted widespread insecticide resistance (IR) and has been associated with changes in mosquito behaviour that reduce their contact with LLINs. The relative importance and rate at which IR and behavioural adaptations emerge are poorly understood. We conducted surveillance of mosquito behaviour and IR at 12 sites in Burkina Faso to assess the magnitude and temporal dynamics of insecticide, biting and resting behaviour in vectors in the 2-year period following mass LLIN distribution. Insecticide resistance was present in all vector populations and increased rapidly over the study period. In contrast, no longitudinal shifts in LLIN-avoidance behaviour (earlier or outdoor biting and resting) were detected. There was a moderate but statistically significant shift in vector species composition from *Anopheles coluzzii* to *Anopheles gambiae* which coincided with a reduction in the proportion of bites preventable by LLINs; this is possibly driven by between-species variation in behaviour. These findings indicate that adaptations based on insecticide resistance arise and intensify more rapidly than behavioural shifts within mosquito vectors. However, longitudinal shifts in mosquito vector species composition were evident within 2 years following a mass LLIN distribution. This ecological shift was characterized by a significant increase in the exophagic species (*An. gambiae*) and coincided with a predicted decline in the degree of protection expected from LLINs. Although the human exposure rate fell through the study period due to reducing vector densities and infection rates, such ecological shifts in vector species along with insecticide resistance were likely to have eroded the efficacy of LLINs. While both adaptations impact malaria control, the rapid increase of the former indicates this strategy develops more quickly in response to selection from LLINS. However, interventions targeting both resistance strategies will be needed.

Partial indoor residual spraying with pirimiphos-methyl as an effective and cost-saving measure for the control of Anopheles gambiae s.l. in northern Ghana

Scientific Reports 2 Sept 2021

Abstract

Partial IRS with pirimiphos-methyl in experimental huts and houses in a village-wide trial was evaluated against *Anopheles gambiae* s.l. in northern Ghana. Four different scenarios were compared in which either the top or bottom half of the walls of experimental huts were sprayed, with or without also spraying the ceiling. Mortality of *An. gambiae* s.l. on partially sprayed walls was compared with the standard procedures in which all walls and ceilings are sprayed. A small-scale trial was then conducted to assess the effectiveness, feasibility and cost of spraying only the upper walls and ceiling as compared to full IRS and no spraying in northern Ghana. Human landing catches were conducted to estimate entomological indices and determine the effectiveness of partial IRS. An established transmission dynamics

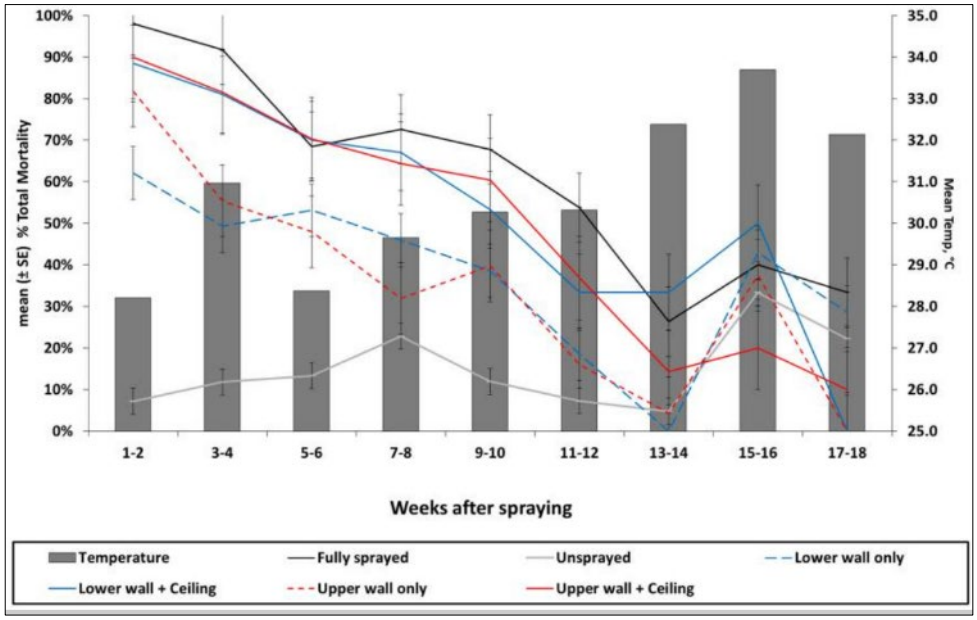


Figure. *Anopheles gambiae s.l.* mean total mortality in experimental huts with different IRS scenarios up to 18 weeks post-intervention. Post-spray mosquito mortality decreased gradually for fully and partially sprayed treatment scenarios and the rate of decrease was consistent over time. Mosquito mortality in experimental huts where upper wall + ceiling (solid red line) or lower wall + ceiling (solid blue line) was not significantly different to that observed in fully sprayed huts (solid black line), whereas spraying only the upper walls (dashed red line) or lower walls (dashed blue line) resulted in significantly lower mosquito mortality. Mosquito mortality in untreated huts (solid gray line) was consistently low throughout the study. A spike in mortality was observed across all treatments in weeks 15–16, during which the mean weekly temperature (gray bars) in experimental huts shown also increased

model was parameterized by an analysis of the experimental hut data and used to predict the epidemiological impact and cost effectiveness of partial IRS for malaria control in northern Ghana. In the experimental huts, partial IRS of the top (IRR 0.89, $p = 0.13$) or bottom (IRR 0.90, $p = 0.15$) half of walls and the ceiling was not significantly less effective than full IRS in terms of mosquito mortality. In the village trial, the annual entomological inoculation rate was higher for the unsprayed control (217 infective bites/person/year (ib/p/yr)) compared with the fully and partially sprayed sites, with 28 and 38 ib/p/yr, respectively. The transmission model predicts that the efficacy of partial IRS against all-age prevalence of malaria after six months would be broadly equivalent to a full IRS campaign in which 40% reduction is expected relative to no spray campaign. **At scale, partial IRS in northern Ghana would have resulted in a 33% cost savings ($496,426) that would enable spraying of 36,000 additional rooms. These findings suggest that partial IRS is an effective, feasible, and cost saving approach to IRS that could be adopted to sustain and expand implementation of this key malaria control intervention.**

From the factory to the field: considerations of product characteristics for insecticide-treated net (ITN) bioefficacy testing

Malaria Journal 6 Sept 2021

Background - Insecticide-treated nets (ITNs) undergo a series of tests to obtain listing by World Health Organization (WHO) Prequalification. These tests characterize the bioefficacy, physical and chemical properties of the ITN. ITN procurers assume that product specifications relate to product performance. Here, ITN test methods and their underlying assumptions are discussed from the perspective of the ITN manufacturing process and product characteristics.

Methods - Data were extracted from WHO Pesticide Evaluation Scheme (WHOPES) meeting reports from 2003 to 2017 and supplemented with additional chemical analysis to critically evaluate ITNs bioassays with a focus on sampling, washing and wash resistance, and bioefficacy testing. Production methods for ITNs and their impact on testing outcomes are described.

Results and recommendations - ITNs are not homogenous products. They vary within panels and between the sides and the roof. Running tests of wash resistance using before/after tests on the same sample or band within a net reduces test variability. As mosquitoes frequently interact with ITN roofs, additional sampling of the roof when evaluating ITNs is advisable because in nets where roof and sides are of the same material, the contribution of roof sample (20–25%) to the average is less than the tolerance for the specification (25%). Mosquito mortality data cannot be reliably used to evaluate net surface concentration to determine regeneration time (RT) and resistance to washing as nets may regenerate beyond the insecticide concentrations needed to kill 100% of susceptible mosquitoes. Chemical assays to quantify surface concentration are needed. The Wash Resistance Index (WRI) averaged over the first four washes is only informative if the product has a log linear loss rate of insecticide. Using a WRI that excludes the first wash off gives more reliable results. Storage conditions used for product specifications are lower than those encountered under product shipping and storage that may exceed 50 °C and should be reconsidered. Operational monitoring of new ITNs and linking observed product performance such as bioefficacy after 2 or 3 years of use with product characteristics, such as WRI, will aid the development of more robust test methods and product specifications for new products coming to market.

Field Efficacy of Larvivorous Fish and Pyriproxyfen Combined with Community Engagement on Dengue Vectors in Cambodia: A Randomized Controlled Trial

Am J Trop Med Hyg 7 Sept 2021

Evidence on the effectiveness of low-cost, sustainable biological vector control tools for *Aedes* mosquitoes is limited. Therefore, the purpose of this trial was to estimate the impact of guppy fish in combination with the larvicide pyriproxyfen (PPF) (Sumilarv® 2MR) and communication for behavioral impact (COMBI) activities to reduce entomological indices in Cambodia. In this cluster randomized, controlled superiority trial, 30 clusters comprised of one or more villages each was allocated in a 1:1:1 ratio to receive 1) all three interventions (guppies, PPF, and COMBI), 2) two interventions (guppies and COMBI), or 3) control (standard vector control). Entomological surveys among 40 randomly selected households per cluster were carried out quarterly. The primary outcome was the population abundance of adult female *Aedes* mosquitoes trapped using adult resting collections. In the primary analysis, adult female *Aedes* abundance and mosquito infection rates were aggregated over follow-up time points to give a single rate per cluster. **The number of *Aedes* females was**

reduced roughly by half compared with the control in both the guppy, PPF, and COMBI arm (AR = 0.54; 95% CI, 0.34-0.85; P = 0.0073); and the guppy and COMBI arm (AR = 0.49; 95% CI, 0.31-0.77; P = 0.0021). The effectiveness demonstrated and extremely low cost of including fish rearing in community-based health structures suggest they should be considered as a vector control tool as long as the benefits outweigh any potential environmental concerns. Sumilarv® 2MR was also highly accepted and preferred over current vector control tools used in Cambodia.

Urban malaria in sub-Saharan Africa: dynamic of the vectorial system and the entomological inoculation rate

Malaria Journal 8 Sept 2021

Sub-Saharan Africa is registering one of the highest urban population growth rates across the world. It is estimated that over 75% of the population in this region will be living in urban settings by 2050. However, it is not known how this rapid urbanization will affect vector populations and disease transmission. The present study summarizes findings from studies conducted in urban settings between the 1970s and 2020 to assess the effects of urbanization on the entomological inoculation rate pattern and anopheline species distribution. The study confirms high malaria transmission in rural compared to urban settings. The study also suggests that there had been an increase in malaria transmission in most cities after 2003 which could also be associated with an increase in sampling, resources and reporting. Species of the Anopheles gambiae complex were the predominant vectors in most urban settings. Anopheline larvae were reported to have adapted to different aquatic habitats. The study provides updated information on the distribution of the vector population and the dynamic of malaria transmission in urban settings. The study also highlights the need for implementing integrated control strategies in urban settings.

Review and Meta-Analysis of the Evidence for Choosing between Specific Pyrethroids for Programmatic Purposes

Insects 14 Sept 2021

This is a very useful review examining resistance across the pyrethroids and discussing questions such as:

- ✓ Do discriminating doses accurately detect resistance in different pyrethroids?
- ✓ Is there molecular evidence for differential resistance among members of the pyrethroid insecticide class?
- ✓ What intrinsic variability do we see from dose-response assays in the lab?
- ✓ Is there evidence for divergent resistance in lab colonies routinely selected using a single pyrethroid?
- ✓ What are potential sources of (non-resistance-associated) variability in the discriminating dose bioassay?
- ✓ What is the evidence for the existence of divergent resistance between pyrethroids? Can differences seen in molecular studies be detected in wild mosquito populations?
- ✓ Do mosquitoes, resistant or susceptible, exhibit different behavioural responses to different pyrethroids?
- ✓ How suitable are existing resistance-monitoring methods for the detection or measurement of behavioural resistance?

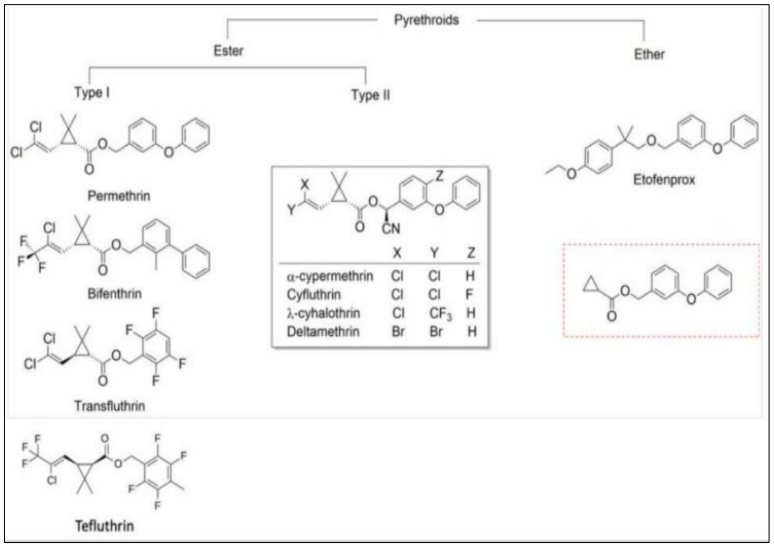


Figure. Chemical structure of pyrethroid insecticides used for malaria vector control. The common scaffold of pyrethroids, boxed in red, was identified by searching 230 million compounds available in the ZINC database

Background: Differential mortality in discriminating dose assays to different pyrethroids is often observed in wild populations. When this occurs, it is unclear if this differential mortality should be interpreted as an indication of differential levels of susceptibility

within the pyrethroid class and, if so, if countries should consider selecting one specific pyrethroid for programmatic use over another. A review of evidence from molecular studies, resistance testing with laboratory colonies and wild populations, and mosquito behavioural assays were conducted to answer these questions. Evidence suggests that in areas where pyrethroid resistance exists, different results in insecticide susceptibility assays with specific pyrethroids currently in common use (deltamethrin, permethrin, α-cypermethrin, and λ-cyhalothrin) are not necessarily indicative of an operationally relevant difference in potential performance. Consequently, it is not advisable to use rotation between these pyrethroids as an insecticide-resistance management strategy. However, molecular studies indicate that structurally diverse pyrethroids such as tefluthrin, transfluthrin, bifenthrin, and etofenprox, which lack the common structural moiety of most pyrethroids, may interact differently with the common resistance mechanisms found in insect population.

Insecticide resistance in Aedes aegypti from Tapachula, Mexico: Spatial variation and response to historical insecticide use

PLoS Negl Trop Dis. 27 Sept 2021

In this study, insecticide resistance in *Ae*. *aegypti* collected across 26 sites in Tapachula, Mexico, was evaluated. In the city of Tapachula, mosquito control programs switched from pyrethroids to organophosphates for outdoor spatial spraying in 2013. Additionally, the spraying scheme switched from total coverage to focused control, prioritizing areas with higher entomological-virological risk. Five years after this strategy had been implemented, the authors evaluated the status and variability of insecticide resistance among *Ae*. *aegypti* collected at 26 sites in Tapachula. The results reveal the response of populations to the historic use of insecticides. High resistance to pyrethroids used for 10 years but not in the previous 5 years, and moderate to high resistance to chlorpyrifos, an insecticide from a different toxicological group and used for the past 5 years, were confirmed. Despite more than 5 years having passed since the removal of pyrethroids from vector control programs in Tapachula, high levels of pyrethroid resistance and *kdr*-associated alleles persist in *Ae*. *aegypti* populations. High variation in resistance across *Ae*. *aegypti* sites suggests that focal selection plays an important role in the evolution of insecticide resistance in the field. Screening several collections sites within a geographical region provides better evidence to support strategies of insecticide management.

Experimental evolution supports the potential of neonicotinoid-pyrethroid combination for managing insecticide resistance in malaria vectors

Scientific Reports 30 Sept 2021

A new insecticide formulation combining clothianidin, a neonicotinoid, and deltamethrin, a pyrethroid, (8:1 w/w) under brand name *Fludora Fusion* was developed by Bayer to be an additional tool for insecticide resistance management in African malaria vectors. The combination of clothianidin with deltamethrin, to which resistance alleles are already circulating in natural populations, may limit its resistance management potential. The hypothesis that such a combination of two modes of action offers a different selection profile across multiple generations, or indeed a benefit, as compared to the individual insecticide components has not been tested in malaria vectors. The primary objective of this work was to compare the dynamics of resistance between *Fludora Fusion* and its two individual insecticide components in *An. gambiae* and to assess the ability of the combination to hinder resistance selection. The secondary objective of this work was to investigate the associated resistance mechanisms using molecular approaches. An *An. gambiae* line carrying resistance alleles to multiple insecticide families at low frequency was created by crossing a multi-resistant strain originating from an intense agricultural area of Côte d'Ivoire and a susceptible strain. The resulting line was then used for selecting, across multiple generations, three lines with *Fludora Fusion*, deltamethrin alone or clothianidin alone. The evolution of resistance levels to each insecticide and target site mutation frequencies was monitored throughout the selection process. The paper describes the outcomes of the study, addressing target site mutations, gene transcription levels, gene polymorphism, and association of CYP6Ms with clothianidin resistance.

Authors' conclusion:

The present study supports the potential of neonicotinoid-pyrethroid combination as a novel vector control tool having the ability to delay the selection of resistance. As such combinations appear to show good efficacy against pyrethroid resistant populations, their deployment within an integrated vector control framework and

under careful monitoring may be of added value for managing insecticide resistance in African malaria vectors.

Emergence of the invasive malaria vector Anopheles stephensi in Khartoum State, Central Sudan

Parasites & Vectors 02 October 2021

The emergence of the Asian invasive malaria vector, Anopheles stephensi, has been identified in Khartoum, the capital city of Sudan. This is the first report that confirms the geographical expansion of this urban mosquito into Central Sudan. We urgently recommend the launch of a national entomological survey to determine the distribution of this invasive disease vector and to generate essential information about its bionomics and susceptibility to available malaria control measures.

Efficacy of targeted indoor residual spraying with the pyrrole insecticide chlorfenapyr against pyrethroid-resistant Aedes aegypti

PLoS Negl Trop Dis 4 Oct 2021

Background - Most research and development of insecticide formulations for the control of Ae. aegypti has focused on their peridomestic use as truck-mounted ULV-sprays or thermal fogs despite the widespread knowledge that most resting Ae. aegypti are found indoors. A recent modification of indoor residual spraying (IRS), termed targeted IRS (TIRS), works by restricting applications to 1.5 m down to the floor and on key Ae. aegypti resting sites (under furniture). TIRS also opens the possibility of evaluating novel residual insecticide formulations currently being developed for malaria IRS.

Methods - We evaluated the residual efficacy of chlorfenapyr, formulated as Sylando 240SC, for 12 months on free-flying field-derived pyrethroid-resistant *Ae*. *aegypti* using a novel experimental house design in Merida, Mexico. On a monthly basis, 600 female *Ae*. *aegypti* were released into the houses and left indoors with access to sugar solution for 24 hours. After the exposure period, dead and alive mosquitoes were counted in houses treated with chlorfenapyr as well as in untreated control houses to calculate 24-h mortality. An evaluation for these exposed cohorts of surviving mosquitoes was extended up to seven days under laboratory conditions to quantify "delayed mortality".

Results - Mean acute (24-h) mortality of pyrethroid-resistant *Ae*. *aegypti* ranged 80–97% over 5 months, dropping below 30% after 7 months post-TIRS. If delayed mortality was considered (quantifying mosquito mortality up to 7 days after exposure), residual efficacy was above 90% for up to 7 months post-TIRS application. Generalized Additive Mixed Models quantified a residual efficacy of chlorfenapyr of 225 days (ca. 7.5 months).

Conclusions - Chlorfenapyr represents a new option for TIRS control of *Ae*. *aegypti* in urban areas, providing a highly-effective time of protection against indoor *Ae*. *aegypti* females of up to 7 months.

Emerging and Re-emerging Vector-Borne Infectious Diseases and the Challenges for Control: A Review

Frontiers in Public Health 5 Oct 2021

This paper reviews the existing literature to explore global patterns of emerging and re-emerging vector-borne infections and the challenges for their control. It also attempts to give insights to the epidemiological profile of major vector-borne diseases including malaria, Zika fever, dengue, West Nile fever, chikungunya, yellow fever and Lyme disease. The review briefly addresses the impact of factors such as climate change and urbanization on the emergence and spread of these pathogens. While not an in-depth review, this paper is a good high-level summary of the topic.

Swarming Behavior in Anopheles gambiae (sensu lato): Current Knowledge and Future Outlook

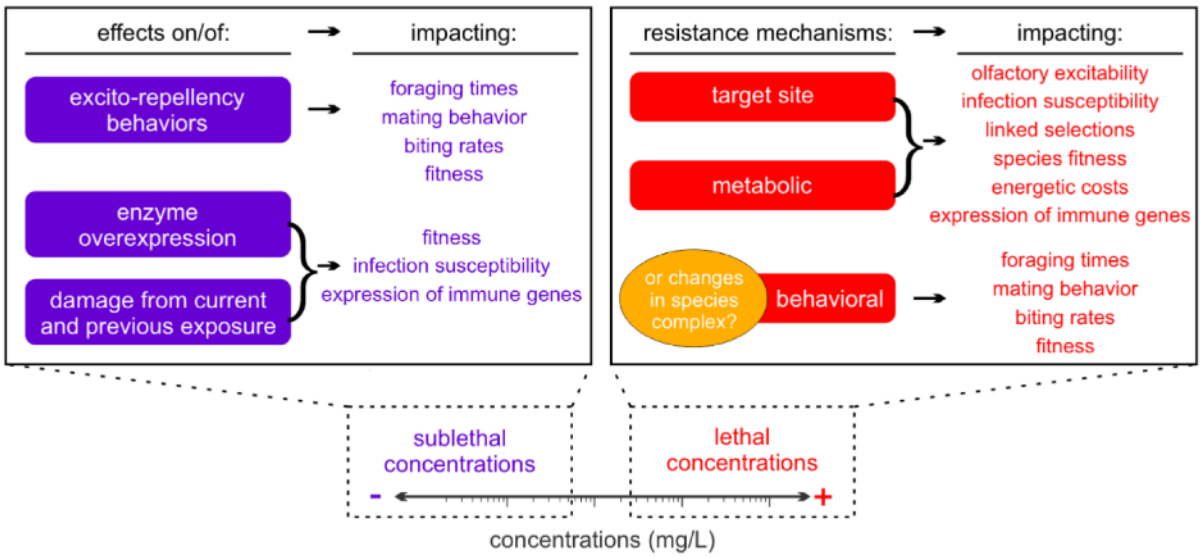
Journal of Medical Entomology 7 October 2021

This review summarizes what is currently known about swarming behavior in *An. gambiae* including its swarm characteristics, mating within and outside of swarms, insemination of females and factors affecting and stimulating swarming. The author concludes that targeting swarming sites to reduce mosquito populations is an effective way to control the spread of mosquito-borne diseases such as malaria and discusses the need for future research on swarming and mating in *Anopheles*.

Implications of Sublethal Insecticide Exposure and the Development of Resistance on Mosquito Physiology, Behavior, and Pathogen Transmission

Insects 8 Oct 2021

In this thorough review, the authors conducted a review on the sublethal effects of insecticides and their contributions to insecticide resistance in mosquitoes with the main focus on pyrethroids. They discuss the direct and acute effects of sublethal concentrations on individuals and populations, the changes in population genetics caused by the selection for resistance after insecticide exposure and the major mechanisms underlying such resistance. Sublethal exposures negatively impact the individual's performance by affecting its physiology and behavior and leaving it at a disadvantage when compared to unexposed organisms. How these sublethal effects could change mosquito population sizes and diversity so that pathogen transmission risks can be affected is less clear. Furthermore, despite the beneficial and acute aspects of lethality, exposure to higher insecticide concentrations clearly impacts the population genetics by selecting resistant individuals which may bring further and complex interactions for mosquitoes, vertebrate hosts and pathogens. Finally, they raise several hypotheses concerning how the here-revised impacts of insecticides on mosquitoes could interplay with vector-mediated pathogens' transmission.



RNAseq-based gene expression profiling of the Anopheles funestus pyrethroid-resistant strain FUMOZ highlights the predominant role of the duplicated CYP6P9a/b cytochrome P450s

G3 Genes|Genomes|Genetics, Corrected proof preprint: 09 October 2021

Here the authors elucidate the molecular bases of resistance in *An. funestus*, informing strategies to better manage widespread resistance across Africa. Using an RNAseq-based transcription analysis, they characterized the gene expression profiles of two laboratory-adapted colonies of *An. funestus*: one selected for resistance to multiple insecticides and the other fully susceptible. This study has revealed a strong association between the over-expression of major resistance genes and the presence of signatures of selective sweep as the duplicated P450 genes *CYP6P9a and CYP6P9b* are massively over-expressed in FUMOZ while exhibiting a drastically reduced diversity compared to the susceptible FANG strain.

Releasing incompatible males drives strong suppression across populations of wild and Wolbachia-carrying Aedes aegypti in Australia

Proc Natl Acad Sci USA 12 Oct 2021

This is another positive result on the *Wolbachia* front.

Abstract

Through a collaborative venture with the "Debug" Verily Life Sciences team, we assessed the incompatible insect technique (IIT) with the mosquito vector *Aedes aegypti* in northern Australia in a replicated treatment control field trial. Backcrossing a US strain of *Ae. aegypti* carrying *Wolbachia* wAlbB from *Aedes albopictus* with a local strain, we generated a *w*AlbB2-F4 strain incompatible with both the wild-type (no *Wolbachia*) and

*w*Mel-*Wolbachia Ae. aegypti* now extant in North Queensland. The wAlbB2-F4 strain was manually mass reared with males separated from females using Verily sex-sorting technologies to obtain no detectable female contamination in the field. With community consent, we delivered a total of three million IIT males into three isolated landscapes of over 200 houses each, releasing ~50 males per house three times a week over 20 weeks. Detecting initial overflooding ratios of between 5:1 and 10:1, strong population declines well beyond 80% were detected across all treatment landscapes when compared to controls. Monitoring through the following season to observe the ongoing effect saw one treatment landscape devoid of adult *Ae. aegypti* early in the season. A second landscape showed reduced adults and the third recovered fully. These encouraging results in suppressing both wild-type and *w*Mel-*Ae. aegypti* confirms the utility of bidirectional incompatibility in the field setting, show the IIT to be robust and indicate that the removal of this arbovirus vector from human-occupied landscapes may be achievable.

Analysing malaria events from 1840 to 2020: the narrative told through postage stamps

Malaria Journal 12 Oct 2021

Now for something lighter of a historical note.
This paper aimed to document and critically examine the messages and stamp designs that accompanied the changing initiatives to investigate, control and/or eradicate malaria up to the present time. The role played by postage stamps in the history of malaria control and eradication has largely gone unrecognized. Nonetheless, postage stamps greatly helped communicate the importance of malaria control programmes to a wide audience and, to some extent, have supported preventive health messages.

WHO News and Publications

WHO recommends ground-breaking malaria vaccine for children at risk

6 Oct 2021

The World Health Organization (WHO) is recommending widespread use of the RTS,S/AS01 (RTS,S) malaria vaccine among children in sub-Saharan Africa and in other regions with moderate to high *P. falciparum* malaria transmission. The recommendation is based on results from an ongoing pilot programme in Ghana, Kenya and Malawi that has reached more than 800,000 children since 2019.

Global insecticide use for vector-borne disease control: a 10-year assessment (2010–2019), sixth edition

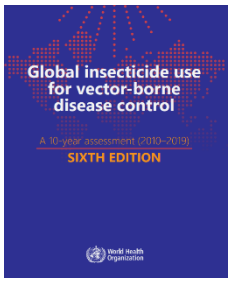


Table 6. Annual use of insecticides for vector control by spraying, by region, type of application and insecticide class, expressed in metric tonnes of active ingredient

	Residual spraying					Space spraying				ITN-kits	Larviciding			
WHO region	OC	OP	C	PY	NN	OP	C	PY	NN	PY	OP	BL	IGR	SP
African	337	388	335	34	35	0	0	0	0	0	3	0	0	0
Americas	0	6	253	31	0	1040	34	45	0	0	58	43	14	10
Eastern Mediterranean	0	0	47	14	1	0	0	11	0	0	15	2	5	5
European	0	1	0	0	0	0	0	0	0	0	0	0	0	0
South-East Asia	2977	62	3	26	0	13	0	5	0	0	18	37	1	0
Western Pacific	0	1	5	11	0	17	0	15	0	2	5	2	0	0
All	3314	457	643	116	36	1070	34	76	0	2	99	84	20	16

BL, bacterial larvicides; C, carbamates; IGR, insect growth regulators; NN, neonicotinoids; OC, organochlorines; OP, organophosphates; PY, pyrethroids; SP, spinosyns

Webinars, websites and other resources

Recent Webinars

Ifakara Master Classes in Public Health & Medical Entomology

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

- 12 August - ***Malaria Strategies***: A MasterClass with Prof. Marcel Tanner
- 14 October - ***Sustaining the [Malaria] Gains***: a MasterClass with Profs. Thomas Churcher & Ellie Sherrard Smith
- 21 October - ***Costs & Coverage of [Malaria] Control***: a MasterClass with Profs. H. Koenker, Yukich & M. Erskine
- 28 October - ***Infected But Not Sick***: a MasterClass with Profs. Chris Drakeley & Teun Bousema

APMEN Webinar YouTube channel

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

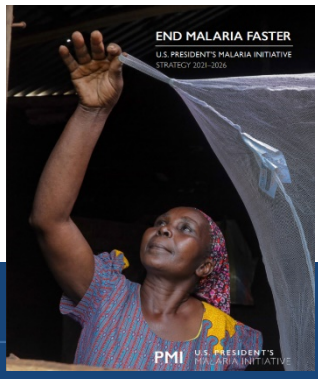
- 12 October – ***Appropriate surveillance: Better local understanding for reduced vector exposure***

PMI's 2021 – 2026 Strategic Plan: End Malaria Faster

6 October 2021

The U.S. President's Malaria Initiative is launching its next strategy for 2021 – 2026, titled "End Malaria Faster." U.S. PMI's strategy aims to greatly reduce malaria deaths and cases in countries that account for 80 percent of the world's malaria burden — contributing to the global goals of saving more than 4 million lives and averting over 1 billion cases by 2025.

Over the next five years, PMI aims to save lives, reduce health inequities and improve disease surveillance and global health security. With partners, PMI will maximize program efficiency by addressing five focus areas: reach the unreached, strengthen community health systems, keep malaria services resilient, invest locally and innovate and lead.



In the news and social media

Several articles on the approval of the malaria vaccine were published in early October following the WHO announcement.

A 'Historic Event': First Malaria Vaccine Approved by W.H.O.
New York Times 6 Oct 2021

Scientists hail historic malaria vaccine approval — but point to challenges ahead
Nature 8 Oct 2021

Malaria vaccine approval: a step change for global health
The Lancet 16 Oct 2021

Note this issue covers the period from August 2021 through 15 October 2021.