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Selected Recent Publications

District-level approach for tailoring and targeting interventions: a new path for malaria control and elimination

Malaria Journal Published 30 March 2020

The business-as-usual approach to malaria control and elimination is no longer reaping gains in an environment of 'flatlined' funding and more complex, heterogeneous transmission patterns. This paper presents a framework for shifting from a one-size-fits-all approach to tailoring and targeting at district level to overcome stalled progress toward malaria control and elimination. Note the presentation on a similar topic from Abdisalan M. Noor, team leader of the Surveillance, Monitoring and Evaluation Unit at the World Health Organization Global Malaria Programme, on the *Use of strategic information to drive impact* which addresses the use of data to stratify and tailor control programs.

Quantifying late-stage host-seeking behaviour of Anopheles gambiae at the insecticidal net interface using a baited-box bioassay

Malaria Journal Published 7 April 2020

Background Insecticide-treated nets (ITNs) are losing efficacy against pyrethroid-resistant malaria vector populations throughout Africa. Safeguarding bed net efficacy, vital for effective malaria control, requires greater knowledge of mosquito–ITN interactions and how this impacts on the mosquito.
Methods A purpose-built benchtop apparatus with a closed 10 cm cubic chamber (the 'Baited-box') was used to video record behaviour of individual free-flying female *Anopheles gambiae* during approach and blood-feeding on a human hand through untreated nets and ITNs at close range. Time and duration of defined behavioural events, and knockdown and mortality at 1- and 24-h post-exposure respectively, were recorded for pyrethroid susceptible and resistant mosquitoes.
Results Using three human volunteers differing in relative attractiveness to mosquitoes, 328 mosquitoes were individually tested. There were no significant differences between response rates to ITNs and untreated nets ($P > 0.1$) or between resistant (Tiassalé) and susceptible (Kisumu) mosquito strains, to untreated nets ($P = 0.39$) or PermaNet 2.0 ($P = 1$). The sequence of behavioural events from host-seeking to completion of blood-feeding was consistent in all tests but duration and start time of events involving net contact were reduced or delayed respectively with ITNs. Blood-feeding durations at untreated nets (means from 4.25 to 8.47 min) were reduced by 37–50% at PermaNet 2.0, in susceptible and resistant strains. Total accumulated net contact was approximately 50% lower at PermaNet and Olyset ITNs ($P < 0.0001$) in susceptible (two of the three volunteers) and resistant mosquitoes. Times prior to first net contact were similar at untreated nets and ITNs ($P > 0.2$), and neither ITN type showed detectable spatial repellency. After initial contact, blood-feeding commenced later at Olyset and PermaNet than untreated netting.
Conclusions The baited box offers a simple method for detailed characterization of mosquito behavioural responses to insecticidal nets, for comparing entomological modes of action between nets and for defining the behavioural responses of particular mosquito strains or populations. The device has potential as a screening assay in the search for novel net treatments and for investigations into behavioural resistance mechanisms.

Note, another paper on the topic of alternative bioassays for testing LLINs was included in the Spring Tech Update. *Use of alternative bioassays to explore the impact of pyrethroid resistance on LLIN efficacy.*

Longevity of the insecticidal effect of three pyrethroid formulations applied to outdoor vegetation on a laboratory-adapted colony of the Southeast Asian malaria vector Anopheles dirus

PLoS One Published 14 April 2020

Outdoor residual spraying is proposed for the control of exophilic mosquitoes. However, the residual effect of insecticide mists applied to outdoor resting habitats of mosquitoes is not well characterized. The objective of this study was to assess the longevity of the residual insecticidal effect of three pyrethroid formulations applied to outdoor vegetation against the Southeast Asian malaria vector *Anopheles dirus*. Lambda-cyhalothrin capsule suspension, deltamethrin emulsifiable concentrate and bifenthrin wettable powder were sprayed on dense bamboo bushes on the Thailand-Myanmar border during the dry season 2018. The duration and magnitude of the residual insecticidal effect were assessed weekly with a standard cone assay, using freshly

collected insecticide-treated bamboo leaves and a laboratory-adapted colony of *Anopheles dirus* sensu stricto susceptible to pyrethroids. The experiment was repeated during the rainy season to assess the persistence of the lambda-cyhalothrin formulation after natural rains and artificial washings. During the dry season (cumulative rainfall = 28 mm in 111 days), mortality and knockdown (KD) rates were >80% for 60 days with bifenthrin and 90 days with lambda-cyhalothrin and deltamethrin. The 50% knockdown time (TKD50) was <15 min with lambda-cyhalothrin and deltamethrin, and <30 min with bifenthrin. **During the rainy season (cumulative rainfall = 465 mm in 51 days), mortality and KD rates were >80% for 42 days** and TKD50 was <15 min with lambda-cyhalothrin. Long-lasting residual insecticidal effect can be obtained when spraying pyrethroid insecticides on the outdoor resting habitats of malaria vectors.

A standardised method of marking male mosquitoes with fluorescent dust

Parasit Vectors Published 15 April 2020

Background: Prior to a major release campaign of sterile insects, including the sterile insect technique, male mosquitoes must be marked and released (small scale) to determine key parameters including wild population abundance, dispersal and survival. Marking insects has been routinely carried out for over 100 years; however, there is no gold standard regarding the marking of specific disease-transmitting mosquitoes including *Anopheles arabiensis, Aedes aegypti* and *Aedes albopictus*. The research presented offers a novel dusting technique and optimal dust colour and quantities, suitable for small-scale releases, such as mark-release-recapture studies.

Methods: We sought to establish a suitable dust colour and quantity for batches of 100 male *An. arabiensis*, that was visible both by eye and under UV light, long-lasting and did not negatively impact longevity. A set of lower dust weights were selected to conduct longevity experiments with both *Ae. aegypti* and *Ae. albopictus* to underpin the optimal dust weight. A further study assessed the potential of marked male *An. arabiensis* to transfer their mark to undusted males and females.

Results: The longevity of male *An. arabiensis* marked with various dust colours was not significantly reduced when compared to unmarked controls. Furthermore, the chosen dust quantity (5 mg) did not negatively impact longevity (P = 0.717) and provided a long-lasting mark. Dust transfer was found to occur from marked *An. arabiensis* males to unmarked males and females when left in close proximity. However, this was only noticeable when examining individuals under a stereomicroscope and thus deemed negligible. Overall, male *Ae. aegypti* and *Ae. albopictus* displayed a greater sensitivity to dusting. Only the lowest dust weight (0.5 mg) did not significantly reduce longevity (P = 0.888) in *Ae. aegypti*, whilst the lowest two dust weights (0.5 and 0.75 mg) had no significant impact on longevity (P = 0.951 and 0.166, respectively) in *Ae. albopictus*.

Conclusion: We have devised a fast, inexpensive and simple marking method and provided recommended dust quantities for several major species of disease-causing mosquitoes. The novel technique provides an evenly distributed, long-lasting mark which is non-detrimental. Our results will be useful for future MRR studies, prior to a major release campaign.

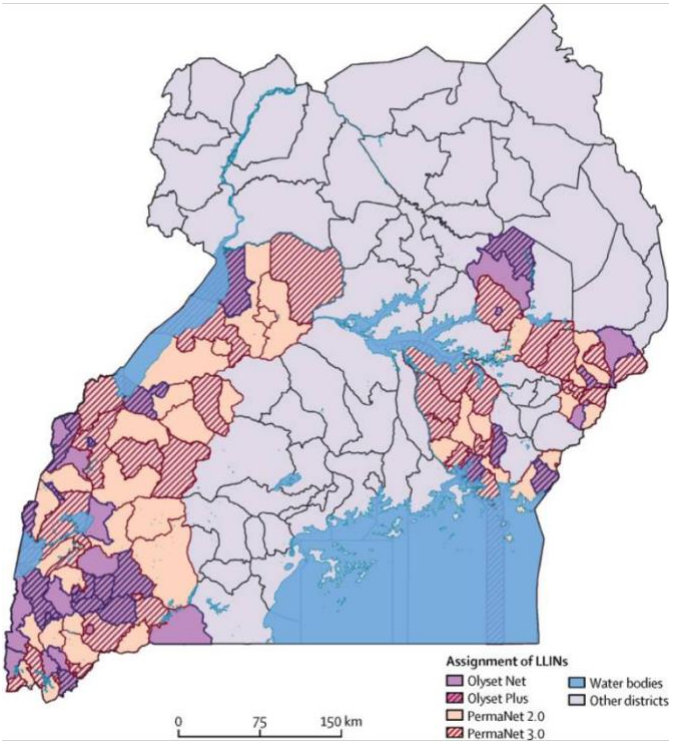
Effect of long-lasting insecticidal nets with and without piperonyl butoxide on malaria indicators in Uganda (LLINEUP): a pragmatic, cluster-randomised trial embedded in a national LLIN distribution campaign

Lancet Published 18 April 2020

Background: Long-lasting insecticidal nets (LLINs) are the primary malaria prevention tool, but their effectiveness is threatened by pyrethroid resistance. We embedded a pragmatic cluster-randomised trial into Uganda's national LLIN campaign to compare conventional LLINs with those containing piperonyl butoxide (PBO), a synergist that can partially restore pyrethroid susceptibility in mosquito vectors.

Methods: 104 health sub-districts, from 48 districts in Uganda, were randomly assigned to LLINs with PBO (PermaNet 3.0 and Olyset Plus) and conventional LLINs (PermaNet 2.0 and Olyset Net) by proportionate randomisation using an iterative process. At baseline 6, 12, and 18 months after LLIN distribution, cross-sectional surveys were done in 50 randomly selected households per cluster (5200 per survey); a subset of ten households per cluster (1040 per survey) were randomly selected for entomological surveys. The primary outcome was parasite prevalence by microscopy in children aged 2-10 years, assessed in the as-treated population at 6, 12, and 18 months.

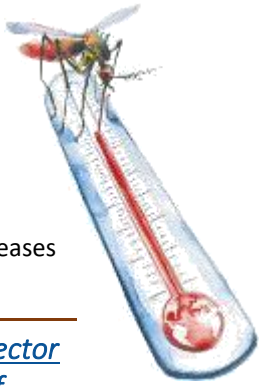
Findings: LLINs were delivered to households from March 25, 2017, to March 18, 2018, 32 clusters were randomly assigned to PermaNet 3.0, 20 to Olyset Plus, 37 to PermaNet 2.0, and 15 to Olyset Net. In the as-treated analysis, three clusters were excluded because no dominant LLIN was received, and four clusters were reassigned, resulting in 49 PBO LLIN clusters (31 received PermaNet 3.0 and 18 received Olyset Plus) and 52 non-PBO LLIN clusters (39 received PermaNet 2.0 and 13 received Olyset Net). At 6 months, parasite prevalence was 11% (386/3614) in the PBO group compared with 15% (556/3844) in the non-PBO group (prevalence ratio [PR] adjusted for baseline values 0·74, 95% CI 0·62-0·87; p=0·0003). Parasite prevalence was similar at month 12 (11% vs 13%; PR 0·73, 95% CI 0·63-0·85; p=0·0001) and month 18 (12% vs 14%; PR 0·84, 95% CI 0·72-0·98; p=0·029).



Interpretation: In Uganda, where pyrethroid resistance is high, PBO LLINs reduced parasite prevalence more effectively than did conventional LLINs for up to 18 months. This study provides evidence needed to support WHO's final recommendation on use of PBO LLINs.

Climate change: an enduring challenge for vector-borne disease prevention and control

Nat Immunol Nature Public Health Emergency Collection Published 20 April 2020



Climate change is already affecting vector-borne disease transmission and spread, and its impacts are likely to worsen. In the face of ongoing climate change, we must intensify efforts to prevent and control vector-borne diseases. Put simply, vectors, which are ectotherms (that is, cold-blooded animals), do better in a warmer world. Here, we discuss how climate affects the transmission dynamics and geographic spread of vector-borne diseases and the impact our changing climate has had thus far.

Effectiveness of reactive focal mass drug administration and reactive focal vector control to reduce malaria transmission in the low malaria-endemic setting of Namibia: a cluster-randomised controlled, open-label, two-by-two factorial design trial

The Lancet Published 25 April 2020

There is growing interest in stratifying malaria risk maps and tailoring intervention packages to maximize cost-effectiveness. The authors claim this is the first study of its kind to demonstrate how focal mass drug administration and focal vector control can be used to accelerate malaria elimination. Two major challenges to malaria elimination are low levels of asymptomatic infection in people and hot spots of transmission in communities that are largely undetectable with standard diagnostics. In order to address these challenges, investigators in Namibia conducted a trial to evaluate the effectiveness and safety of two interventions: reactive focal mass drug administration (rfMDA) and reactive focal vector control (RAVC). Researchers found that rfMDA and RAVC significantly reduced malaria transmission among high-risk populations in the Zambezi region of Namibia when implemented separately and together. When used in combination, the two interventions had an additive effect. As both the first-ever randomized, controlled trial of reactive focal malaria interventions and the first to simultaneously assess drug and vector control interventions separately and in combination, the study shows how targeting and tailoring existing tools can help countries to accelerate progress towards malaria elimination.

The influence of feeding behaviour and temperature on the capacity of mosquitoes to transmit malaria

Nat Ecol Evol Published 4 May 2020

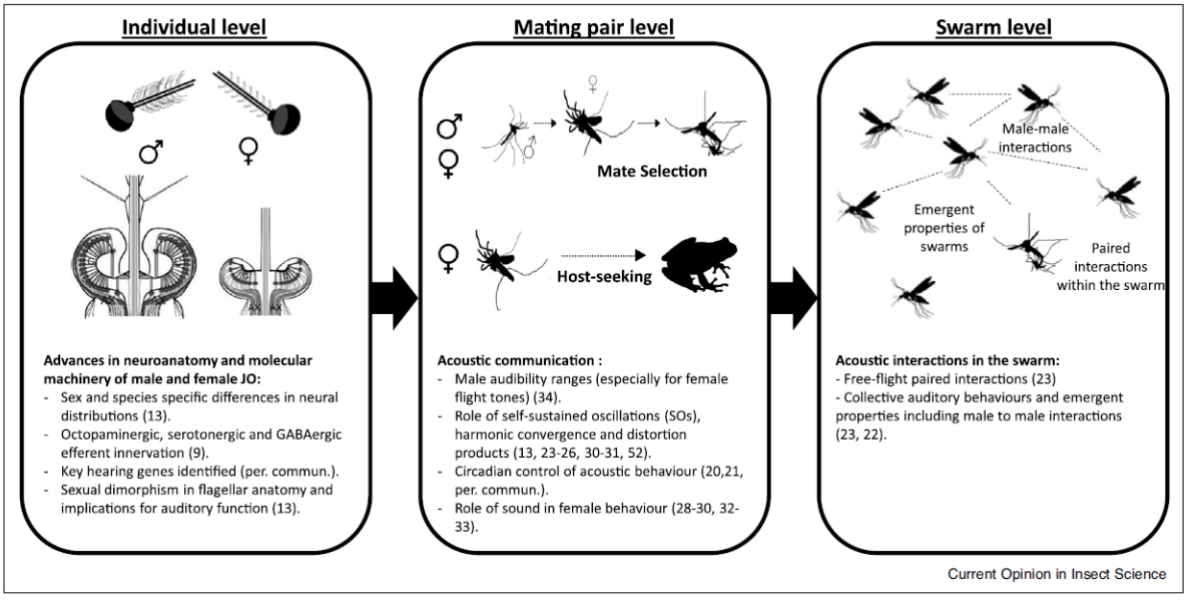
Insecticide-treated bed nets reduce malaria transmission by limiting contact between mosquito vectors and human hosts when mosquitoes feed during the night. However, malaria vectors can also feed in the early evening and in the morning when people are not protected. Here, we explored how the timing of blood feeding interacts with environmental temperature to influence the capacity of *Anopheles* mosquitoes to transmit the human malaria parasite *Plasmodium falciparum*. In laboratory experiments, we found no effect of biting time itself on the proportion of mosquitoes that became infectious (vector competence) at constant temperature. However, when mosquitoes were maintained under more realistic fluctuating temperatures, there was a significant increase in competence for mosquitoes feeding in the evening (18:00), and a significant reduction in competence for those feeding in the morning (06:00), relative to those feeding at midnight (00:00). These effects appear to be due to thermal sensitivity of malaria parasites during the initial stages of parasite development within the mosquito, and the fact that mosquitoes feeding in the evening experience cooling temperatures during the night, whereas mosquitoes feeding in the morning quickly experience warming temperatures that are inhibitory to parasite establishment. A transmission dynamics model illustrates that such differences in competence could have important implications for malaria prevalence, the extent of transmission that persists in the presence of bed nets, and the epidemiological impact of behavioural resistance. These results indicate that the interaction of temperature and feeding behaviour could be a major ecological determinant of the vectorial capacity of malaria mosquitoes.

Buzzkill: targeting the mosquito auditory system

Curr Opin Insect Sci. Published 6 May 2020

Sound plays an important role in mosquito sensory ecology. Acoustic perception and acoustically driven behaviours therefore represent potentially effective control targets. Previous scientific efforts around acoustic-based control and surveillance have not been systematic and ambiguity around the exact role of acoustic communication in conspecific interactions remains. Here, we briefly review recent advances in mosquito auditory physiology and behavioural ecology as well as ongoing activities to incorporate sound into control and surveillance tools. We highlight areas where increased collaboration between physiologists, molecular biologists, behavioural ecologists and control experts is needed to capitalize on this progress and realize the potential of sound-based technologies and strategies.

Figure 1



Evaluation of human-baited double net trap and human-odour-baited CDC light trap for outdoor host-seeking malaria vector surveillance in Kenya and Ethiopia

Malaria Journal Published 7 May 2020

Background: Surveillance of outdoor host-seeking malaria vectors is crucial to monitor changes in vector biting behaviour and evaluate the impact of vector control interventions. Human landing catch (HLC) has been considered the most reliable and gold standard surveillance method to estimate human-biting rates. However, it is labour-intensive, and its use is facing an increasing ethical concern due to potential risk of exposure to infectious mosquito bites. Thus, alternative methods are required. This study was conducted to evaluate the performance of human-odour-baited CDC light trap (HBLT) and human-baited double net trap (HDNT) for outdoor host-seeking malaria vector surveillance in Kenya and Ethiopia.
Methods: The sampling efficiency of HBLT and HDNT was compared with CDC light trap and HLC using Latin Square Design in Ahero and Iguhu sites, western Kenya and Bulbul site, southwestern Ethiopia between November 2015 and December 2018. The differences in Anopheles mosquito density among the trapping methods were compared using generalized linear model.
Results: Overall, 16,963 female *Anopheles* mosquitoes comprising *Anopheles gambiae* sensu lato (s.l.), *Anopheles funestus* s.l., *Anopheles pharoensis*, *Anopheles coustani* and *Anopheles squamosus* were collected. PCR results (n = 552) showed that *Anopheles arabiensis* was the only member of *An. gambiae* s.l. in Ahero and Bulbul, while 15.7% *An. arabiensis* and 84.3% *An. gambiae* sensu stricto (s.s.) constituted *An. gambiae* s.l. in Iguhu. In Ahero, HBLT captured 2.23 times as many *An. arabiensis* and 2.11 times as many *An. funestus* as CDC light trap. In the same site, HDNT yielded 3.43 times more *An. arabiensis* and 3.24 times more *An. funestus* than HBLT. In Iguhu, the density of *Anopheles* mosquitoes did not vary between the traps ($p > 0.05$). In Bulbul, HBLT caught 2.19 times as many *An. arabiensis* as CDC light trap, while HDNT caught 6.53 times as many *An. arabiensis* as CDC light trap. The mean density of *An. arabiensis* did not vary between HDNT and HLC ($p = 0.098$), whereas the HLC yielded significantly higher density of *An. arabiensis* compared to HBLT and CDC light trap. There was a significant density-independent positive correlation between HDNT and HLC ($r = 0.69$).
Conclusion: This study revealed that both HBLT and HDNT caught higher density of malaria vectors than conventional CDC light trap. Moreover, HDNT yielded a similar vector density as HLC, suggesting that it could be an alternative tool to HLC for outdoor host-seeking malaria vector surveillance.

Insecticide resistance and malaria control: A genetics-epidemiology modeling approach

Math Biosci ePublished 11 May 2020

This study presents a novel mathematical model, which couples malaria epidemiology with mosquito population genetics, for assessing the impact of insecticides resistance on malaria epidemiology. Numerical simulations of the model, using data relevant to malaria transmission dynamics in the Jimma Zone of Southwestern Ethiopia, show that the implementation of a control strategy based on using LLINs alone can lead to the effective control of malaria, while also effectively managing insecticide resistance, if the LLINs coverage in the community is high enough (over 90%). It is further shown that combining LLINs with IRS (both at reduced and realistically-attainable coverage levels) can lead to the aforementioned effective control of malaria and effective management of insecticide resistance if their coverage levels lie within a certain effective control window in the LLINs-IRS coverage parameter space (this result generally holds regardless of whether or not larviciding is implemented in the community). The study identifies three key parameters of the model that negatively affect the size of the effective control window, namely parameters related with the coverage level of larviciding, the number of new adult mosquitoes that are females and the initial size of the frequency of resistant allele in the community. For the coverage of LLINs and IRS within the effective control window, an additional increase in the values of the aforementioned three parameters may lead to a shrinkage in the size of the effective control window (thereby causing the failure of the insecticides-based control).

Advances in oral RNAi for disease vector mosquito research and control

Curr Opin Insect Sci Published 13 May 2020

Current vector control tools are reaching the limits of their effectiveness, necessitating the introduction of innovative vector control technologies. RNAi, which facilitates functional characterization of mosquito genes in the laboratory, could one day be applied as a new method of vector control. Recent advances in the oral administration of microbial-based systems for delivery of species-specific interfering RNA pesticides to mosquitoes may facilitate translation of this technology to the field. Oral RNAi-based pesticides represent a new class of biorational pesticides that could combat increased global incidence of insecticide resistance and which could one day become critical components of integrated human disease vector mosquito control programs.

Highlights:

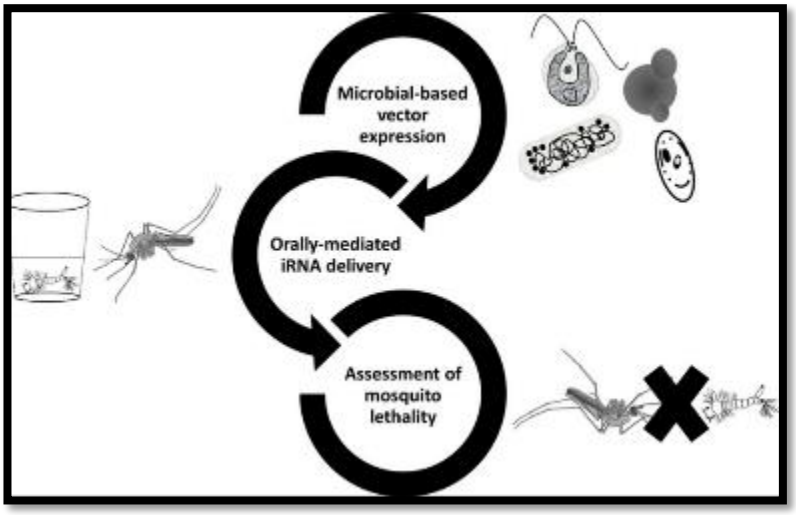
• Oral RNA interference (RNAi) permits functional characterization of mosquito genes.

• Microbial-based oral RNAi methods are highly effective in mosquitoes.

• Interfering RNAs are a new class of pesticides that can combat resistance.

• Oral RNAi may facilitate species-specific biorational mosquito control.

• Further development and evaluation of RNAi control strategies are critical.

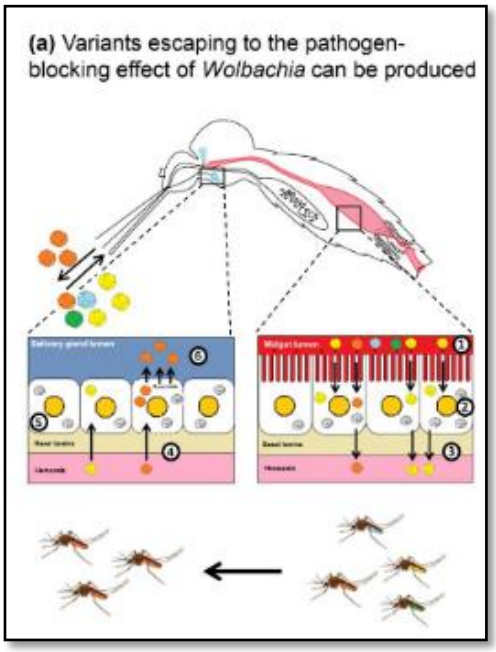


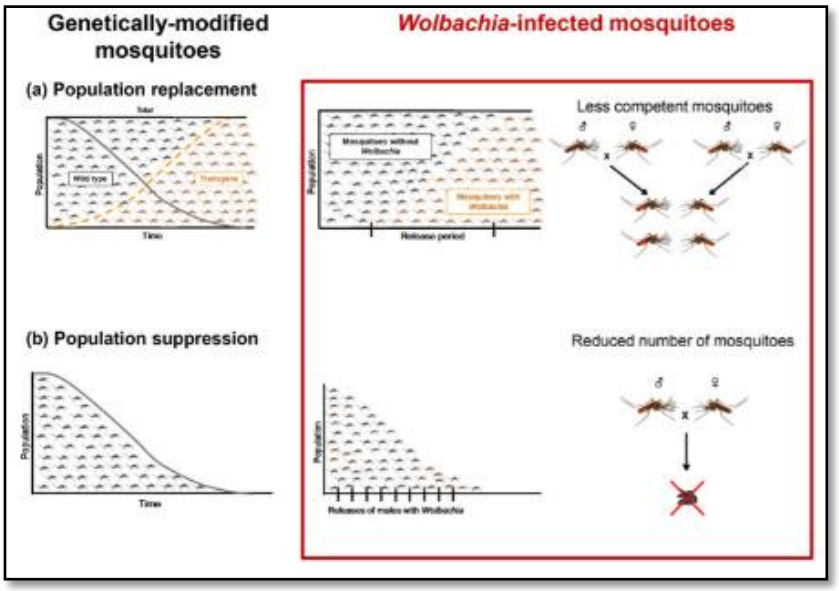
A Review: Wolbachia-Based Population Replacement for Mosquito Control Shares Common Points with Genetically Modified Control Approaches

Pathogens Published 22 May 2020

Although this paper focuses on arbovirus vectors, it is a useful review which covers a variety of topics pertinent to two novel mosquito control approaches.

The growing expansion of mosquito vectors has made mosquito-borne arboviral diseases a global threat to public health, and the lack of licensed vaccines and treatments highlight the urgent need for efficient mosquito vector control. Compared to genetically modified control strategies, the intracellular bacterium *Wolbachia*, endowing a





pathogen-blocking phenotype, is considered an environmentally friendly strategy to replace the target population for controlling arboviral diseases. However, the incomplete knowledge regarding the pathogen-blocking mechanism weakens the reliability of a *Wolbachia*-based population replacement strategy. *Wolbachia* infections are also vulnerable to environmental factors, temperature, and host diet, affecting their densities in mosquitoes and thus the virus-blocking phenotype. Here, we review the properties of the *Wolbachia* strategy as an approach to control mosquito populations in comparison with genetically modified control methods. Both strategies tend to limit arbovirus infections but increase the risk of selecting arbovirus escape mutants, rendering these strategies less reliable.

Long-lasting insecticidal nets and the quest for malaria eradication: a mathematical modeling approach

J Mathematical Biology Published online 23 May 2020

The authors employ a new differential-equations based mathematical model, which incorporates the full, weather-dependent mosquito lifecycle, to assess the population-level impact of the large-scale use of LLINs, under different levels of *Anopheles* pyrethroid insecticide resistance, on malaria transmission dynamics and control in a community. They describe the bednet-mosquito interaction using parameters that can be estimated from the large experimental hut trial literature under varying levels of effective pyrethroid resistance. An expression for the basic reproduction number, R_0, as a function of population-level bednet coverage, is derived. It is shown, owing to the phenomenon of backward bifurcation, that R_0 must be pushed appreciably below 1 to eliminate malaria in endemic areas, potentially complicating eradication efforts. Numerical simulations of the model suggest that, when the baseline R_0 is high (corresponding roughly to holoendemic malaria), very high bednet coverage with highly effective nets is necessary to approach conditions for malaria elimination. Further, while >50% bednet coverage is likely sufficient to strongly control or eliminate malaria from areas with a mesoendemic malaria baseline, pyrethroid resistance could undermine control and elimination efforts even in this setting. The simulations show that pyrethroid resistance in mosquitoes appreciably reduces bednet effectiveness across parameter space. This modeling study also suggests that increasing pre-bloodmeal deterrence of mosquitoes (deterring them from entry into protected homes) actually hampers elimination efforts, as it may focus mosquito biting onto a smaller unprotected host subpopulation. Finally, they observe that temperature affects malaria potential independently of bednet coverage and pyrethroid-resistance levels, with both climate change and pyrethroid resistance posing future threats to malaria control.

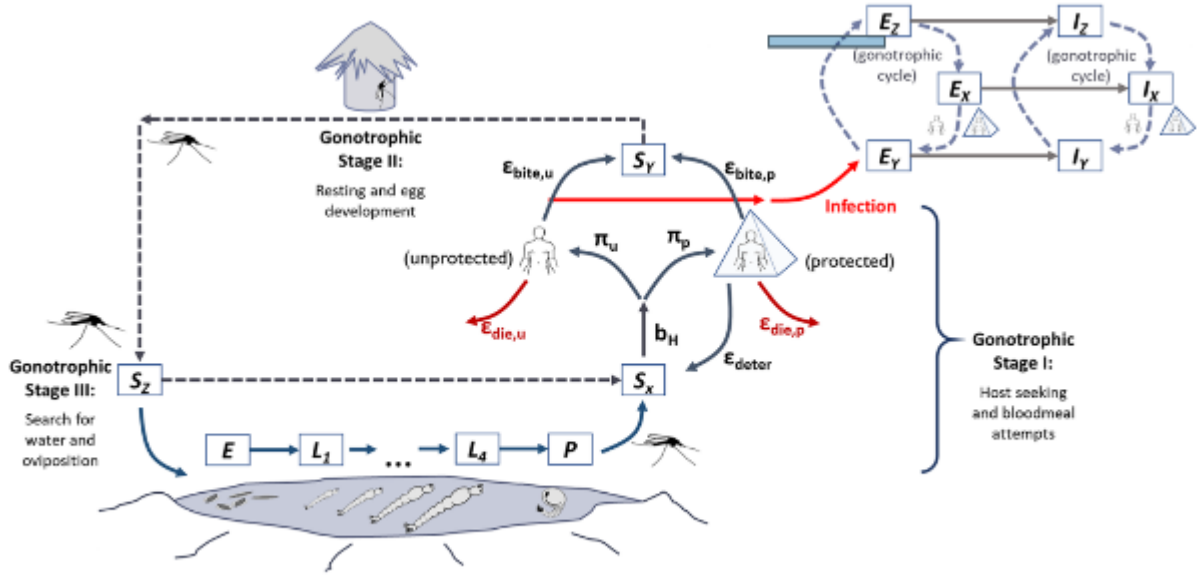


Fig. 1 Flow diagram of the model (2.1), (2.2), (2.4)

Imergard ™ WP: A Non-Chemical Alternative for an Indoor Residual Spray, Effective against Pyrethroid-Resistant Anopheles gambiae *(s.l.) in Africa*

Insects Published 23 May 2020

The efficacy of a novel mechanical insecticidal mineral derived from volcanic rock, Imergard™WP, was investigated to determine its efficacy as a stand-alone residual wall spray and as a mixture with deltamethrin (K-Othrine® Polyzone) in experimental huts in Cove, Benin. The evaluation was conducted with susceptible (Kisumu) and wild-type *Anopheles gambiae* (s.l.). Deltamethrin applied alone demonstrated 40-45% mortality (at 72 h post-exposure) during the first four months, which declined to 25% at six months for wild *An. gambiae* from Cove. Imergard™WP alone and mixed with deltamethrin, under the same assay conditions, produced 79-82% and 73-81% mortality, respectively, during the same six-month period. Imergard™WP met the 80% WHO bio-efficacy threshold for residual activity for the first five months with 78% residual activity at six months. Imergard™WP can be used as a mixture with chemical insecticides or as a stand-alone pesticide for mosquito control in Africa.
Note that results from another Imergard trial conducted in Tanzania by the Ifakara Health Institute and Swiss Tropical and Public Health Institute have been presented and are available on the *RBM Partnership to End Malaria website here*.

'What I cannot create, I do not understand': functionally validated synergism of metabolic and target site insecticide resistance

Proc Biol Sci Published 27 May 2020

The putative synergistic action of target-site mutations and enhanced detoxification in pyrethroid resistance in insects has been hypothesized as a major evolutionary mechanism responsible for dramatic consequences in malaria incidence and crop production. Combining genetic transformation and CRISPR/Cas9 genome modification, we generated transgenic *Drosophila* lines expressing pyrethroid metabolizing P450 enzymes in a genetic background along with engineered mutations in the voltage-gated sodium channel (*para*) known to confer target-site resistance. Genotypes expressing the yellow fever mosquito *Aedes aegypti Cyp9J28* while also bearing the $para^{V1016G}$ mutation displayed substantially greater resistance ratio (RR) against deltamethrin than the product of each individual mechanism ($RR_{combined}$: 19.85 > $RR_{Cyp9J28}$: 1.77 × RR_{V1016G}: 3.00). Genotypes expressing *Brassicogethes aeneus* pollen beetle *Cyp6BQ23* and also bearing the $para^{L1014F}$ (*kdr*) mutation, displayed an almost multiplicative RR ($RR_{combined}$: 75.19 ≥ $RR_{Cyp6BQ23}$: 5.74 × RR_{L1014F}: 12.74). Reduced pyrethroid affinity at the target site, delaying saturation while simultaneously extending the duration of P450-driven detoxification, is proposed as a possible underlying mechanism. Combinations of target site and P450 resistance loci might be unfavourable in field populations in the absence of insecticide selection, as they exert some fitness disadvantage in development time and fecundity. These are major considerations from the insecticide resistance management viewpoint in both public health and agriculture.

An Africa-wide genomic evolution of insecticide resistance in the malaria vector Anopheles funestus involves selective sweeps, copy number variations, gene conversion and transposons

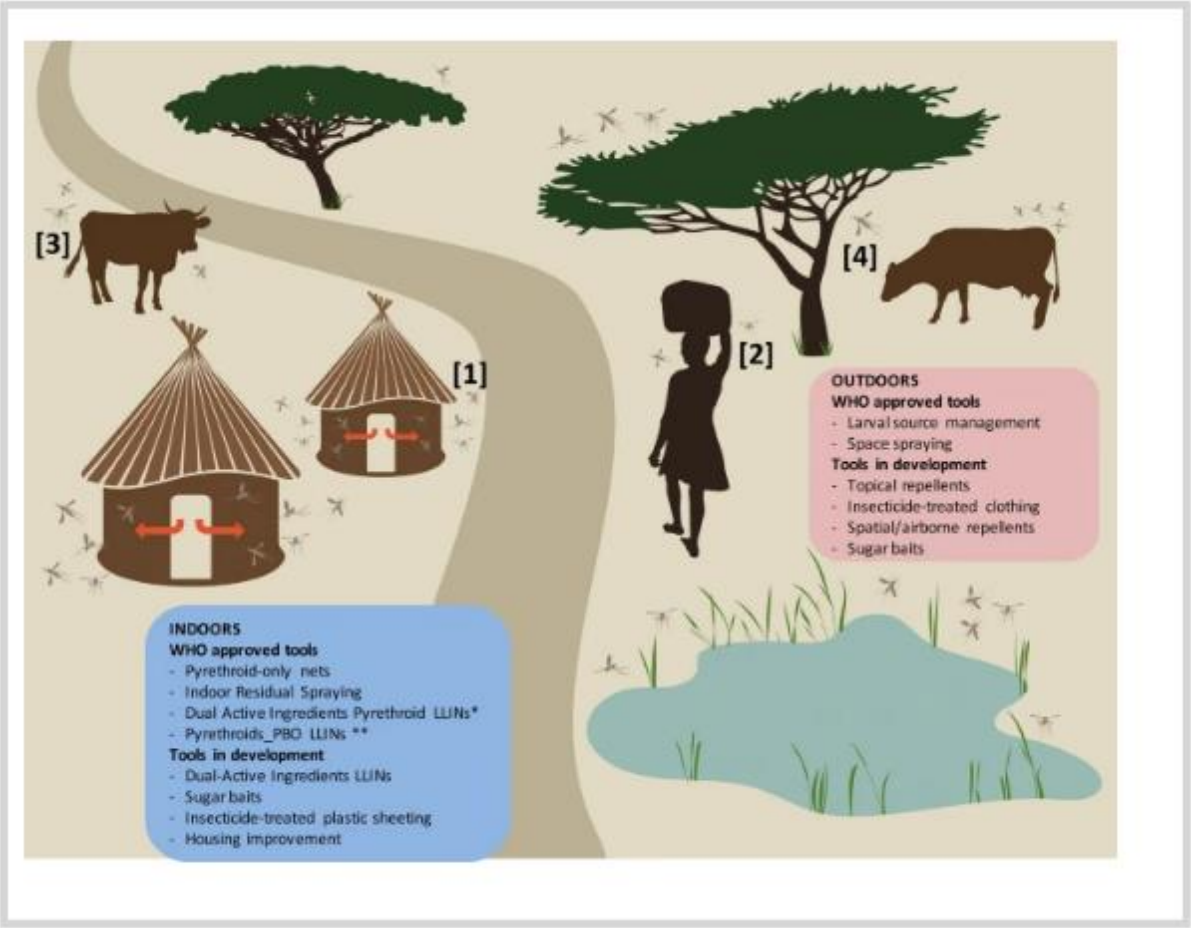
Plos Genetics Published 4 June 2020

Malaria control currently relies heavily on insecticide-based vector control interventions. Unfortunately, resistance to insecticides is threatening their continued effectiveness. Metabolic resistance has the greatest operational significance, yet it remains unclear how mosquito populations evolutionarily respond to the massive selection pressure from control interventions including insecticide-treated nets. Deciphering patterns of gene flow between populations of major malaria vectors such as *Anopheles funestus* and elucidating genomic signature of resistance evolution are crucial for designing resistance management strategies and preventing malaria resurgence. Here, we performed a genome-wide survey of *An*. *funestus* genetic diversity from across its continental range using reduced-genome representation (ddRADseq) and whole genome (PoolSeq) approaches revealing evidence of significant barriers to gene flow impacting the spread of insecticide resistance alleles. This study detected signatures of strong selective sweeps occurring in genomic regions controlling cytochrome P450-based and glutathione s-transferase metabolic resistance to insecticides in this species. Fine-scale analysis of the major pyrethroid resistance-associated genomic regions revealed complex molecular evolution with evidence of copy number variation, transposon insertion and gene conversion highlighting the risk that if this level of selection and spread of resistance continues unabated, our ability to control malaria with current interventions will be compromised.

The need for new vector control approaches targeting outdoor biting anopheline malaria vector communities

Parasites & Vectors Published 10 June 2020

In this review the authors discuss existing and novel approaches that may be used to target outdoor communities of malaria vectors.



Above is a schematic representation of mosquito distribution in a typical rural habitat. The selective pressure on indoor mosquito populations resulting from the implantation of ITNs and IRS induce behavioural changes of mosquitoes that bite increasingly outdoors (1), earlier at dusk and/or later at dawn when humans are not protected (2). Mosquitoes may also feed more often on non-human hosts (3), and rest outdoors (4) to avoid exposure to vector control. Most WHO-approved tools currently focus on the control of indoor populations (blue boxes) and those that are in development or under interim approval follow the same trend (*), leaving few current options for scalable control of outdoor biting populations (www.who.int/vector-control/vcag/new-interventions/en/). *Interim approval; ** Pyrethroid-PBO net in areas with metabolic resistance

Developing laboratory capacity for Good Laboratory Practice certification: lessons from a Tanzanian insecticide testing facility

Gates Open Research Published 12 June 2020

Background: With increasing insecticide resistance in malaria-endemic countries there is an urgent need for safe and effective novel vector control products. To improve the capacity of facilities that test insecticides in sub-Saharan Africa, a programme is supporting seven facilities towards Good Laboratory Practice (GLP) certification, the globally recognized standard for quality management system (QMS) for the conduct of non-clinical and environmental studies. The World Health Organization (WHO) GLP Handbook provides guidance on a stepwise approach to implement a GLP compliant QMS. This study assesses auditor GLP checklists and timings outlined in the WHO GLP Handbook in the real-life context of a Tanzanian insecticide-testing facility, evaluating their implementation in this context.

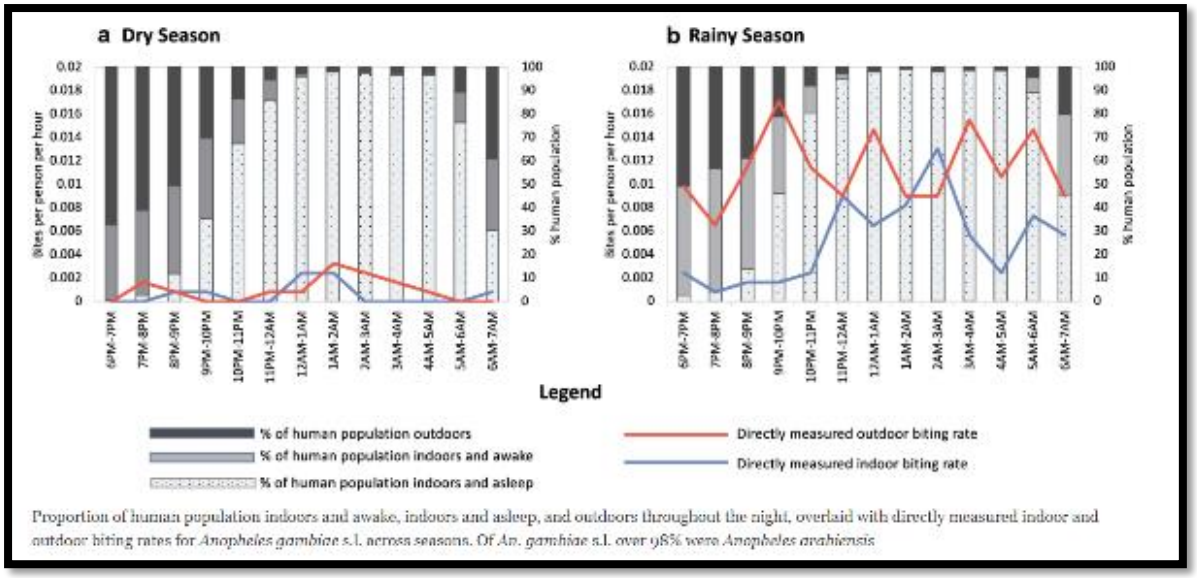
Methods and Principle Findings: We conducted document review and semi-structured interviews with staff at all levels of the test facility to explore factors that influenced progress towards GLP certification. We found that while auditor GLP checklists underemphasised computer systems, they were otherwise broadly applicable. Factors that delayed time to completion of GLP certification included the need for extensive

infrastructure improvements, the availability of regional expertise related to GLP, the capacity of national and regional external systems and services to meet GLP compliance requirements, and training development required for Standard Operating Procedure implementation.
Conclusion: The standards required for full GLP compliance are rigorous, with an expected completion timeline to implementation of 24 months. This study shows that in low and middle-income countries this timeline may be unrealistic due to challenges related to infrastructure development and lack of regional capacity and expertise. We recommend a comprehensive gap analysis when starting a project, including these areas which are beyond those recommended by the WHO GLP Handbook. These challenges can be successfully overcome and the experience in Tanzania provides key lessons for other facilities seeking GLP certification or the development of similar QMS.

Patterns of human exposure to malaria vectors in Zanzibar and implications for malaria elimination efforts

Malaria Journal Published 22 June 2020

Background: Zanzibar provides a good case study for malaria elimination. The islands have experienced a dramatic reduction in malaria burden since the introduction of effective vector control interventions and case management. Malaria prevalence has now been maintained below 1% for the past decade and the islands can feasibly aim for elimination.
Methods: To better understand factors that may contribute to remaining low-level malaria transmission in Zanzibar, layered human behavioural and entomological research was conducted between December 2016 and December 2017 in 135 randomly selected households across six administrative wards. The study included: (1) household surveys, (2) structured household observations of nighttime activity and sleeping patterns, and (3) paired indoor and outdoor mosquito collections. Entomological and human behavioural data were integrated to provide weighted estimates of exposure to vector bites, accounting for proportions of people indoors or outdoors, and protected by insecticide-treated nets (ITNs) each hour of the night.
Results: Overall, 92% of female *Anopheles* mosquitoes were caught in the rainy season compared to 8% in the dry season and 72% were caught outdoors compared to 28% indoors. For individual ITN users, ITNs prevented an estimated two-thirds (66%) of exposure to vector bites and nearly three quarters (73%) of residual exposure was estimated to occur outdoors. Based on observed levels of ITN use in the study sites, the population-wide mean personal protection provided by ITNs was 42%.
Discussion/conclusions: This study identified gaps in malaria prevention in Zanzibar with results directly applicable for improving ongoing programme activities. While overall biting risk was low, the most notable finding was that current levels of ITN use are estimated to prevent less than half of exposure to malaria vector bites. Variation in ITN use across sites and seasons suggests that additional gains could be made through targeted social and behaviour change interventions. However, even for ITN users, gaps in protection remain, with a majority of exposure to vector bites occurring outdoors before going to sleep. Supplemental



Proportion of human population indoors and awake, indoors and asleep, and outdoors throughout the night, overlaid with directly measured indoor and outdoor biting rates for *Anopheles gambiae* s.l. across seasons. Of *An. gambiae* s.l. over 98% were *Anopheles arabiensis*

interventions targeting outdoor exposure to malaria vectors, and groups that may be at increased risk of exposure to malaria vectors, should be explored.

Mapping trends in insecticide resistance phenotypes in African malaria vectors

PLoS Biology Published 25 June 2020

Mitigating the threat of insecticide resistance in African malaria vector populations requires comprehensive information about where resistance occurs, to what degree, and how this has changed over time. Estimating these trends is complicated by the sparse, heterogeneous distribution of observations of resistance phenotypes in field populations. We use 6,423 observations of the prevalence of resistance to the most important vector control insecticides to inform a Bayesian geostatistical ensemble modelling approach, generating fine-scale predictive maps of resistance phenotypes in mosquitoes from the *Anopheles gambiae* complex across Africa. Our models are informed by a suite of 111 predictor variables describing potential drivers of selection for resistance. Our maps show alarming increases in the prevalence of resistance to pyrethroids and DDT across sub-Saharan Africa from 2005 to 2017, with mean mortality following insecticide exposure declining from almost 100% to less than 30% in some areas, as well as substantial spatial variation in resistance trends.

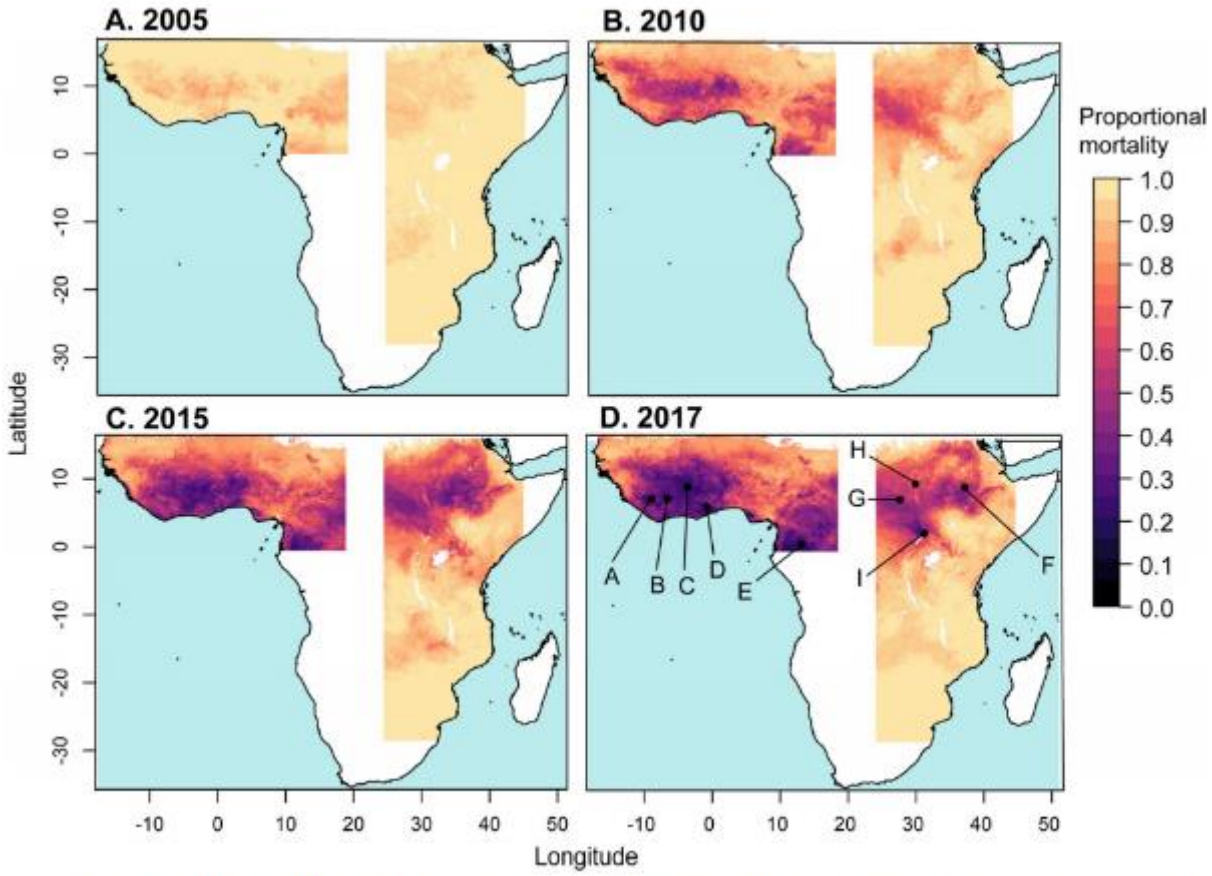


Fig 2. Predicted mean proportional mortality to deltamethrin across the west and east regions. (A) 2005, (B) 2010, (C) 2015, and (D) 2017. See 10.6084/m9.figshare.9912623.

Leveraging risk maps of malaria vector abundance to guide control efforts reduces malaria incidence in Eastern Province, Zambia

Nature Scientific Reports Published 25 June 2020

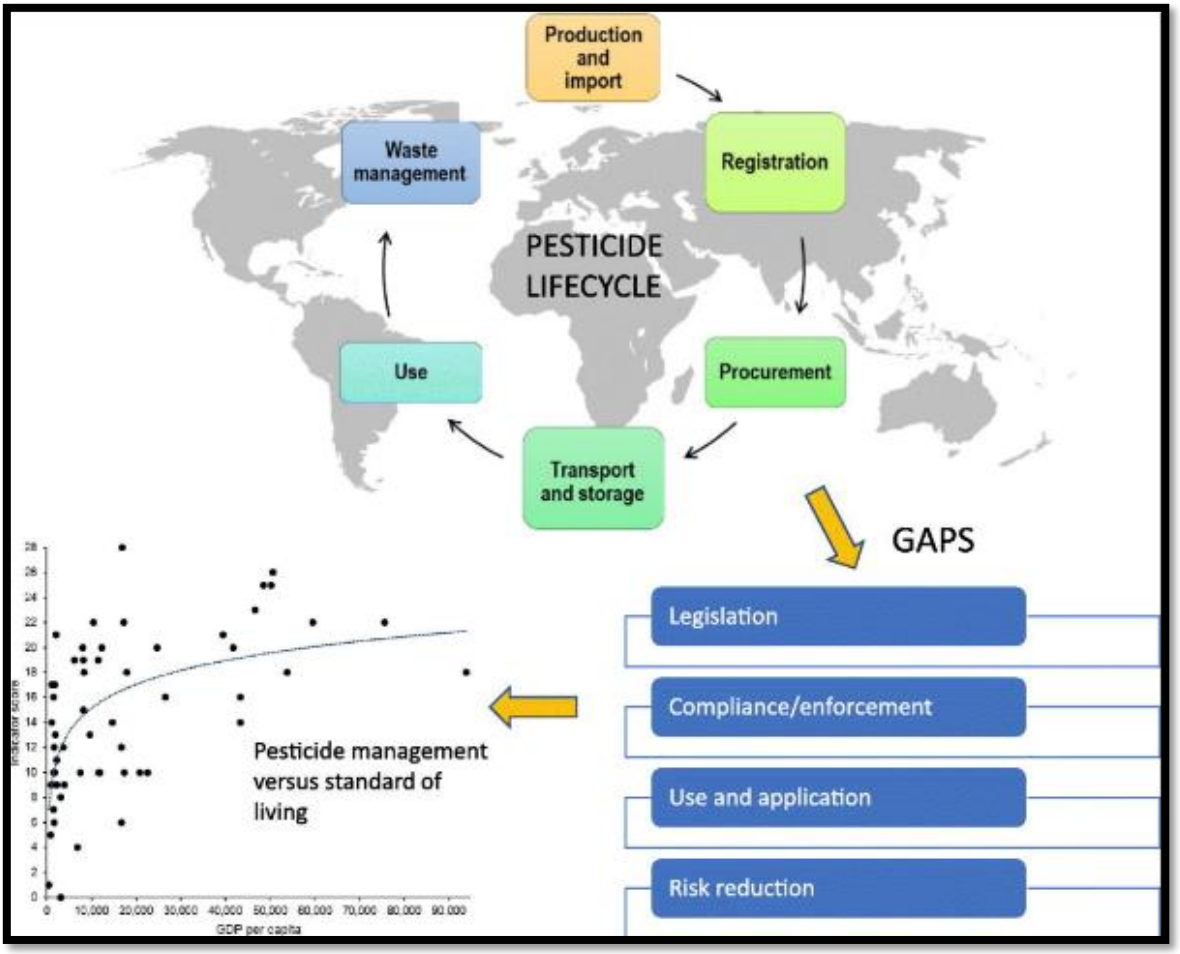
With increasing acceptance of the need to stratify the malaria risk map and focus resources to optimize cost-effectiveness, this paper provides some useful data regarding IRS targeting strategies. The authors conclude, the use of ecologically-derived risk maps for malaria to guide allocation of IRS resources was associated with a 13% decrease in malaria incidence compared to the traditional approach of geographically concentrating those resources. IRS programs may see increased impact if areas of greatest malaria vector abundance are targeted.

Abstract: Although transmission of malaria and other mosquito-borne diseases is geographically heterogeneous, in sub-Saharan Africa risk maps are rarely used to determine which communities receive vector control interventions. We compared outcomes in areas receiving different indoor residual spray (IRS) strategies in Eastern Province, Zambia: (1) concentrating IRS interventions within a geographical area, (2) prioritizing communities to receive IRS based on predicted probabilities of *Anopheles funestus*, and (3) prioritizing communities to receive IRS based on observed malaria incidence at nearby health centers. Here we show that the use of predicted probabilities of *An. funestus* to guide IRS implementation saw the largest decrease in malaria incidence at health centers, a 13% reduction (95% confidence interval = 5–21%) compared to concentrating IRS geographically and a 37% reduction (95% confidence interval = 30–44%) compared to targeting IRS based on health facility incidence. These results suggest that vector control programs could produce better outcomes by prioritizing IRS according to malaria-vector risk maps.

Figure 8. A diagram showing how spatial error differs when attributing risk to household locations.

Pesticide lifecycle management in agriculture and public health: Where are the gaps?

Science of the Total Environment Available online 30 June 2020



Pesticide lifecycle management encompasses a range of elements from legislation, regulation, manufacturing, application, risk reduction, monitoring, and enforcement to disposal of pesticide waste. A survey was conducted in 2017–2018 to describe the contemporary global status of pesticide lifecycle management, to identify where the gaps are found. A three-tiered questionnaire was distributed to government entities in 194 countries. The results showed gaps for most of the selected indicators of pesticide management, suggesting that pesticide efficacy and safety to human health and the environment are likely being compromised at various stages of the pesticide lifecycle, and at varying degrees across the globe. Low-income countries generally had the highest incidence of gaps. Particular shortcomings were deficiencies in pesticide legislation, inadequate capacity for pesticide registration, protection against occupational exposure to pesticides, consumer protection against residues in food, and environmental protection against pesticide contamination. Policy support for, and implementation of, pesticide use-reduction strategies such as integrated pest management and integrated vector management has been inadequate across regions. Priority actions for structural improvement in pesticide lifecycle management are proposed, including pesticide use-reduction strategies, targeted interventions, and resource mobilization.

Highlights:
• Gaps in lifecycle management of agriculture and public health pesticides were common.
• Low-income countries had most gaps, affecting pesticide efficacy and safety.
• Pesticide legislation and registration showed shortcomings in most countries.
• Inadequate measures against pesticide exposure and contamination were a concern.
• To reduce pesticide use, IPM and IVM should be prioritized in international policy.

Efficacy of a Spatial Repellent for Control of Malaria in Indonesia: A Cluster-Randomized Controlled Trial

AJTMH Published 8 July 2020 (the pre review draft of this paper was included in the Winter 2019 Tech Update)

A cluster randomized, double-blinded, placebo-controlled trial was conducted to estimate protective efficacy of a spatial repellent (a passive transfluthrin emanator from SC Johnson) against malaria infection at Sumba, Indonesia. Following radical cure in 1,341 children aged ≥6 months - ≤5 years in 24 clusters, households were given transfluthrin or placebo passive emanators. Monthly blood screening and biweekly human-landing mosquito catches (HLC) were performed during 10-months baseline (June 2015 to March 2016) and a 24-month intervention period (April 2016 to April 2018). Screening detected 164 first-time malaria infections and an accumulative total of 459 infections in 667 subjects in placebo-control households; and 134 first-time and 253 accumulative total infections among 665 subjects in active intervention households. The 24-cluster protective effect of 27.7% and 31.3%, for time to first-event and overall (total new) infections, respectively, was not statistically significant. Purportedly, **this was likely due in part to zero to low incidence in some clusters, undermining the ability to detect a protective effect from spatial repellent intervention.** Subgroup analysis of 19 clusters where at least one malaria infection occurred during the baseline showed 36.0% and 40.9% (statistically significant at 1-sided 5% significance level; p =0.0236) protective effect to first-infection and overall infections, respectively. **Among 12 moderate- to high-risk clusters, a statistically significant decrease on infection by the spatial repellent was detected (60% protective efficacy).**
In addition to the encouraging results, the authors point out that this study highlights several challenges for consideration in future spatial repellent trials as well for new vector control intervention classes more broadly: the importance of having 'adaptive' study designs, especially for evaluation of interventions in low to moderate malaria transmission settings and/or settings with inherently large cluster-to-cluster variance on transmission intensity; and defining and identification of the 'key' entomological correlates of protection.

Methods and indicators for measuring patterns of human exposure to malaria vectors

Malaria Journal Published 13 July 2020

An improved understanding of human and mosquito behaviour, and how they overlap in time and space, is critical to estimating the impact of insecticide-treated nets (ITNs) and determining when and where supplemental personal protection tools are needed. Methods for weighting estimates of human exposure to biting Anopheles mosquitoes according to where people spend their time were first developed over half a century ago. However, crude indoor and outdoor biting rates are still commonly interpreted as indicative of human-vector contact patterns without any adjustment for human behaviour or the personal protection effects of ITNs. This article presents an integrated perspective on relevant indicators of human-vector

interactions, the critical entomological and human behavioural data elements required to quantify human-vector interactions, and recommendations for collecting and analysing such data.

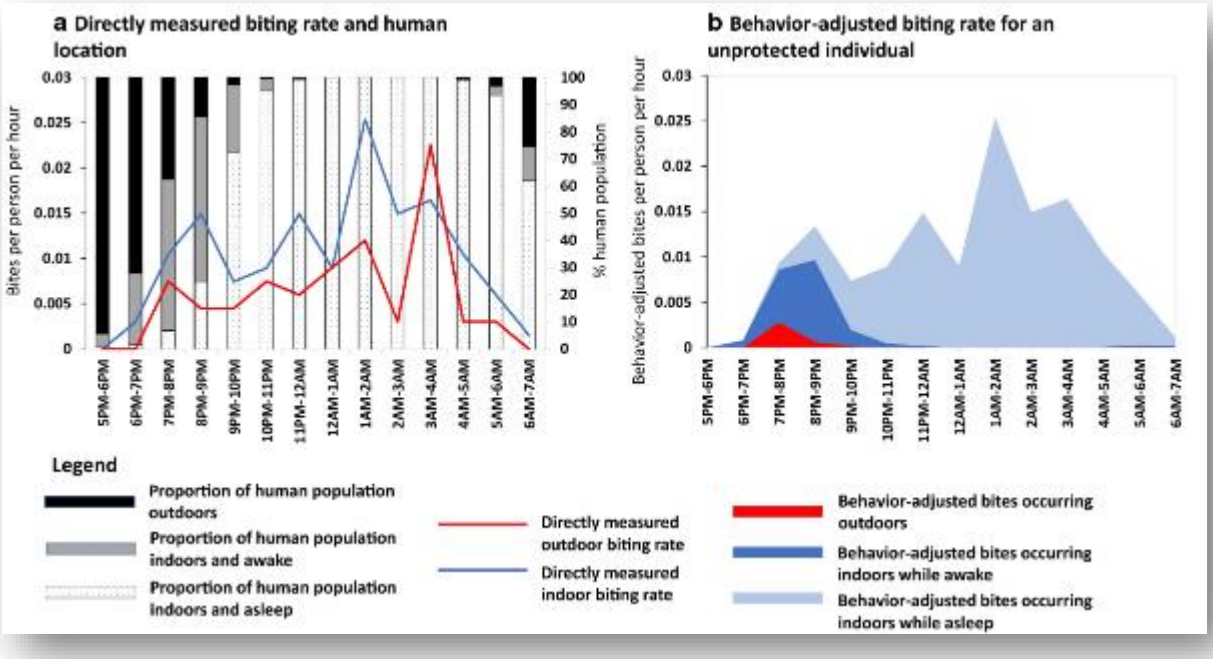


Figure 1. Example of directly measured and behaviour-adjusted estimates of human exposure to malaria vectors from Asembo, western Kenya in 2011

Indoor spraying with chlorfenapyr (a pyrrole insecticide) provides residual control of pyrethroid-resistant malaria vectors in southern Benin

Malaria Journal Published 13 July 2020

Chlorfenapyr, a novel pyrrole insecticide with a unique mode of action, is being developed as a long-lasting IRS formulation. The efficacy of several formulations of chlorfenapyr alone and as mixtures with alpha-cypermethrin were evaluated in an experimental hut trial against wild pyrethroid-resistant *Anopheles gambiae* sensu lato in Cové, Benin, in an attempt to identify the most effective and long-lasting formulations for IRS. The trial lasted 12 months. A comparison was made with alpha-cypermethrin and bendiocarb formulations. Conclusion: Indoor residual spraying with chlorfenapyr (Sylando® 240SC) provides moderate but prolonged control of pyrethroid-resistant malaria vectors compared to pyrethroid and bendiocarb IRS. Wall cone bioassays on chlorfenapyr-treated walls required longer exposure times of 2 h than the customary 30 min indicating that WHO guidelines on residual cone bioassays need to be more insecticide-specific.

WHO News and Publications

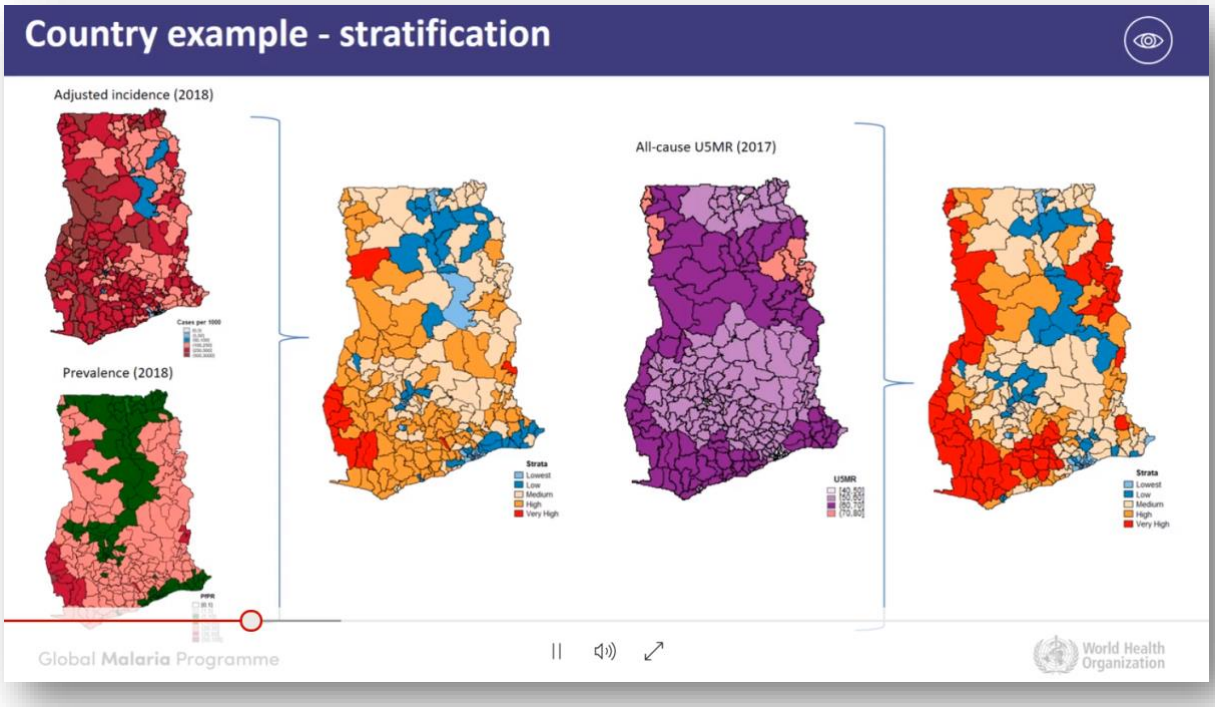
News

Malaria Policy Advisory Committee – call for applications

Please note that the WHO Global Malaria Programme is accepting applications from malaria experts to be considered for membership on the Malaria Policy Advisory Committee and is **looking for vector control expertise in particular for this rotation**. For more information on how to apply please visit call for MPAC applications. The closing date for expressions of interest is 15 September 2020.

MPAC meeting 13-14 May Presentations available online

Also available for your viewing is a recording of the session 4 presentation from Abdisalan M. Noor on the *Use of strategic information to drive impact* which addresses the use of data to stratify and tailor control programs. Well worth the 30 minutes.



Webinars, websites and other resources

Recent Webinars

Malaria's Rising Toll in the COVID Shadow
Rotarian Malaria Partners 17 July 2020

Rotarian Malaria Partners

NgenIRS end of project evidence summary

The Unitaid-funded NgenIRS Project has released the NgenIRS evidence materials, consisting of a video, overview document and evidence slides (in French and English). These are available on the IVCC website both the **NgenIRS page** and the IVCC **Resource Library**.

The team also hosted a recent webinar interview with experts on the effects of layering IRS and LLINs. The ***slide presentations are available here.*** The panel included:

Sergi Alonso, PhD, ISGlobal *in conversation with* **Rose Zulliger**, PhD, US President's Malaria Initiative/Center for Disease Control, Division of Parasitic Diseases and Malaria

> ***Discussion topic***: Evidence from a cluster-randomized control trial in Mopeia, Mozambique on the direct and indirect costs of IRS with non-pyrethroid insecticide in a high burden area of Mozambique with high coverage of LLINs.

Ellie Sherrard-Smith, PhD, Imperial College *in conversation with* **Helen Jamet**, PhD, Bill & Melinda Gates Foundation

Discussion topic: Using models to make product layering decisions.

Joshua Yukich, PhD, Tulane University *in conversation with* **Alexandra Cameron**, PhD, Unitaid

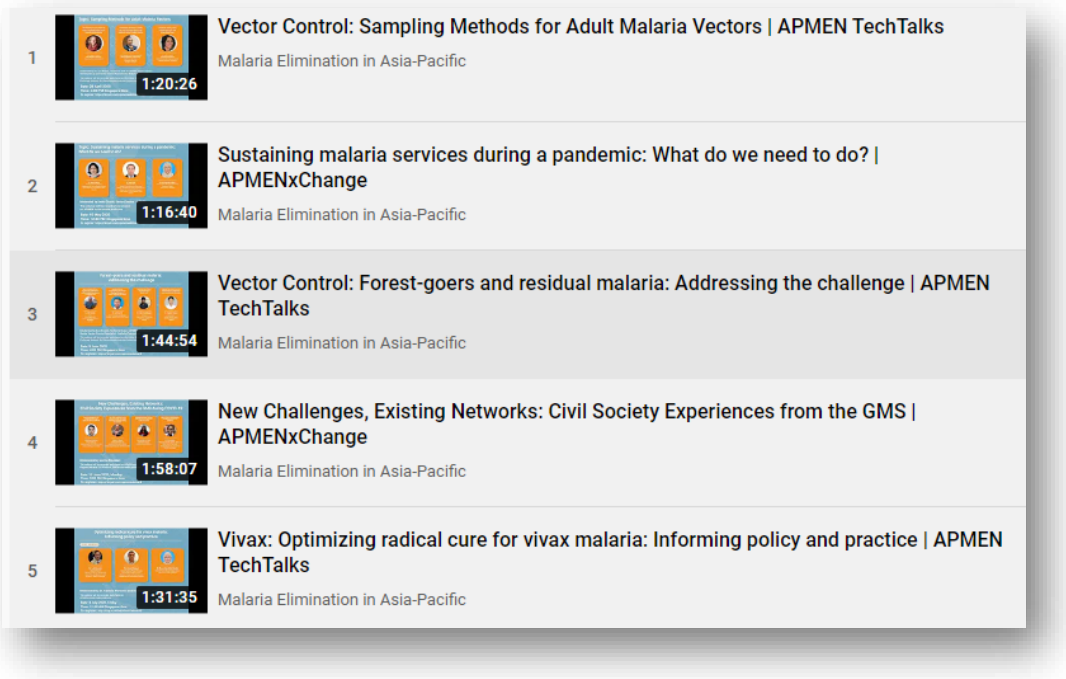
Discussion topic: Meta-analysis of the cost and cost-effectiveness of 3GIRS products in Ghana, Mali, Mozambique, and Uganda in areas with access to LLINs.

Online Event: Mitigating Africa's and Asia's Locust Infestation amid the Covid-19 Pandemic

29 April 2020

These are exceedingly difficult times for farmers in East Africa and South Asia. Amid the economic fallout of the Covid-19 pandemic, swarms of locusts numbering in the hundreds of billions are inundating the regions—the worst infestation of its kind in 25 years. In East Africa, the FAO believes the oncoming second wave of locusts "represents an unprecedented threat to food security and livelihoods because [the second wave] coincides with the beginning of the long rains and the planting season."

APMEN Webinars are available for those who missed them.



An online workshop, entitled: *'The impact of COVID-19 on global vector control efforts'* took place on **Wednesday 22 July**. This workshop aimed to establish the impact of COVID-19 on the current vector control situation in different settings. Speakers will identify gaps in our knowledge and data availability, assess funding and communication needs, and propose mitigation efforts. They also addressed how vector control operations might need to change to improve epidemic preparedness and prevent future outbreaks.

Chair: Dr Frederik Seelig, Partnerships Manager | The Global Vector Hub; LSHTM, UK

Speakers:

- **Professor James Logan,** Head of the Department of Disease Control, LSHTM, Founder and Director of ARCTEC
- **Dr Raman Velayudhan,** Unit Head, Veterinary Public Health, Vector Control and Environment unit (VVE), Department of Control of Neglected Tropical Diseases (UCN/NTD), World Health Organization (WHO). Geneva, Switzerland.
- **Dr Damaris Matoke-Muhia,** Senior research scientist, Kenya Medical Research Institute (KEMRI); Director of Capacity Building, Gender Mainstreaming, and Career Progression, Pan-African Mosquito Control Association (PAMCA), Kenya.
- **Dr Grayson Brown,** Executive Director, Puerto Rico Vector Control Unit; Puerto Rico.

Bayer webinar series

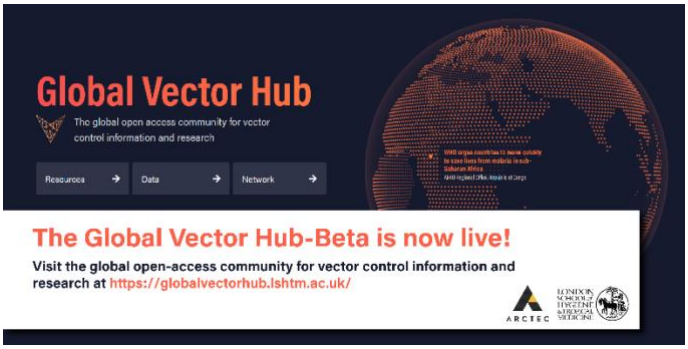
Dengue in times of a pandemic: fighting on two fronts

16 June 2020

A cluster randomized controlled trial to measure the impact of an integrated preventive vector control program on dengue incidence.

9 July 2020

The Global Vector Hub at LSHTM & ARCTEC decided to launch an early version of the GVH ('GVH-Beta') to address the critical need to continue to fight vector-borne diseases, share knowledge and provide information on how to protect communities, build capacity and manage health systems. This will be a pared-down version without the data and networking aspects of the full version, which will be launched subsequently. Instead, we will focus on resources on vector



control to assist in capacity building, and by providing comprehensive information packs for different groups of users (public health officials; vector control agents; researchers, general public) and diseases (malaria, Aedes-borne viral diseases, Chagas disease and Leishmaniases).

New tool developed to improve planning for entomological surveillance

In response to malaria program demand, the MEI and the University of Notre Dame led the development of an Entomological Surveillance Planning Tool (ESPT). The ESPT aligns with and aims to distil WHO guidance into an operational decision-support tool for national malaria programs to support cost effective, locally tailored, and evidence-based vector control. The ESPT has several use case scenarios: annual entomological surveillance planning, capacity gap analysis, training framework for entomological surveillance, field and laboratory data collection, integrated data analysis, program-oriented transmission investigations, and intervention evaluations. To support these applications, the ESPT provides a step-by step guide on what field and laboratory data are necessary to answer priority questions, when and how to integrate entomological data with epidemiological and human behavior data, as well as specific guidance on selecting the appropriate field sampling methods for addressing program questions appropriately and effectively.
Download the ESPT tool.
Download the two page overview.

SADC Malaria Elimination Eight Initiative ANNUAL REPORT 2019

2019 marked 10 years since the historic declaration in 2009 by Eight (8) Ministers of Health to establish the Malaria Elimination 8 regional initiative under the auspice of the Southern Africa Development Community (SADC). This report includes data over ten years on confirmed malaria cases in the eight countries as well as highlights and key issues facing the Initiative.

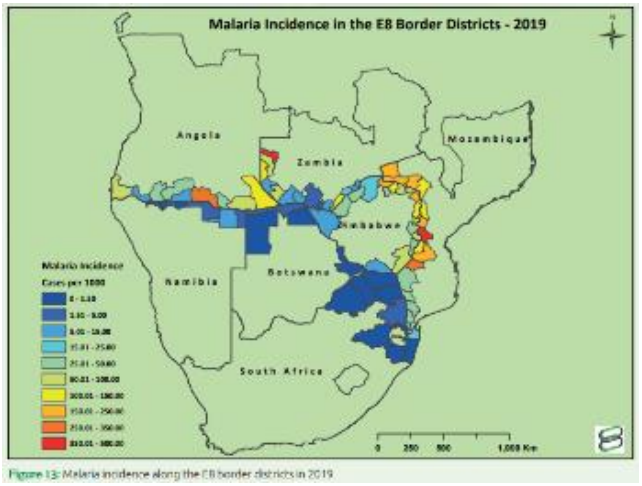
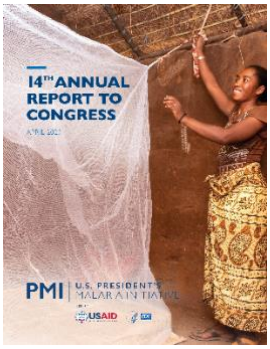


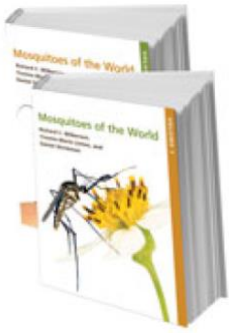
Figure 13: Malaria incidence along the E8 border districts in 2019

2020 PMI Fourteenth Annual Report

The U.S. President's Malaria Initiative's (PMI's) Fourteenth Annual Report to Congress describes the U.S. Government's leadership and technical and financial contributions to the fight against malaria in FY 2019. With PMI support, hundreds of millions of people have benefited from protective measures and have been diagnosed and treated for malaria. With national governments in the lead and in close collaboration with global and local partners, PMI has helped countries achieve and maintain substantial reductions in malaria cases while continuing to save more lives each year.



1st Quarter Net Mapping data is available here.



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Richard C. Wilkerson, Yvonne-Marie Linton, and Daniel Strickman

Biting multiple times on two, three, or more different hosts, it is no surprise that some species of mosquitoes have co-evolved with pathogens. For humans and other animals, the result has been some of the most challenging diseases known. It has been said that Anopheles gambiae, as the primary transmitter of malaria parasites to humans, is the most dangerous animal in the world. Certainly malaria has killed more people than all the wars that ever took place. Even now, despite drugs and mosquito control, malaria claims the lives of 405,000 per year. The vast majority of mosquito species are not involved in pathogen transmission to humans, but those that are make a huge impact on global health.

In this two-volume set, three of the world's leading experts on mosquito disease, ecology, and systematics offer readers unique insights into the fascinating world of mosquitoes while illustrating their diagnostic morphological features in detail. Comprehensively addressing the natural diversity of mosquitoes, the book explains their life histories, bionomic traits, and the physiological and physical adaptations they evolved in response to ever-changing environmental conditions. Mosquitoes are one of the best-known groups of insects, making this book a great starting place for anyone who would like to understand entomology by knowing the details about a representative family.

Ordering Information

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Daniel Strickman is a consultant for the Innovative Vector Control Consortium, recently retired from the Bill & Melinda Gates Foundation. He is a coauthor of *Prevention of Bug Bites, Stings, and Disease* and a coeditor of two editions of *Insect* Repellents Handbook. **Richard C. Wilkerson** is a research associate in the Dept. of Entomology at the Smithsonian Museum of Natural History. **Yvonne-Marie Linton** is the research director of the Walter Reed Biosystematics Unit for the US Army and curator for the Entomology Dept. of the Smithsonian Museum of Natural History, where she is responsible for the US National Mosquito Collection.

MESA Track: find out more about the platform and get involved

Watch the video here to learn more about the MESA Track online platform, an open and living database of malaria research. This user-friendly and open-access tool informs the malaria community about which questions are being addressed, which innovative strategies are being tested, and aids collaboration and information-sharing. Find out more about the MESA Track online platform and join the database of researchers, funders and institutions working to combat malaria!

Upcoming events of note

The Malaria Modeling Consortium Secretariat virtual Summer Lightning Talks. The Malaria Modeling Consortium Secretariat invites you to register for a virtual Summer Lightning Talks. The purpose of the virtual lightning talks is to build community engagement and provide an opportunity for exchange among the malaria modeling community while global travel restrictions are in place.

There will be two sessions held virtually via Zoom on the following dates:

Session 1: Thursday 27 August at 9:00AM PDT (UTC-7)

Session 2: Thursday 10 September at 6:00AM PDT (UTC-7)

Please rigister **here**.

Upcoming conferences and meetings.
The following meeting schedules are subject to COVID-19 related changes:

- ***Kigali Summit on Malaria & NTDs*** As a result of the ongoing Covid-19 pandemic, the organisers have decided it is necessary to postpone the 26th Commonwealth Heads of Government Meeting (CHOGM) scheduled to take place in Kigali, Rwanda on 22-27 June 2020. As a consequence, the Kigali Summit on Malaria and NTDs will not be held on 25 June 2020. The 26th CHOGM and associated events are currently planned to be held in Kigali at a time to be announced in due course.
- ***3rd BOVA Open Network Meeting/*** UN-Habitat IG-UTP symposium; 14-17 September 2020, Mohammed VI Polytechnic University, Benguerir, Morocco
- ***The 20th International Congress for Tropical Medicine and Malaria (ICTMM)***
Has been postponed from Sep 2020 to August 2021, Bangkok, Thailand
- The 69th American Society of Tropical Medicine and Hygiene (ASTMH) Annual Meeting
Will now be a virtual meeting November 15 - 19
- Note that the ***7th Pan - African Mosquito Control Association (PAMCA) Annual Conference*** was postponed until a date in 2021
- ***The 87th American Mosquito Control Association Annual Meeting***; March 1-5, 2021, Salt Lake City, Utah, U.S.
The AMCA Annual Meeting is an excellent education and networking event for researchers, educators, vector control professionals, industry representatives, and students in mosquito control. Every year since 1935, hundreds gather to hear the latest research, share ideas, and form collaborations. An educational sessions and exhibit hall help to put attendees on the cutting-edge of this ever-expanding field.

A special issue of the Journal Insects in tribute to Professor William (Bill) Black

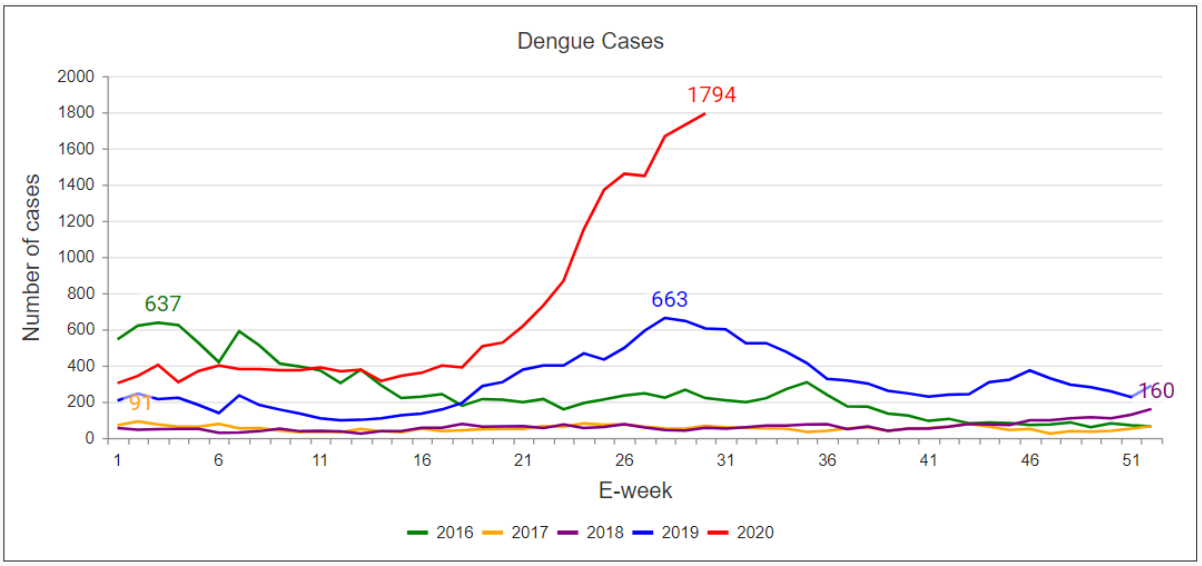
In honor of our respected colleague, Bill Black, a special collection has been organized through the Journal, *Insects*. Bill has significantly impacted the field of medical entomology over the years through his extensive research on ticks and mosquitoes, as well as his dedication to teaching and mentoring. Click here for a complete description of the collection and scope of articles sought. The deadline for submission is Dec 31, 2020.
Questions or ideas regarding a potential submission can be directed to Rebekah C. Kading, PhD at Rebekah.Kading@colostate.edu

In the news and social media

Worst dengue outbreak in Singapore's history

In response to the worst dengue outbreak in Singapore's history, plans are underway to carry out ***two-week intensive island-wide vector control exercise to combat dengue outbreak***

1,794 dengue cases were reported in the week ending 25 July 2020. This is 63 cases more than that in the previous week. This figure is the highest number of weekly dengue cases ever recorded in Singapore, and is more than double the record high of 891 cases in 2014.This is the seventh consecutive week in which the weekly number of reported dengue cases has exceeded 1,000. The cumulative number of dengue cases for this year (as of 27 July 2020) stands at more than 20,600. See more at the ***Singapore National Environment Agency website***

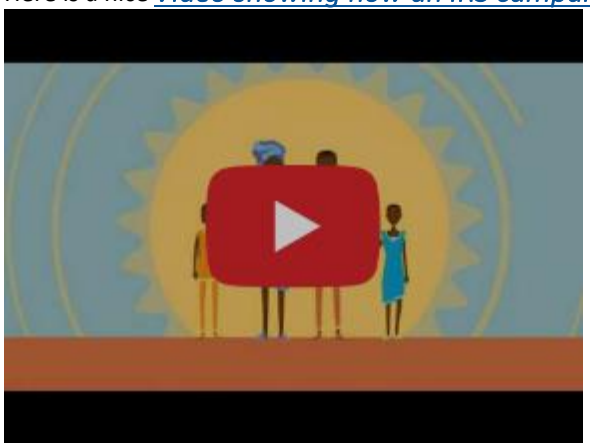


EPA Approves Experimental Use Permit to Test Innovative Biopesticide Tool to Better Protect Public Health

For Release: May 1, 2020

The U.S. Environmental Protection Agency (EPA) has granted an experimental use permit (EUP) to Oxitec Ltd. to field test the use of genetically engineered Aedes aegypti mosquitoes as a way to reduce mosquito populations to protect public health from mosquito-borne illnesses. Oxitec's carefully developed field tests will be conducted, if approved by state and local authorities, over a two-year period in Monroe County, Florida, beginning in summer 2020, and in Harris County, Texas, beginning in 2021.

Here is a nice *Video showing how an IRS campaign works*



How SC Johnson Works to Enable Better Lives at the Base of the Pyramid

At SC Johnson, we have long been committed to making life better for families around the world. Since 1937, we've given 5% of all pretax profits to charities. Twenty years ago, we set out to do even more to help some of the world's most vulnerable populations

Malawi eliminates lymphatic filariasis

14 April 2020

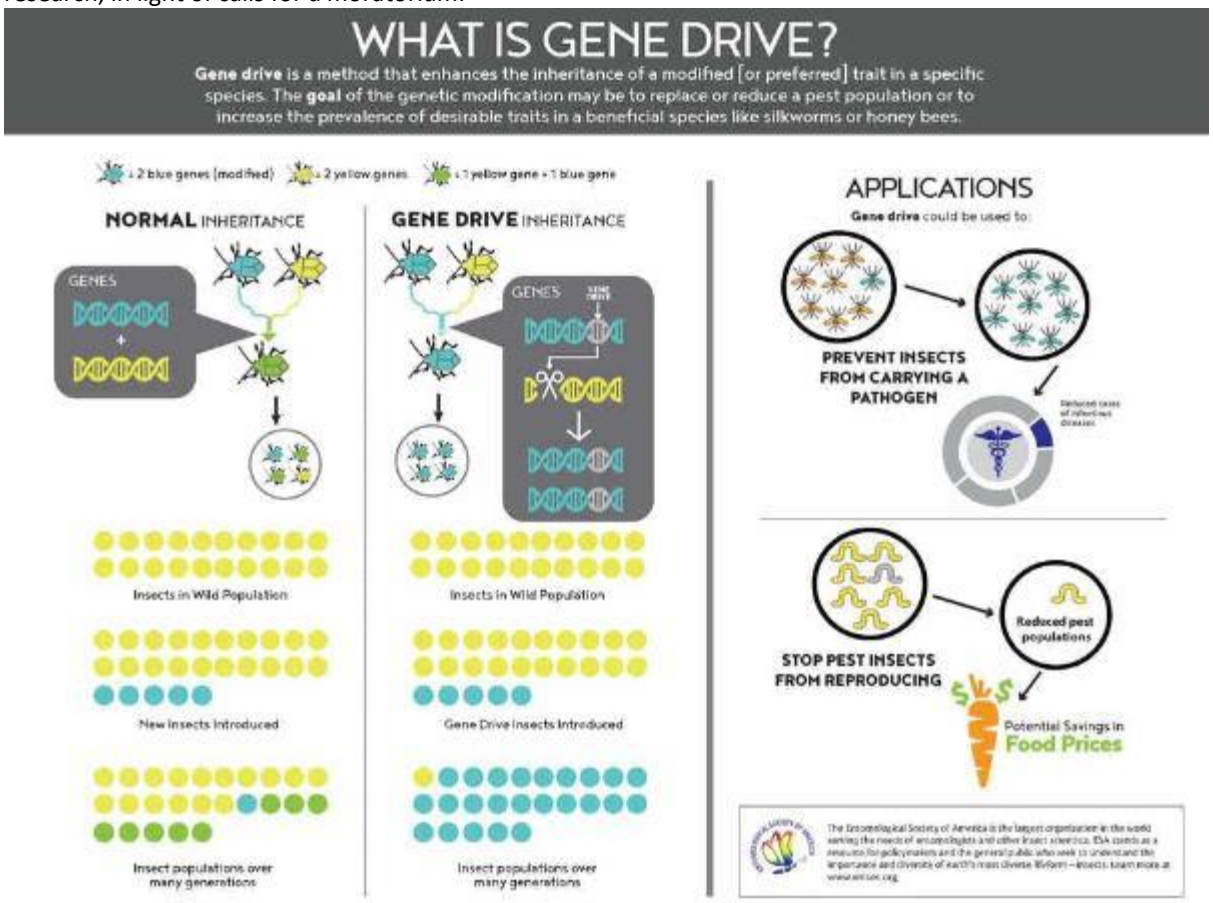
The World Health Organization has declared that Malawi has eliminated lymphatic filariasis as a public health problem with the help of LSTM's Centre for Neglected Tropical Diseases, which has

worked with Malawi's Ministry of Health for more than a decade.

An argument for gene drive technology to genetically control insects like mosquitoes and locusts

The Conversation 14 July 2020

This is a nice lay persons explanation of gene drive and the authors advocate for continuing gene drive research, in light of calls for a moratorium.



How a vaccine made of mosquito spit could help stop the next epidemic

Reuters WORLD NEWS 11 June 2020

Note this issue covers the period from 1 April through 15 July 2020.

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