Malaria Centre 2020–22

LONDON SCHOOL of HYGIENE &TROPICAL MEDICINE

Contents

Foreword

Together with the wider malaria community, we find ourselves at a critical juncture.

The steady reduction in malaria cases and deaths has stalled, and even reversed in some countries, owing to drug and insecticide resistance, expanding transmission areas, and long-lasting impacts of the COVID-19 pandemic. Unprecedented funding challenges have also emerged very close to home, leading to the cancellation of vital malaria projects and jeopardising future funding streams.

Thankfully, the last two years have also seen the development of new and effective tools against both the parasite and its vector: the WHO made its first recommendation for a malaria vaccine, the culmination of thirty years of work from thousands of members of the malaria community, including many at the Malaria Centre, a large trial showed that bed nets with a new class of insecticide were more efficacious than standard bed nets in an area with pyrethroid-resistant vectors, and despite the pandemic, malaria workers in endemic countries worked tirelessly to ensure interventions continued as planned across many sub-Saharan African countries.

Whilst there is much to celebrate, there is still so much more to do. The malaria research community must unite and mobilise to not only deploy all the tools we have at our disposal, but also develop innovative approaches in the wake of the COVID-19 pandemic.

The pandemic had a profound impact on our social interactions, and as we look to the future, rebuilding the sense of community within the Centre is one of our key priorities to ensure that together we continue to foster interdisciplinary collaborations and encourage blue sky thinking. We held our first ever hybrid retreat in September 2021, which facilitated virtual attendance from members abroad for the first time. This was an inaugural step towards more inclusive and accessible activities organised by the Centre.

This brochure gives a snapshot of the work that members are involved in, highlighting our rich expertise on the malaria parasites, their vectors, the human response to infection and the influence of the environment on disease transmission. It also highlights the key teaching activities undertaken by Centre members and the huge contributions we have made to help shape WHO policies going forward. None of this work would be possible without our collaborators from across the globe (listed on page 45–46), with whom we hope to continue these productive partnerships.

Together we have achieved so much, despite the shifting sands of the last couple of years. Now more than ever, we need to continue our efforts through teamwork, ingenuity and by fostering the new generation of malaria scientists to bring fresh energy and zeal in the fight against malaria.

Dr Jackie Cook
Associate Professor of Malaria Epidemiology & Co-director of the Malaria Centre

Dr Sam Wassmer
Associate Professor of Malaria Pathogenesis & Co-director of the Malaria Centre

Director statement

In the face of a disease which still kills over half a million people each year and impacts the most vulnerable, LSHTM's Malaria Centre plays a vital role in our mission to improve health and health equity worldwide.

Professor Liam Smeeth
LSHTM Director

LSHTM researchers are continually seeking novel approaches to reduce cases and deaths: recent trials demonstrated how smart interventions, and seasonal vaccination and preventative drug combinations, can reduce malaria incidence, whilst a new insecticide for use on nets could save many young lives. Through continued close collaboration with our global partners, we have a serious chance of ridding the world of malaria within the next generation.

LSHTM Malaria Centre 2020–22

Steering committee

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Communications Officer

Access full profiles:

Our story

We're the Malaria Centre at The London School of Hygiene and Tropical Medicine. Founded in 1998, we're a global network of over 350 researchers, postgraduate students and support staff working together in 40 countries around the world.

The story of malaria is still being written. The constant battle between people and this persistent disease features throughout so much of human history – sometimes we've had the upper hand, and sometimes not. While important achievements have been made over the past 30 years and the global burden has been dramatically reduced, evidence shows us that we're losing ground and these hard-won gains are now under threat. Malaria continues to prevail, too many lives are still being impacted and too many lives are still being lost. It's a disease with complex levels and layers, with many factors contributing to its ever-changing and rapid evolution including human behaviour, economic, social and political upheaval, the effects of poverty, drug-resistant pathogens, the role of the vector, disrupted environments and climate change.

Humanity has made great progress over the years, saving and improving many lives, eliminating malaria in dozens of countries, making powerful breakthroughs, and finding new ways to work together for greater effect. But we know if we take our foot off the accelerator, even for a moment, malaria comes surging back. The effect of the global pandemic is a prime example, showing us just how quickly progress can be reversed. At the Malaria Centre, we know that now is the time to dig deeper and push harder than ever before. That's why we've dedicated our work and ourselves to the acceleration of progress in the fight against malaria. As an international teaching and research institute, our members work across education and research, informing policy change and translating new knowledge into tools and technologies that drive us forward. We do what we do at the Malaria Centre because ultimately, we believe human ingenuity and adaptability will help us get ahead of malaria.

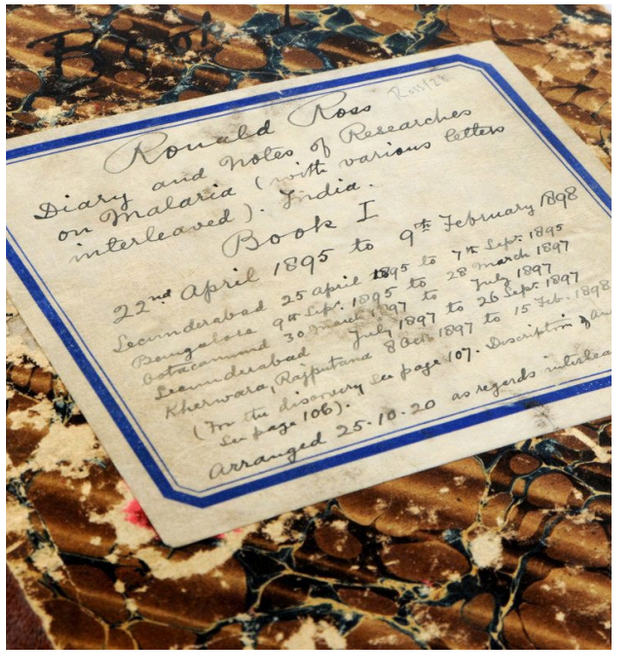
Our work is driven by three key principles:

1. Powered by a rich mix of expertise

If we're going to be adaptable enough to get ahead of malaria, we know we'll need the powerful creativity that only comes from interdisciplinary and multidisciplinary ways of working. To spark new ideas, leap ahead and out-manoeuvre this complex disease we'll need more minds, more perspectives, more lived experience and more people working on different aspects of the challenge. Getting ahead of malaria demands many angles of attack and the richest mix of expertise. And we need to keep growing that mix by training the next generation of malaria researchers and collaborators to bring fresh energy and zeal to drive us forward in the fight against the disease.

2. Driven to connect and inspire change

To accelerate progress in the fight against malaria we need to make even more of our growing, global network of colleagues and collaborators. New ideas can come from anyone and anywhere, that's why we're committed to being a pivotal connector and an open partner, committed to inspire change. That means reaching out further and finding new and better ways of working with one another, wherever we are in the world. It means learning from lived experience to break down barriers. It means listening, responding and challenging power dynamics to promote equity and equality across the malaria research community.



3. Building on a journey of 125 years

We're not starting from a blank page at the Malaria Centre. We're fortunate to have very tall shoulders to stand on that help us see further than ever before. In everything we do we leverage the solid foundations of LSHTM's 125-year journey of discovery to launch us forward to deeper understanding, better insight, further breakthroughs and accelerated progress.

Statistics

Over 650 publications between 2020 & 2022

650

Over 350 members

350

We have received nearly £85 million of funding for our work between 2020 & 2022

85

We receive support from over 40 different funders

40

Research areas

Epidemiology

Health economics · Global health · Statistics

Immunology

Entomology

Clinical trials

Drug discovery & development
Molecular biology · Pharmacology · Virology
Complex interventions · Disease surveillance
Diagnostics · Vector control · Social sciences

Disease control

Vaccinology · Health promotion · Child health

Parasitology

Projects & collaborations by region:

Teaching

"The lectures cover a really interesting range of topics, and the lecturers are all experts in their fields, so they were fantastic to talk to."

Control of Infectious Disease MSc student, 2020

Face to face

At LSHTM, we have a malaria-specific face-to-face module, 'Malaria, from science to policy and practice', which covers topics including disease transmission and epidemiology, tools for control and threats to efficacy, measuring impact, malaria in pregnancy, vaccines and health economics. The module has been running for more than 30 years and includes inputs from approximately 50 staff members. Each year around 40 students take the course as part of a variety of MScs including Medical Parasitology, Tropical Medicine and International Health, and Public Health. Many students come from a medical background, whilst some are working for non-governmental organisations in low- and middle-income countries, where the disease is endemic. Our students go on to a range of careers after taking the module, including working in National Malaria Control Programmes, the World Health Organization and the United Nations.

Distance Learning

We also provide distance learning teaching through the module titled 'Malaria', ran in collaboration with University of London Worldwide. Aimed at health professionals and scientists intending to gain a broader understanding of malaria, the module covers broad aspects of the disease, including prevention and treatment, biology of malaria parasites and their mosquito vectors, pathogenesis of severe disease, as well as intervention and control approaches. On average 85 international students take the module each year, with around 30% based in malaria-endemic countries.

Q&A with Claire Rogers
Principal Biomedical Scientist and Head of the Teaching and Diagnostic Unit at LSHTM. Claire has worked at LSHTM for 38 years.

What role do you play in the malaria teaching at LSHTM?

I teach diagnostic parasitology, i.e., how to recognise parasites in blood, faeces, tissue, and other clinical specimens. This ranges from teaching students to identify the presence of malaria parasites in a blood film to healthcare professionals and visiting clinical haematology, microbiology, and infectious disease departments.

Tell us about your students

I teach lots of students! Around 450 every year. Several of our MSc students are still here in the Faculty, either working as Research Assistants, Scientific Officers or undertaking a PhD. Every year we also offer the MSc students the opportunity to become Student Demonstrators to work alongside the team during practicals. As well as developing their own diagnostic parasitology skills further, they are ideally placed to draw on their recent experience as a student and provide reassurance and advice to the new cohort.

What's your favourite part of your job?

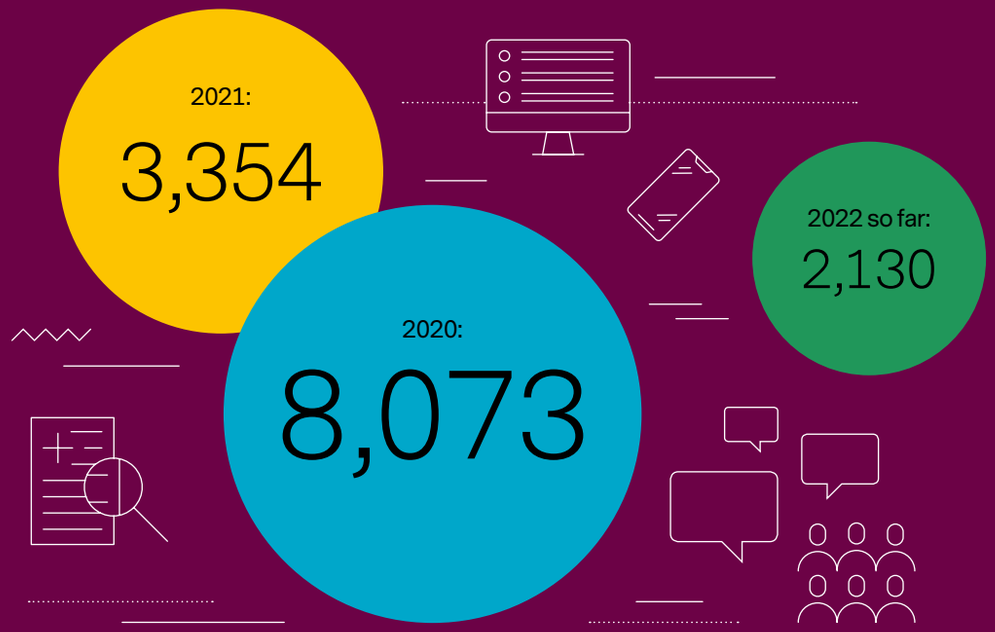
"Seeing students arrive in the lab for the first time, unsure of how to use the equipment, then seeing them at the end of the course, able to make a confident differential diagnosis of parasites and admitting how much, often to their surprise, they have enjoyed the practicals!"


LSHTM Malaria Centre 2020–22

Public engagement

Our Centre members provide independent and expert advice to policymakers, media, and stakeholders around the world. With the many scientific developments of the past two years, we have been very busy giving comment and feedback on policy and innovation.

The number of times our work was mentioned in broadcast media, spanning online and print:



And our comments were translated into 24 different languages:

- Afrikaans
- Arabic
- Catalonian
- Chinese
- Danish
- Dutch
- Flemish
- Finnish
- French
- German
- Greek
- Hindi
- Indonesian
- Italian
- Korean
- Malay
- Norwegian
- Polish
- Portuguese
- Spanish
- Swedish
- Tagalog
- Thai
- Vietnamese

2020

Our highlights in 2020 include sniffer dogs using their expert snouts to detect COVID-19 after earning their stripes smelling malaria on socks collected from young children in The Gambia; Centre experts dispelling misinformation when hydroxychloroquine was badged as a cure for COVID-19 by the then American president; the report that *Anopheles stephensi* – an invasive mosquito vector – had reached the shores of Africa; previous Centre Director, Prof Chris Whitty, gracing our screens each night to provide calm and concise updates on the pandemic in the UK; and of course the collective effort of our community to keep malaria on the agenda when the lens of global health was firmly trained elsewhere.

2021

2021 was all about vaccines with the advent of the COVID-19 vaccines and the first malaria vaccine RTS,S, hailed as 'a historic moment' in the fight against the disease, alongside the first signs that the lockdown had contributed to a spike in malaria cases and deaths globally; COP26 in Glasgow saw our experts successfully introduce health, specifically vector-borne disease, to the climate change agenda; some of our members played a role in declaring China malaria-free; and an analysis of James Bond's exposure to infectious agents showed he has a wilful ignorance of pathogen transmission. We featured across podcasts, live news channels, and within print and online media.

2022

2022 brought fresh innovations but also new challenges as UK research was stripped of EU funding; we explained the difference between pandemic and endemic as the terms were bandied around UK press; a report was published into our institution's colonial heritage and our members commented on what that means for malaria research today; two bed net studies from Tanzania were received with excitement by global media; and we featured in a World Malaria Day campaign alongside David Beckham. We were also interviewed in labs, in the field and at conferences.

Some of the many media outlets we feature in:

All Africa
Al Jazeera
Associated Press
BBC World Service
Daily Mail
Deutsche Welle
Financial Times
Forbes
La Libre Belgique
The Guardian
The Economist
The East African
The Washington Post
The Times

Collaboration with centres

The Malaria Centre sits within a network of Centres at LSHTM which have many cross-cutting and overlapping themes.

Over the past couple of years, we held events spanning multi-disease approaches to maternal and child health, discussed malaria vaccines, and looked at the impact of climate change on vector-borne disease. There has also been Twitter chats, collaboration on COVID-19 interventions and mini symposiums.

Intermittent Preventive Treatment of malaria in infants (IPTi) project

Researchers from different disciplines across the Malaria Centre, led by the previous co-Directors, collaborated with two Centres, MARCH Centre and the Centre for Evaluation, in a Unitaid-funded project known as 'Intermittent Preventive Treatment in infants – Plus' (IPTI+). This work is a collaboration between Population Services International (PSI) and LSHTM, working directly with the Ministries of Health in Benin, Cameroon, Côte d'Ivoire, and Mozambique.

IPTi with sulfadoxine-pyrimethamine (SP) is a safe, affordable, and effective intervention shown to reduce rates of malaria and anaemia in children under one year of age by 30% and 21% respectively. The World Health Organization (WHO) recommended IPTi for use in 2010, yet the intervention has not been widely adopted in Africa, and only implemented in Sierra Leone to date.

LSHTM will be generating evidence to inform country and global-level adoption and scale-up of IPTi+, evaluating the impact, process, and cost-effectiveness. The overall aim is to reach more children, more frequently, in their first year of life.

Our collaborations include:

VaC

cmmid centre *for* mathematical modelling *of* infectious diseases

MARCH MATERNAL ADOLESCENT REPRODUCTIVE & CHILD HEALTH

Climate Change & Planetary Health

Facilities

Malaria Reference Laboratory

The UK Health Security Agency (UKHSA) Malaria Reference Laboratory (MRL) is the national reference centre for malaria diagnosis in the UK and provides specialist diagnostics on malaria for NHS laboratories throughout the country. It is also the national centre for epidemiological monitoring and surveillance of malaria, conducts applied research relevant to UK malaria patients, and is an advisory service for complex questions on malaria.

The MRL is contracted by UKHSA to provide a comprehensive reference diagnostic service for malaria parasitology, checking the diagnosis on all suspected malaria blood films and assessing parasites for drug resistance-associated genes.

Current active applied research activities include monitoring of *hrp2* deletion mutants in UK *P. falciparum* infections, genetic analysis of recrudescent parasite isolates and genomic studies of non-falciparum malaria.

Malaria Transmission Facility

One important, but understudied, part of the malaria lifecycle is the development of the parasite in the mosquito. To promote the study of these stages of the parasites' lifecycle, in 2022 LSHTM established a transmission facility where human malaria parasites can be transmitted to mosquitoes.

This facility is open to all members of the wider malaria community, enabling research into compounds and vaccines that can block transmission, parasite genes essential for transmission, and parasite-mosquito interactions.

Email: malariatransmission@lshtm.ac.uk

Malaria research at MRC Unit The Gambia at LSHTM

Across the sites we have 3 insectaries, a molecular lab, a parasitology lab, and genomic and serology platforms.

These high-spec facilities enable scientists to process large numbers of malaria samples for diagnostic, monitoring and research purposes.

Staff: 88 people work on malaria including PhDs and postdocs.

Teaching: There is in-house teaching module for malaria microscopy run by a senior, WHO-accredited microscopist, training the next generation of malaria scientists.

The goal of the Malaria Research Program in The Gambia is to contribute to the 2030 malaria elimination goal in West Africa through the delivery of innovative research, and the strengthening of local capacities. There are four research groups working in fields that aim to understand different aspects of the complex interactions between the parasite, mosquito, human and the environment.

The four groups and their main objectives are:

i) Malaria parasitology and population biology: to strengthen *P. falciparum* genomic surveillance and monitor anti-malarial drug resistance in West Africa;

ii) Vector biology: to design and evaluate the efficacy of new vector control strategies and to monitor insecticide resistance;

iii) Malaria epidemiology: to understand the micro-epidemiology of malaria in different ecological settings and identify the main factors contributing to residual transmission;

iv) Social science and climate change: i) to strengthen social science research to optimise the effectiveness of existing and new malaria control interventions; ii) To understand the impact of climate change on malaria risks in West Africa .

The four groups closely collaborate with each other to ensure the successful implementation of different projects and to optimise research outputs. Some of the current projects include:

***Plasmodium falciparum* infection dynamics and transmission to inform elimination (INDIE 1b)**

This trial explores whether interventions targeting the human reservoir of infections, namely weekly fever screening and treatment, monthly malaria screening and treatment, or mass drug administration would reduce malaria transmission in medium to low transmission settings. The study examines the natural dynamics of malaria infections, their infectivity to mosquitoes and transmission networks in the Upper River Region in The Gambia. As part of the study, a method has been developed to maintain *P. falciparum* gametocyte infectivity during blood collection in the field to use in experiments following transportation to the insectary for mosquito feeding assays.

Novel antimalaria combination vaccine (VAC086)

A study at the Unit is implementing a Phase 1bmulti-stage *Plasmodium falciparum* malaria vaccine study to assess the safety and immunogenicity of the blood-stage vaccine candidate RH5.2 virus-like particle (VLP) in Matrix-M™ and the pre-erythrocytic stage vaccine candidate R21 in Matrix-M™, both alone and in combination, in adults and infants. Sensitisation and training activities will be conducted at the end of 2022, while enrolment is planned to start in January 2023.

Interactions between genetically diverse human populations and malaria parasites in Africa (PAMGEN)

The MRCG at LSHTM coordinates this consortium across seven countries (The Gambia, Ghana, Mali, Cameroon, Ethiopia, Tanzania, and Madagascar) to determine genetic diversity of red blood cell receptors and outcomes of malaria parasite infections. The project will sequence 400 human genomes and 7,000 *Plasmodium spp* genomes in collaboration with the MalariaGEN program at the Wellcome Sanger Institute.

Using medical-detection dogs to identify people with malaria parasites (MDD2)

This study investigates whether medical-detection dogs can be trained to detect asymptomatic malaria infections in individuals. This has been done by collecting odour samples and microbiome swabs from 35 malaria positive and 35 malaria negative individuals in June-August 2021 in the Upper River Region (Basse). Samples were shipped to UK where they will be used to train medical detection dogs.

Investigating Malaria -COVID-19 interactions in The Gambia (MALCOVID):

This study will use a multiplex serological platform to investigate the malaria-COVID-19 interactions in different regions of The Gambia. This will be done by analysing dried blood on filter paper collected within different studies across the country to identify antibodies against *P. falciparum* and SARS-CoV-2 and explore possible interactions between the two diseases.

Parasite

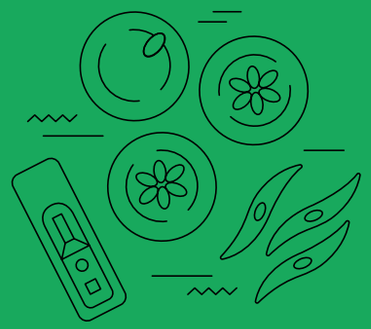
Plasmodium falciparum histidine-rich protein 2 and 3 deletions: mechanism, impact, and consequences

Many malaria Rapid Diagnostic Tests (mRDTs) are based on the detection of the HRP2 protein in the malaria parasite. *Plasmodium falciparum* with histidine-rich protein gene *(hrp2/3)* deletions have emerged globally which has significant implications for the sensitivity of malaria RDTs. The deletions also affect the genomic structure of the parasites, which may impact parasite fitness and onward transmission.

Collaborative LSHTM research helped develop an effective molecular tool to detect *hrp2/3* deletions in malaria parasites and conducted surveillance to identify the presence of parasites with these deletions in Somalia, Kenya, Tanzania, Yemen, Nigeria and other African countries, as well as in UK travellers.

Using the new tool, *hrp2/3*-deleted parasites were identified in several African countries and the tool has been supporting WHO-sponsored surveillance efforts. *hrp2/3*-deleted *P. falciparum* clinical isolates have successfully been culture-adapted, which helps understand the consequences of deletions and facilitates generation of high-quality genomic data. Thus far, more than 200 genes deleted together with *hrp2/3* have been identified.

These findings contributed to the implementation of country-wide systematic surveillance of *hrp2/3* deletions in malaria parasites in several African countries, providing vital information for malaria diagnostic policy.



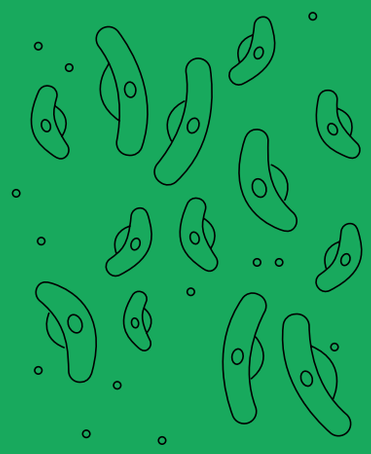
Single dose Tafenoquine to stop human-to-mosquito transmission

Standard antimalarial therapies are effective at killing disease-causing blood stage malaria parasites, but have limited impact on gametocytes, the stages transmitted from humans to mosquitoes. A single low dose of a drug like primaquine can entirely stop transmission, but primaquine is only active for a matter of hours. Tafenoquine (TQ) has a far longer half-life, yet its efficacy as a transmission blocker for *P. falciparum* in humans had never been tested.

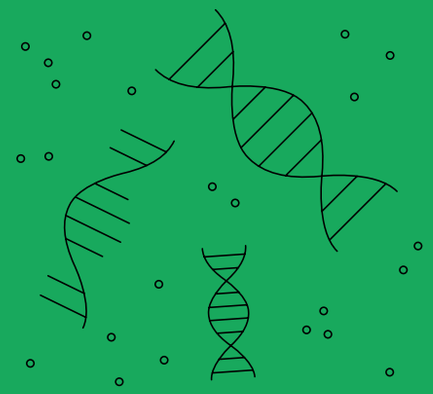
Together with collaborators, LSHTM teams conducted a clinical trial in Ouelessebougou, Mali, to test the transmission blocking activity of TQ, in combination with standard artemisinin combination therapy (ACT). Transmission was assessed using direct membrane feeding assays, in which blood from the malaria positive recruits was provided to mosquitoes in a heated glass apparatus.

Malaria transmission stopped more rapidly in all TQ treatment groups compared to the ACT only control. In the highest TQ dose group, transmission completely stopped between 3-7 days post-treatment, whereas in the ACT-only group, transmission was observed until the end of measurements at day 14. Subsequent trials demonstrated the transmission reducing effect occurs at 3-5 days post treatment.

These results indicate that single low doses of TQ are effective in reducing transmission of *P. falciparum* in humans; future trials must demonstrate whether this effect is long lasting.



Monitoring markers of antimalarial resistance using genomic surveillance



Malaria parasites have developed resistance to artemisinin combination therapies in Southeast Asia- with signs that this is now also occurring across Africa. This project identifies genomic DNA and RNA markers of antimalarial resistance, which are used to develop genomic surveillance panels for African malaria parasite populations.

This vital research, taking place in The Gambia, Senegal, Ghana, and Nigeria, has built capacity for and is generating data on *in vitro* antimalarial susceptibility testing of malaria parasites across these countries. Tested parasite isolate genomes and transcriptomes are then generated to determine genetic variants and pathways modulating differences in response to antimalarial drugs.

Comparable and reproducible *in vitro* antimalarial sensitivity test results are now possible from Ghana, The Gambia, and Nigeria, while Senegal is developing the infrastructure for testing. Pilot genome-wide association analysis revealed multi-linked genomic interactions that correlate with *in vitro* drug responses. These markers are being surveyed in natural populations, with over 1000 genomes of *P. falciparum* from Nigeria already analysed.

This project enables comparable assessment of antimalarial susceptibility and molecular surveillance between regional laboratories, improving the monitoring of current antimalarial drugs across Africa.

Shapeshifters - Adaptive variation in malaria parasites

Understanding how pathogens survive and reproduce in different environments should guide implementation of available control methods and help elimination strategies. This is particularly important for the natural variation in asexual and sexual replication rates of malaria parasites, which affect how easily the disease is transmitted.

Together with collaborators, LSHTM teams investigated the multiplication rate variation for parasites from different endemic populations. *P. falciparum* parasites also exhibit naturally occurring switch rates to sexual differentiation per asexual cycle. Both were monitored to identify the determinants for clinical isolates as well as laboratory-adapted clones.

Asexual multiplication rates of different isolates varied between 2 and 8-fold per 48-hour cycle in exponential growth assays, sexual switching rates per cycle from the same population varied between 3 – 12% per cycle. These results indicate that parasites adapt to changes in environment by regulating multiplication rate which impacts spread of disease. Understanding the environmental cues for these changes could help shape future malaria control.

Scan here to access the publications:

Mosquito

No flight, no bite – ‘Mosquito grounding’ bed net nearly halves malaria infection in Tanzania children

Long-lasting insecticidal nets are the cornerstone of malaria control in sub-Saharan Africa. However, the recent resurgence in malaria is partly due to the bed nets’ effectiveness being compromised by widespread resistance to pyrethroid insecticides in Anopheline mosquitoes. Chlorfenapyr, a different class of insecticide, works very differently to pyrethroids, causing wing muscle cramps that stop the flight muscles from functioning.

To generate evidence for the effectiveness of chlorfenapyr nets (and two other next-generation nets), a large cluster randomised trial took place in Misungwi, Tanzania.

After 24 months, malaria infection was reduced by 37% in children that received the chlorfenapyr net compared to those receiving standard pyrethroid net. The trial showed that chlorfenapyr nets were safe, decreased malaria infection and cases in children, and were cost-effective.

This trial generated vital evidence for the WHO and malaria control programmes to help guide decisions regarding which type of nets to distribute when mosquitoes are resistant to pyrethroids.

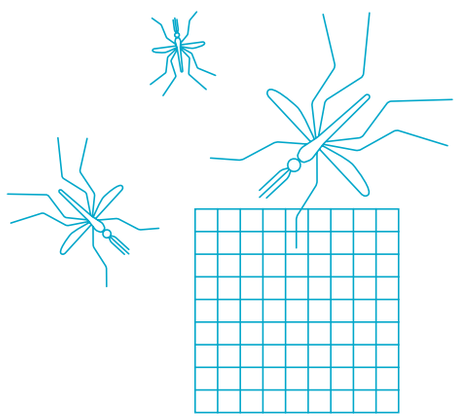
New insecticide for indoor residual spraying (IRS) tested in southern Benin

Indoor residual spraying (IRS) has contributed to recent reductions in malaria. However, its impact is threatened by the development of insecticide resistance in malaria vectors. VECTRON T500™, a new broflanilide IRS product, has shown potential to provide improved and prolonged control of pyrethroid resistant malaria vector populations. The prolonged activity of VECTRON T500™ could also have positive implications on the cost-effectiveness of IRS when applied in communities.

In Benin, VECTRON T500™ was compared to a WHO prequalified IRS product to see whether it’s impact on malaria transmission was similar. Approximately 11,000 households in 16 villages enrolled in the study received IRS with VECTRON T500™ or a WHO prequalified product. The IRS application was performed in May 2021 and the impact on malaria transmission is being evaluated over 12-18 months post-intervention.

So far VECTRON T500™ has shown prolonged residual efficacy lasting over 18 months in Benin. Results on its impact on entomological indices of malaria transmission (vector density, entomological inoculation rate, species composition, insecticide resistance) in village communities will be available at the end of 2022.

VECTRON T500™ shows potential to provide substantial control of malaria transmitted by pyrethroid resistant mosquito vectors when applied as indoor residual spraying and its long-lasting efficacy will likely make it a cost-effective alternative to currently recommended IRS insecticides.



Monitoring for the presence of invasive mosquito species

The invasion of *An. stephensi* mosquitoes in the Horn of Africa represents a significant threat which may jeopardise malaria control, particularly in urban areas that were formerly malaria-free. Novel vector surveillance methods are urgently needed, which are quick and easy to implement.

The use of environmental DNA (eDNA) for simultaneous detection of mosquito species, *An. stephensi* and *Ae. aegypti*, in artificial breeding sites and detection of insecticide resistance genes of the two species was validated, using 50ml and 1L containers.

The study demonstrates *An. stephensi* and *Ae. aegypti* eDNA deposited by a single larva was detectable under lab conditions. Characterization of molecular insecticide resistance mechanisms, using genomic sequencing was also possible from eDNA. *An. stephensi* eDNA was remarkably stable, and detectable almost two weeks later.

eDNA surveillance could be implemented in local endemic communities as part of citizen science initiatives, and in cargo ports at points of country entry, to monitor the spread of invasive malaria vector species.

Does my skin microbiome explain why I get bitten by mosquitoes?

Some people get bitten more often by mosquitoes than others and are therefore at increased risk of contracting deadly vector borne diseases like malaria. There are natural differences in human body odour between people who are highly- and poorly-attractive to mosquitoes. This study investigated if this differential attractiveness is associated with differences in skin microbiome composition (the mix of microorganisms, such as bacteria, fungi and viruses that live on the skin).

Two cohorts of 100 twin pairs in the UK and The Gambia were recruited. Skin microbiome, body odour and socks (for behavioural testing with mosquitoes) were collected and tested for participants attractiveness to mosquitoes. Using genetic sequencing, samples were tested to look for differences in the skin microbiome composition between the twins.

In the UK cohort, differences were found in skin microbiome composition between highly- and poorly-attractive groups, with 10 differing bacterial sequences identified between the groups. The trial then investigated differences in metabolic pathways and the role of compounds in these pathways in attractiveness to mosquitoes. Work is ongoing for the Gambia cohort.

In the future, products using specific microbial compounds could be used to improve current odour-based technology or to develop next generation vector control tools.

Mass drug administration (MDA) with Ivermectin: a promising tool for malaria elimination

Progress in malaria control has stalled. To reverse this trend, novel and innovative interventions are needed. This cluster-randomised trial assessed the combined effect of mass drug administration (MDA) with two drugs (ivermectin and dihydroartemisinin–piperaquine) on malaria transmission and malaria vector survival. Ivermectin acts by killing mosquitoes who feed on people who have taken the drug, whilst dihydroartemisnin-piperaquine kills the parasites within the human.

The intervention group (16 villages) received three monthly rounds of MDA, and significantly reduced malaria prevalence and incidence compared to the control group (16 villages). Although there was no difference observed on vector survival, the intervention resulted in significantly lower vector density and the mosquito killing effect of ivermectin at individual level was evident up to 21 days post-treatment.

Ivermectin could represent an additional tool for malaria control to further reduce malaria transmission in combination with other interventions. Another LSHTM collaborative project is ongoing in the Bijagós archipelago comparing MDA using dihydroartemisinin-piperquine, with and without the addition of Ivermectin. This will help elucidate the added benefit of the Ivermectin.

Scan here to access the publications:

Human

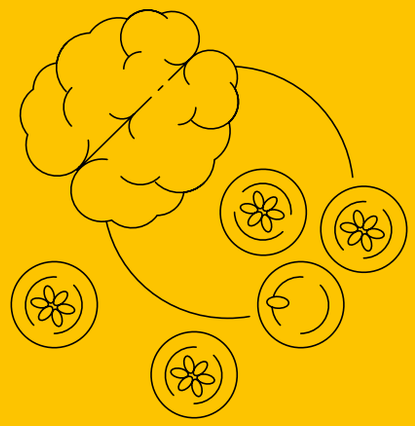
Combining a malaria vaccine with Seasonal Malaria Chemoprevention reduces child hospitalisations and deaths from malaria by at least 60% compared to either intervention alone

Giving young children the world's first malaria vaccine RTS,S/AS01E and antimalarial drugs before the rainy season could substantially reduce cases of life-threatening malaria in the African Sahel, where malaria is highly seasonal. In this trial, 6,000 children were split into three intervention groups – one that received the RTS,S/AS01E vaccine alone, another that received seasonal malaria chemoprevention (SMC) alone, and a third that received a combination of vaccine and SMC.

Episodes of clinical malaria, hospital admissions with WHO-defined severe malaria and deaths from malaria were reduced by 62.8%, 70.5% and 72.9% respectively in the combination group compared to the SMC alone group. Similarly, these outcomes were reduced by 59.6%, 70.6%, and 75.3% respectively in the combination group compared to the vaccine alone group.

The combination of the RTS,S vaccine with SMC results in much greater impact on malaria transmission than either intervention on their own. This innovative use of the first vaccine in combination with SMC provides an effective way to reduce cases in seasonal settings across Africa.

Silent disease – cerebral malaria more common than previously thought

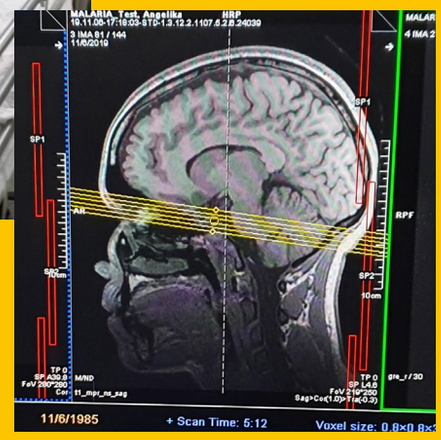


Cerebral malaria is the most severe neurological complication of *Plasmodium falciparum* infection. It is currently characterised by a rapidly progressive coma, has a high fatality rate, and leads to long term health repercussions for survivors. Understanding the mechanisms leading to this syndrome is crucial to inform effective treatments.

Long-term neurological effects usually seen in cerebral malaria survivors were also recently reported in malaria cases without coma. These surprising new findings indicate that the brain can be affected irrespective of the patient's state of consciousness. The study used magnetic resonance imaging (MRI) to investigate the occurrence of brain changes in malaria patients without coma in India.

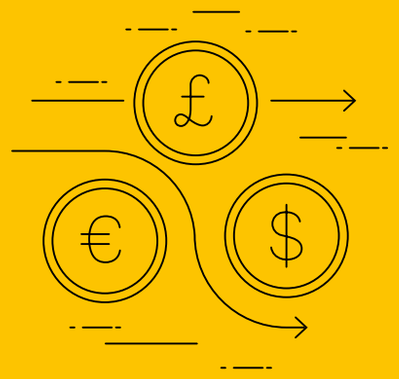
It found that malaria infection caused by the *Plasmodium falciparum* parasite often causes undetected brain changes, which suggests many more malaria patients could be experiencing neurological damage that remains undiagnosed as they fall between the current diagnostic cut-offs.

This research highlights the need for new ways to identify cases with 'silent' cerebral malaria and improve their treatment pathways.



Targeted spraying strategy in low-transmission setting halves the cost of current practice

Indoor residual spraying (IRS) has been used effectively in South Africa since 1945. However, increasing insecticide costs and constrained malaria budgets could make universal vector control strategies, such as IRS, unsustainable in settings where there is low malaria transmission. More efficient approaches are therefore urgently required to sustain elimination efforts in South Africa and other low transmission settings.



This trial compared reactive, targeted IRS, where only houses of index cases and their immediate neighbours were sprayed, with the standard practice of annual mass spray campaigns, in northeastern South Africa over two malaria seasons. Disability-adjusted life-years (DALYS) were estimated for each strategy based on trial endpoints, and health service costs of real-world implementation were modelled.

Targeted IRS was non-inferior to mass spraying, at less than half the cost. At the incidence observed in the trial (less than 1 case per 1000 people in a year), a targeted strategy would have a 94–98% probability of being cost-effective.

This is the first study to evaluate whether routine blanket vector control can be safely replaced with a reactive, targeted strategy. Findings indicate that targeted IRS could be cautiously implemented in areas with very low malaria transmission and strong surveillance systems, enabling scarce resources to be used more effectively for other life-saving activities.

Optimising the impact of Seasonal Malaria Chemoprevention with operational research adapted to the local context

The most intense malaria transmission occurs in West and Central Africa during and shortly after the rainy season. Seasonal malaria chemoprevention (SMC) is a proven strategy developed specifically for these areas, which was first introduced in 2012.

SMC was rapidly expanded through the ACCESS-SMC project, which showed that high coverage could be achieved and there were marked reductions in the number of malaria cases, severe cases, and deaths in hospital malaria due to malaria when SMC was introduced.

But the impact could be greater if delivery was better adapted to the local context, to ensure all eligible children are reached throughout the high-risk period each year. Through the OPT-SMC partnership, 13 national malaria control programmes (NMCPs) involved in SMC are being supported to conduct operational research to improve delivery of SMC, and to put their findings into practice, through small grants and technical assistance.

In 2021, SMC programmes reached about 43 million children in west and central Africa. The OPT-SMC project aims to help NMCPs ensure these programmes have optimum impact.

Getting rid of *Plasmodium vivax* in Cambodia: Let's get radical!

P. vivax is difficult to eliminate. The part of its life cycle that causes multiple relapses, known as hypnozoites, can only be killed by drugs such as primaquine. However, primaquine can cause life-threatening breakdown of red blood cells in individuals with G6PD-specific deficiency and has therefore not been deployed widely. Now, point of care testing for G6PD deficiency makes it feasible to implement a radical cure for *P. vivax*.

This study developed, implemented, and evaluated a new model of care for *P. vivax*. Patients diagnosed in the community with *P. vivax* infection were referred to the local health centre for point of care testing, then commenced 14 day or 8 weekly radical cure treatment with primaquine depending on their G6PD test result, and were then followed up in the community.

The new model of care was highly feasible and acceptable to health care workers and to patients who were finally cured of recurrent malaria. Overall, tolerance and adherence to the primaquine course were high, leading to scale up of this method throughout Cambodia.

Scan here to access the publications:

Environment

Re-thinking the relationship between rice and malaria

Rice fields in Africa are major breeding sites for malaria vectors. However, reviews conducted in the 1990s revealed that communities with irrigated rice fields did not necessarily have more malaria. Since then, intervention coverage has been massively scaled up and malaria prevalence has halved. This calls for a re-examination of the rice-malaria relationship.

A systematic review and meta-analysis were conducted on observational studies that compared malaria epidemiological and entomological outcomes between people living in rice-growing and non-rice growing communities in sub-Saharan Africa. This study looked at whether the decline in malaria transmission has changed the associations between rice cultivation and malaria risk.

It was confirmed that before the year 2003, malaria prevalence was not higher in rice-growing communities. However, after 2003, it was almost two times higher in rice villages. It was also confirmed that as underlying malaria intensity decreased, there was an increase in the strength of association between rice cultivation and malaria risk.

As rice cultivation brings increased malaria risk, expansion of irrigated rice production may interfere with plans for malaria elimination in sub-Saharan Africa.

The impact of global environmental change on mosquito-borne disease

Anthropogenic pressures on the Earth can have devastating consequences for human health, including an increased threat of mosquito-borne diseases. There is a growing need to understand the joint impact of climate variation and land-use change on mosquito-borne diseases, in conjunction with socioeconomic factors and vector control.

The studies used models informed by remotely -sensed environmental data to assess the spatiotemporal variation of mosquito-borne diseases in Ecuador and Venezuela. Different sources of climate data were compared to assess their impact on the models, and mosquito biodiversity was modelled across different land-use types in Latin America and the Caribbean.

There was a difference in the effectiveness of control measures and the impact of climate variation on the two malaria parasites, *P. falciparum* and *P vivax*, in Ecuador. In Venezuela, the effect of temperature on malaria incidence was amplified in areas degraded by mining activity. Further, there were declines in mosquito biodiversity in areas altered by human activity.

This project advances knowledge of how climate variation, land-use change, and socioeconomic factors interact to determine mosquito-borne disease risk, which can inform disease control activities.

Lethal house lures reduce malaria case incidence by 40% in Côte d'Ivoire

Malaria transmission remains unacceptably high in areas of Central and West Africa, despite high coverage of insecticide treated nets. New tools with different modes of action are required to further reduce the malaria burden.

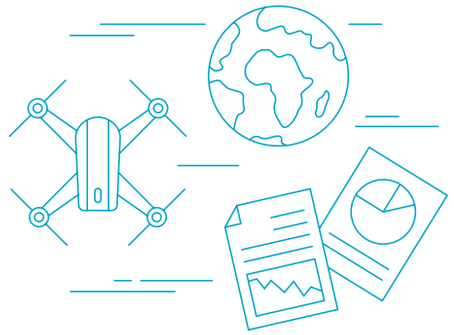
In a large cluster randomised control trial in Côte d'Ivoire, house screening and insecticide-treated Eave Tubes were installed in 3000 houses to both prevent mosquitoes from entering houses and to reduce mosquito populations through killing them via insecticide. Malaria transmission metrics were compared between villages with the intervention and villages where only bed nets were used.

Malaria case incidence was reduced by 40% in children living in clusters where the interventions were fitted, compared to those living in clusters only using bed nets. The numbers of mosquitoes found indoors were reduced by 61%. The impact on malaria case incidence was higher in villages where the coverage of the intervention was higher and those living in intervention villages, but without the intervention, also appeared to benefit from the effects. The combined intervention was similarly cost-effective to other core vector control interventions in sub-Saharan Africa.

With human populations expanding across the world, building protective measures into new houses will be an important intervention in the arsenal of tools to reduce malaria.

Land use change and zoonoses – the case of *P. knowlesi* malaria

P. knowlesi, the most common malaria in Malaysia and found elsewhere in SE Asia, can be fatal if not treated. Environmental and land use changes are bringing the parasites' natural hosts, macaques, into close human contact, thus increasing the risk of infection. It is important that the drivers of risk are understood to prevent spread of zoonotic infections.



A combination of epidemiological, entomological and primate surveys were conducted in Malaysian Borneo in areas where detailed land cover was assessed with remote sensing and drones. This project used laboratory assays to assess exposure to, and infection with, *P. knowlesi*, and modelled the risk of infection from environmental, human, and macaque movement, and epidemiological data.

Results demonstrated environmental and habitat change influences the presence of mosquito vectors and macaque hosts to increase the potential risk of zoonotic malaria to humans. Conventional malaria control methods offer some protection, but novel approaches are required. However, data reviews and modelling suggest the likelihood of sustained human to human transmission is very low.

Controlling *P. knowlesi* malaria will require a multisectoral approach which could provide the basis for control of other existing and emergent zoonotic infections.

Scan here to access the publications:

Contribution to WHO policies

Malaria Centre staff work with the World Health Organization (WHO), generating evidence, providing technical support, and helping translate research into guidance.

In addition, many projects led by our members are directly addressing some of the priorities identified by the WHO.

Generating evidence to inform policy

Much of the work of Malaria Centre members and their collaborators feeds into WHO policy decisions, including rigorous trials to evaluate new or improved malaria interventions such as insecticide treated mosquito nets, the RTS, S malaria vaccine, and chemoprevention.

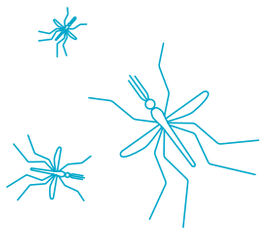
Case study: Chemoprevention

The use of medicines to prevent malaria has been investigated since the 1980s by some of our members. These approaches include seasonal malaria chemoprevention (SMC), and intermittent preventive treatment (IPT) of malaria in pregnancy (ITPp), and in infants (IPTi). All three recommendations have been updated in June 2022 by the WHO, drawing on evidence generated in part by Malaria Centre researchers and their collaborators.

Evidence review and guideline development

WHO uses robust, systematic processes to review evidence and develop guidelines, providing malaria endemic countries with reliable recommendations to guide their work in communities most at risk from malaria. In the past two years, Centre members:

- Produced Systematic reviews commissioned by WHO, including assessing community impact of bed nets and vector control for humanitarian situations
- Were invited experts for Guideline Development Groups and Technical Working Groups
- Contributed to Preferred Product Characteristics of future interventions such as vaccines, drugs, and monoclonal antibodies
- Are members of the highest WHO advisory group on malaria, the Malaria Policy Advisory Group, and of the committee responsible for declaring country-level malaria elimination.



Focus on WHO priorities

The 2021 WHO world malaria report once again confirmed worrying increases in malaria disease and death.

Some of the key challenges faced by the scientific community in the fight against malaria were compounded by the COVID pandemic. In addition to their direct work with the WHO, researchers at the Malaria Centre are also involved in projects focussing on priorities outlined in the latest report. These include:

A convergence of threats in sub-Saharan Africa

- Drug resistance: parasites partially resistant to artemisinin – the mainstay compound in our first line of treatment against malaria – have emerged in Rwanda, Uganda, and the Horn of Africa (page 23).
- New vectors: an invasive species imported from India, *Anopheles stephensi*, is spreading in Nigeria, Ethiopia and Eritrea. Worryingly, this mosquito is better suited to urban environments and may lead to malaria transmission in African cities (page 27).
- Insecticide resistance: similarly, malaria vectors are showing resistance to pyrethroids, the main active ingredient used in treated bed nets and indoor residual spraying, across sub-Saharan Africa. Our research into novel compounds resulted in the first new insecticide class suitable for use on bed nets in 40 years (page 25).

Harnessing innovation

- Development of the RTS,S vaccine: This is the first vaccine to be developed against human parasitic disease and was recommended by WHO in October 2021. It works by triggering an immune response when *P. falciparum* enters a person's bloodstream. The vaccine is currently given to young children as part of a package for maximum impact in high-burden areas (page 29).
- Combining tools: Malaria will not be defeated with a one size fits all approach. Our research combined use of RTS,S with SMC on a seasonal basis to provide stronger preventative coverage than vaccine or antimalarials alone (page 29).
- New diagnostic tools: Using molecular approaches to identify patients at risk of developing severe or lethal malaria, and detect individuals with asymptomatic but transmissible infections (page 30).

Download the WHO World Malaria Report 2021:

PhD students

PhD students and early career researchers are a key demographic of the Malaria Centre. They will be the next generation of malaria researchers and bring energy and innovation to the group. Approximately half our students are based in London, with half being based in other countries around the world. Their PhD projects are varied and range from focussing on individual antigens of the parasite to working on large clinical trials.

What were you doing before?

After completing an MSc in Medical Parasitology at LSHTM, I worked at the University of Edinburgh as a Research Assistant.

What's an average day?

I work with parasite culture, so a lot of my time is spent taking care of cells! I spend most of my day in the lab away from my desk, but try to occasionally do some reading, too.

What is your favourite aspect of working in science?

"Every day is different - it keeps you on your toes! As well as being in the lab working on my PhD project, I've helped to teach MSc students and medical doctors how to diagnose parasitic infections, which was great fun."

I've also done public engagement sessions in local primary schools, showing off some of the giant mosquito species we have at LSHTM - they were a big hit!

Overview of my project

Plasmodium vivax is the leading cause of malaria outside Africa. Despite this, vaccine development lags far behind *P. falciparum*. Additionally, the closely related parasite, *P. knowlesi*, was only discovered to cause widespread zoonotic malaria in southeast Asia in the past two decades, and little is known about the details of host-pathogen interactions during infection. *P. knowlesi* and *P. vivax* are both significantly more challenging to control using traditional case detection and vector control methods than *P. falciparum*, so vaccines for these two species are urgently needed. My PhD uses *P. knowlesi* cultures expressing *P. vivax* cellular characteristics to identify potential vaccine candidates in both species, and to explore how targeting multiple families of molecules may simultaneously impact vaccine efficacy.

Sophia Donvito
2nd year PhD student

What were you doing before?

I graduated as a Doctor in Pharmacy in 2010 at The University of Technical Sciences and Technologies of Bamako-Mali (Entomological Department of Malaria Research and Training Centre (MRTC/ICER-Mali) after completing my thesis on the monitoring and effectiveness of indoor residual spraying for malaria vector control in two districts of Mali. I then worked as full-time research assistant in Entomology at MRTC where I was responsible for the implementation of various research projects with both field and lab activities. From 2012-2017 I worked at the department of immunology and epidemiology of the MRTC where I was in charge of designing and conducting experimental infestation studies such as vaccine and drug trials aiming at blocking malaria transmission.

Overview of my project

I work at the MRCG@LSHTM as an Entomology Manager in charge of the insectary, mosquito infection studies, field entomology investigation, evaluation, and data analyses. I was recently leading the entomology components of two trials; one on the impact of Ivermectin MDA on malaria vectors ("MASSIV"), and the other assessing the contribution of asymptomatic and symptomatic infection to onward malaria transmission in low transmission settings ("INDIE"). Results of both studies are currently being published and form the basis of my PhD thesis.

What's next?

"My ambition is to become an internationally recognised researcher to contribute to the elimination of major vector-borne diseases in West Africa and to the development of the next generation of young scientists working for better health in Africa."

Harouna Massire Soumare
Final year PhD student

What were you doing before?

I studied biomedical sciences at Durham University, then did an MSc in Control of Infectious Diseases at LSHTM. My MSc summer project involved collecting mosquitoes in Côte d'Ivoire and it inspired me to do a PhD!

What's an average day?

My project is split into lab work and bioinformatics.

"If I'm in the lab I'll probably be there all day, preparing samples for sequencing or running PCRs to look for expression of insecticide resistance genes in *Anopheles* mosquitoes."

Lab days can be quite long, so I listen to a lot of audiobooks and musicals to pass the time! If I'm working on bioinformatics I'll be working from home, writing code, analysing my data and attempting to learn python and R to make nice graphs! I have regular supervision meetings and am part of the Malaria Centre and other student groups, so there's zoom or in-person meetings which break up my days a little.

Advice to future PhD students

Use the first few months/year of your PhD to gain as many skills as possible. The start can sometimes feel slow and frustrating (ethics delays, figuring out who to ask for help, obtaining samples or datasets etc) so having some short term, skills based goals will really help you structure your days. This could be something like brushing up on your stats knowledge, learning some of the local language if you'll be doing fieldwork, learning to code or doing an MSc module or taught course. You won't have time for this later on!

Overview of my project

Insecticide resistance is threatening global malaria vector control and is rapidly evolving in response to an increased use of pesticides and insecticides in agriculture and public health. My PhD examines multiple mechanisms of resistance using next generation sequencing (NGS) techniques. We use whole sequencing to detect novel resistance mechanisms in specimens from Côte d'Ivoire, Guinea, Benin, Tanzania, and the Democratic Republic of the Congo.

Bethanie Pelloquin
Final year PhD student

What are you doing now?

"I am currently the Laboratory Director for the Uganda National Health Services (UNHLS), a department in the Ministry of Health that oversees laboratory services in the country."

We provide specialised reference services and support public health response to outbreaks and epidemic control. I am also a principal investigator for a 3 year Bill and Melinda Gates Foundation grant to build malaria genomic capacity to support the National malaria control programme.

Overview of my project

My PhD explored the impact of *P. falciparum* transmission intensity on the quality of antimalarial antibodies. Antibodies play a critical role in malaria immunity. Malaria immunity is gained slowly after multiple infections and reduces over time without exposure to malaria. Antibody quality may provide insight into the slow acquisition and poor maintenance of malaria immunity. My work found that antibodies of lower binding strength were quickly produced, and quickly lost, compared to those of higher binding strength- though some higher binding antibodies persisted in the absence of reinfection.

How have the results of your PhD project impacted future malaria research?

My project underscored the need to investigate mechanisms by which *P. falciparum* prevents the production of highly binding antibodies. This knowledge will help to optimise the development of malaria vaccines to ensure they induce effective and lasting immunity.

Dr Isaac Ssewanyana
Finished his PhD in 2021

Collaborators

Australia
- Australian Defence Force Malaria and Infectious Disease Institute
- University of Sydney

Austria
- University of Health and Allied Sciences

Belgium
- Institute of Tropical Medicine Antwerp

Benin
- Centre de Researche de Entomologique Cotonou (CREC)
- Republique du Benin, Programme National de Lutte contre le Paludisme du Benin

Burkina Faso
- Burkina Faso, Programme National de Lutte contre le Paludisme
- Institut de Recherche en Sciences de la Sante (IRSS)
- Institut des Sciences et Techniques de Bobo

Brazil
- University of São Paulo Fiocruz: Fundação Oswaldo Cruz

Cambodia
- Health and Social Development Institut Pasteur
- National Centre of parasitology, entomology and malaria control (CNM)
- National Institute of Public Health

Cameroon
- Cameroon National Malaria Control Programme
- Centre for Research in Infectious Diseases (CRID)
- The Centre for Health Implementation and Translational Research at the Fobang Institutes & the LAPHER Biotech, University of Yaounde

Canada
- Ottawa Hospital Research Institute
- University of Ottawa

Cape Verde
- Instituto Nacional de Saúde Pública (INSP)
- Jean Piaget University

Chad
- République du Tchad: Programme National de Lutte contre le Paludisme du Tchad

Colombia
- Facultad de Medicina, Universidad de Antioquia

Côte d'Ivoire
- Africa Rice Center
- Centre Suisse de Recherches Scientifiques (CSRS)
- Institut National de Sante Publique (INSP)
- Institutet Pierre Richet
- Université Alassane Ouattara

Denmark
- University of Copenhagen
- Royal Danish Academy

DRC
- University of Kinshasa

Ethiopia
- Jimma University

France
- Institut Pasteur France - Paris
- INSERM U1016-CNRS
- MIVEGEC Laboratory

Gabon
- Centre International de Recherches Médicales de Franceville

Germany
- Centre for Structural Systems Biology (CSSB)

Ghana
- Ghana, National Malaria Control Programme
- Kintampo Health Research Centre
- University of Ghana

Guinea
- Centre National de Formation de Recherche en Sante Rurale de Maferinyah
- République du Guinea, Programme National de Lutte contre le Paludisme

Guinea Bissau
- Programa Nacional de Luta contra o Paludismo – PNLP
- Projecto de Saude Bandim

India
- Community Welfare Society Hospital
- Ispat General Hospital
- National Institute of Malaria Research

Japan
- Kanazawa University
- Nagasaki University

Kenya
- Kenya Medical Research Institute (KEMRI)

Latvia
- Latvian Organic Synthesis Institute

Mali
- University of Bamako
- Malaria Research and Training Centre (MRTC), University of Bamako
- République du Mali, Programme National de Lutte contre le Paludisme

Mozambique
- Centro de Investigacao em Saude da Manhica (CISM)
- Faculty of Medicine Edulardo Mondlane University

Namibia
- Southern African Development
- Community Malaria Elimination Eight Secretariat

Netherlands
- Amesterdam University Medical Centre (AMC)
- Radboud University Medical Centre, Nijmegen
- HeathNet TPO

Niger
- République du Niger, Programme National de Lutte contre le Paludisme du Niger

Nigeria
- Federal Republic of Nigeria, National Malaria Elimination Programme
- International Institute of Tropical Agriculture
- Nigeria Institute of Medical Research (NIMR)

Peru
- Universidad Nacional Toribio Rodríguez de Mendoza de Amazonas
- Universidad Peruana Cayetano Heredia

Philippines
- International Rice Research Institute

Saudi Arabia
- King Abdullah University of Science and Technology

Portugal
- Instituto de Higiene e Medicina Tropical de Lisboa

Senegal
- Cheikh Anta Diop University
- Institut de recherche pour le développement (IRD)
- République du Senegal, Programme National de Lutte contre le Paludisme
- University of Thiès, Senegal

Singapore
- Lee Kong Chian School of Medicine
- National University of Singapore

Somalia
- National Malaria Control Program

South Africa
- University of the Witwatersrand
- African Institute for Research in Infectious Diseases

Spain
- European Molecular Biology Laboratory in Barcelona
- Instituto de Salud Carlos III
- Barcelona Instutite for Global Health (ISGlobal)

Sudan
- Omdurman Islamic University

Switzerland
- Bern Inselspital
- Medicines for Malaria Venture (MMV), Switzerland
- Swiss Tropical and Public Health Institute
- UNDP/UNICEF/World Bank/WHO
- Special Program for Research and Training in Tropical Diseases (TDR)
- University of Basel
- University of Geneva

Tanzania
- Ifakara Health Institute
- Kilimanjaro Christian Medical College (KCMC)
- National Institute of Medical Research (NIMR)
- Kilimanjaro Christian Medical University College (KCMUCo)
- Pan-African Malaria Vector Research Consortium
- Pan African Mosquito Control Association

Thailand
- MORU Bangkok
- Mahidol University

The Gambia
- MRC Unit The Gambia at LSHTM
- Republic of The Gambia, National Malaria Control Programme

Togo
- République du Togo, Programme National de Lutte contre le Paludisme

Uganda
- Infectious Diseases Research Collaboration, Kampala
- Makerere University

UK
- Aberystwyth University
- Durham University
- Imperial College London
- Innovative Vector Control Consortium (IVCC)
- University College London
- Liverpool School of Tropical Medicine
- Malaria Consortium
- St Georges University
- University of Cambridge
- University of Cardiff
- University of Dundee
- University of Glasgow
- University of Nottingham
- University of Oxford, Jenner Institute

USA
- CDC USA
- National Institute of Allergy and Infectious Diseases (NIAID)
- New York University
- Penn State University
- Save the Children International
- Seattle Children's Hospital
- Stanford University
- University of California, Irvine
- University of California, San Francisco
- University of Maryland
- University of Nevada Las Vegas
- University of North Carolina
- Virginia Tech

Vietnam
- National Institute of Malariology, Parasitology and Entomology (NIMPE)

Zanzibar
- Zanzibar Malaria Elimination Programme (ZAMEP)

Obituaries

Dr Amit Bhasin, Ph.D
1967 – 2020

Amit joined LSHTM in 2002 and played a key role in establishing the Gates Malaria Partnership as an innovative research capacity development programme. He became its manager in 2006, and then of its successor, the Malaria Capacity Development Consortium.

These consortia involved multiple partners in Africa and Asia and much of their success was due to Amit. He was a brilliant administrator but, more importantly, hugely skilled in bringing people together effectively and making collaborative working fun. His ability to gain the trust and friendship of all categories of staff, from director of a research centre to an entomology field worker was remarkable.

Before joining LSHTM, Amit obtained a PhD in entomology at the University of Aberdeen. Subsequently, he held a post-doctoral fellowship at Hadassah University, Jerusalem, undertaking fieldwork in Mali where he developed his love of Africa and made many lasting friends.

Amit was a family man, huge sports and music fan, and enormously generous with his time and skills. His legacy continues supporting young African science.

Professor David C. Warhurst
1938-2021

David was an Emeritus Professor of Protozoan Chemotherapy at LSHTM. An internationally recognised parasitologist and one of the foremost experts in antimalarial chemotherapy of his generation.

In September 1968, David took a position as Research Fellow at the Liverpool School of Tropical Medicine to work on the chemotherapy of protozoal diseases and drug resistance. Together with Prof. Peters, David developed a number of *in vivo* tests using rodent malaria parasites, allowing both sensitive and drug resistant strains to be studied. For several decades the tests developed by this team were widely used throughout the world to evaluate chloroquine susceptibility.

David returned to London and joined LSHTM in 1976 where he became co-Director of the Malaria Reference Laboratory (MRL), and worked closely with the MRL staff, until his retirement in October 2003.

There was never any self-promotion with David; he generously shared what he knew or discovered with colleagues, including the many doctoral students and younger scientists with whom he was associated. He energised all those around him and will be greatly missed.

To accelerate progress in the fight against malaria

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