



Best of British:

How British-backed science can accelerate the end of malaria



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Contents

3	Acronyms
6	INTRODUCTION
10	SECTION 1: Emerging threats to progress against malaria
14	SECTION 2: Fighting back - How british science is leading the way in responding to emerging threats
14	Combating mosquito resistance with cutting-edge technology
16	Transforming global disease diagnosis, control and surveillance
18	Fighting drug resistance with advances in treatment
19	Strengthening our toolbox for the future with malaria vaccines research
21	Securing the future for people and planet
22	SECTION 3: Recommendations

Acronyms

ACTs	Artemisinin-combination Treatments
AMR	Antimicrobial Resistance
ATSB	Attractive Targeted Sugar Bait
DFID	Department for International Development
FCDO	Foreign, Commonwealth & Development Office
GSK	GlaxoSmithKline
GTS	Global Technical Strategy
HRP2	Histidine-rich Protein 2
IRS	Indoor Residual Spraying
ITN	Insecticide-treated Net
IVCC	Innovative Vector Control Consortium
KEMRI	The Kenya Medical Research Institute
LSHTM	The London School of Hygiene & Tropical Medicine
LSTM	The Liverpool School of Tropical Medicine
MMV	Medicines for Malaria Venture
PDP	Product Development Partnership
RDT	Rapid Diagnostic Test

Foreword



Rt Hon Sir Stephen O'Brien KBE

Chair of IVCC, former DFID Minister and former United Nations Under-Secretary-General for Humanitarian Affairs and Emergency Relief Coordinator

The coronavirus pandemic has shown us that what happens around the world can have a devastating impact on the health of UK citizens. It has also demonstrated the importance of UK leadership in science and innovation in reducing disease burdens on developing countries around the world who have been faced with the dual challenge of tackling COVID-19, alongside existing deadly diseases like malaria.

As the second largest international donor to the fight against malaria, the UK has been at the forefront of efforts that have

helped to save 7 million lives and prevent more than 1 billion cases since 2000. The fight against malaria has long drawn on the best of British science and innovation, stretching back to the discovery of malaria transmission by British scientist and first ever lecturer at the Liverpool School of Tropical Medicine, Sir Ronald Ross in 1897, which laid the foundation for efforts to combat the disease.

But after years of steady decline, progress has plateaued. Funding has levelled off, and drug and insecticide resistance are increasing, risking a resurgence of the disease and loss of hard-won gains. The coronavirus pandemic has caused further disruption, although many countries have shown great resolve in adapting and continuing malaria programmes as planned.

The coronavirus pandemic has demonstrated the importance of science and innovation to overcoming global disease threats, and the scale of what can be achieved with the right funding and international commitments.

There is a great opportunity to build on this momentum, by doubling down our efforts to tackle malaria – a disease which still kills a child every 2 minutes. Already this year there have been exciting breakthroughs in the development of malaria vaccines, and this report contains many more examples of the exciting British-backed tools and innovations which are bringing the goal of malaria eradication ever closer.

Much like Britain's success with the COVID-19 vaccine, being at the forefront of scientific and medical discovery also creates new trading opportunities abroad, expands our diplomatic and influencing reach on a world stage and showcases our proud record of investing in research and development to tackle global challenges.

By continuing to fund vital research, Britain can help to save lives and build its reputation as a global science superpower. But it is just as important to maintain our efforts to strengthen community health systems and support frontline health workers, to ensure that innovation is translated into impact, as demonstrated by the success of our NHS vaccine roll out. This support helps build the foundations for tackling both existing and future diseases, keeping us all safer.

With the right tools, malaria is a disease we can end within a generation. However, like the fight against coronavirus, it will require belief, perseverance, and cross-sector collaboration. It will be vital to ensure that the UK government's longstanding investments in tackling malaria and strengthening community health systems, through research and development, bilateral programmes, and funding for the Global Fund to Fight AIDS, Tuberculosis, and Malaria, are protected in future spending rounds.

With renewed commitment, the UK can lead the world in consigning this devastating disease to history – an ambition truly worthy of a global Britain.

Introduction

UK-led research and innovation, backed by critical funding from the UK Government, have contributed to tremendous progress in the fight against malaria – but emerging threats and stalling progress are putting children’s lives and global health security at risk

Nearly half of the world’s population are at risk of malaria, a life-threatening disease caused by parasites that are transmitted to people through bites from infected mosquitoes. Over the last two decades great progress has been made, with a 47% decline in malaria mortality rates between 2001 and 2015, averting an estimated 4.3 million deathsⁱ. This progress has been underpinned by the invention and up-take of new products and interventions, such as long-lasting insecticide-treated mosquito nets which were responsible for 68% of the malaria cases prevented in Africa between 2000 and 2015ⁱⁱ. British individuals, businesses, and universities have all played a critical role in the development and delivery of such tools, supported by the UK Government’s commitment to the life sciences sector and its promise to lead the way in the eradication of malaria.

However, malaria continues to take a heavy toll across sub-Saharan Africa, particularly on pregnant women and children, claiming the life of a child every two minutes. Stalled progress means that in 2019 there were still 229 million cases of malaria and 409,000 deaths – two thirds of which were children under fiveⁱⁱⁱ.

Emerging challenges pose further risks to the malaria fight on several fronts, whether it be growing biological and technical challenges emerging due to

British Science can help save almost 2 million additional lives

drug and insecticide resistance, the evolution of parasites to evade detection, or the increasingly rapid loss of natural habitats which are the source of many new medicines. More recently, the COVID-19 pandemic has emerged as an additional threat to malaria responses worldwide, jeopardising our continued progress and increasing the risk of a malaria resurgence that could undo years of progress.

Without a step change in progress, it is clear that the global ambition to end the epidemic of malaria by 2030, as set out in the Sustainable Development Goals and the World Health Organisation’s (WHO) Global Technical Strategy for malaria, will not be met. Not only does this risk the preventable deaths of thousands of children in endemic countries, but it also puts us all at risk. With its potential to overwhelm health services and blind us to emerging disease threats, malaria undermines our collective health security and our readiness to detect and respond to current and future pandemics.

British science can play a leading role in helping us get back on track, saving almost two million additional lives

Malaria is too complex and dynamic a disease for any one tool to defeat it on

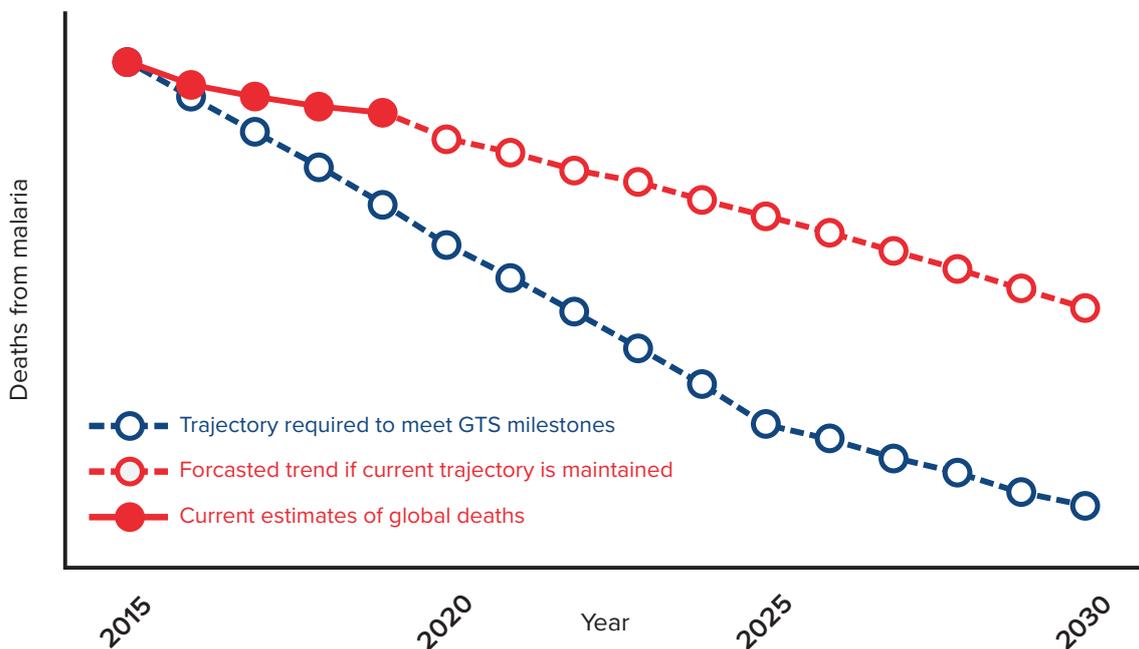
its own. Getting back on track in our fight to end malaria will depend on both expanding access to proven interventions, and ongoing innovation to ensure a pipeline of effective tools that allow us to stay one step ahead of the disease. Strategic, innovative, and well-coordinated malaria R&D funding is therefore needed now more than ever^{iv}, and the potential benefits are enormous. When combined with improved malaria control and health system strengthening, investments in malaria research and innovation have the potential to help save almost two million additional lives from malaria by 2030, as well as strengthening global health security by building our capacity to prevent, detect and treat infectious disease.

The UK is uniquely positioned to play a leading role, with British-backed scientists and institutions at the cutting edge of developing many of the solutions needed to navigate emerging threats, supported by vital UK government funding. In particular, the UK government has been a critical supporter of key Product Development Partnerships (PDPs) that bring together private and public sectors to drive innovation against malaria, accounting for around a quarter of their funding.

Not only does this save lives, it also demonstrates the UK’s scientific and manufacturing prowess on the world stage, lending significant weight to our diplomatic relations, and opening new business and trade opportunities to British entrepreneurs and researchers.

Recognising the emerging biological and environmental threats to progress against malaria (Section 1), this report shows that potentially transformative new tools are increasingly within reach, with British funding, institutions and scientists leading the way (Section 2). It calls on the UK government to build on the momentum generated by UK science’s world leading role in combatting COVID-19 by backing malaria research and innovation, as well as renewing investments in crucial mechanisms such as the Global Fund to Fight AIDS, Tuberculosis and Malaria, to allow countries to sustain critical malaria interventions in the face of COVID-19 and ensure key tools get to those that need them (Section 3). By doing so the UK can cement itself as a science superpower and play a historic role in freeing humanity of this insidious disease for good, and creating a safer world for us all.

Getting back on track to meet the GTS targets could save 2 million additional lives



7.6 MILLION



Success in malaria control over the last two decades has prevented 1.5 billion cases and saved 7.6 million lives



409,000

In 2019, there were 409,000 deaths, 2/3 of which were children under 5

46%

In 2000, only 2% of people in Africa were protected by an insecticide-treated net, today 46% of people are protected



9^{OUT} OF 10

Nine out of ten Commonwealth citizens live in a malaria-endemic country

267 MILLION

In 2019, over 267 million rapid diagnostic tests and over 183 million first-line malaria treatments were distributed



1/2 THE POPULATION

In 2019, nearly half of the world's population was at risk of malaria

US\$ 2.6 BILLION



The funding gap for malaria has continued to widen over recent years, increasing from US\$ 1.3 billion in 2017 to US\$ 2.6 billion in 2019

500 MILLION



Between 2016 and 2021 the UK Government committed £500 million a year to ending malaria



UK FUNDING IS KEY

UK funding to PDPs such as MMV has been key for the development of new treatments for malaria

2ND LARGEST



The UK is the second largest global funder in the fight against malaria

LIVERPOOL

Scientists at IVCC in Liverpool are developing and distributing 35 million next generation mosquito nets, to protect an estimated 63 million people

OXFORD

The Jenner Institute, behind the Oxford-AstraZeneca COVID-19 vaccine, have developed a first-generation malaria vaccine

LONDON

Researchers at Imperial College London have developed a way to diagnose multiple diseases, including new ones, in one device

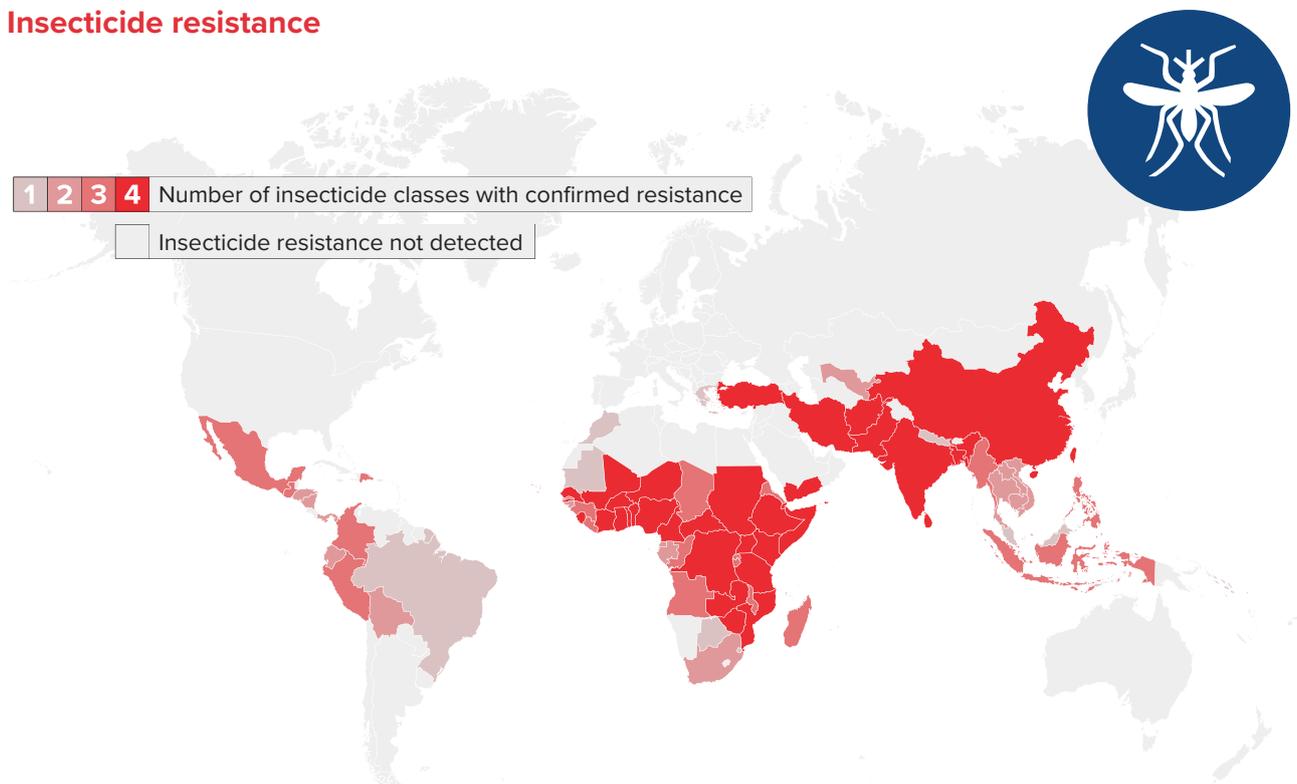
SECTION 1:

Emerging threats to progress against malaria

In recent years, the WHO has repeatedly warned that progress against malaria is plateauing due to stalling funding. Now several emerging threats could see the gains of the last two decades reversed, if left unchecked.

- Insecticide resistance could reduce the effectiveness of chemicals currently used in insecticide-treated mosquito nets and insecticide sprays.
- Gene-deletions could cause the tests used to diagnose 74% of malaria cases in sub-Saharan Africa to produce inaccurate results^v.
- Drug resistance could lead to more people developing severe forms of malaria, and cause deaths from the disease to increase rapidly.
- Changes in the natural environment, including loss of biodiversity, could reduce our ability to find new treatments to combat drug resistance, whilst wider environmental and climatic changes make tackling malaria ever more complex.

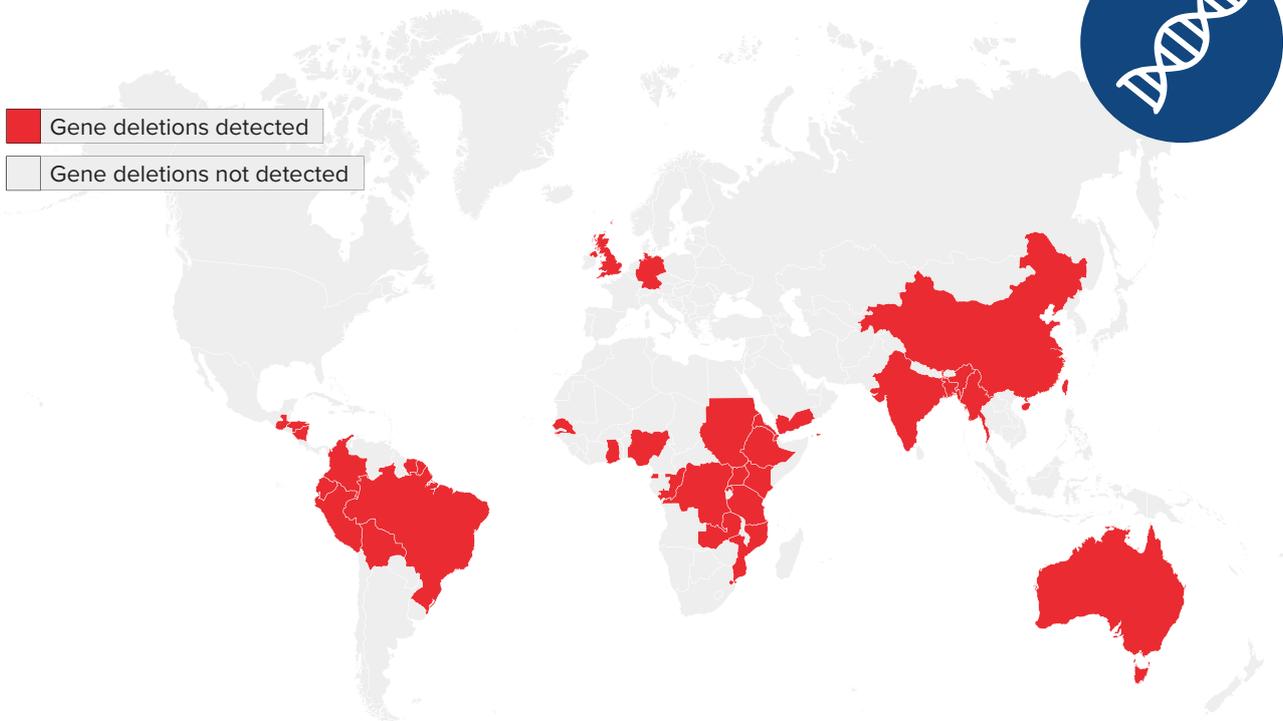
Insecticide resistance



Gene deletions that undermine accurate diagnosis



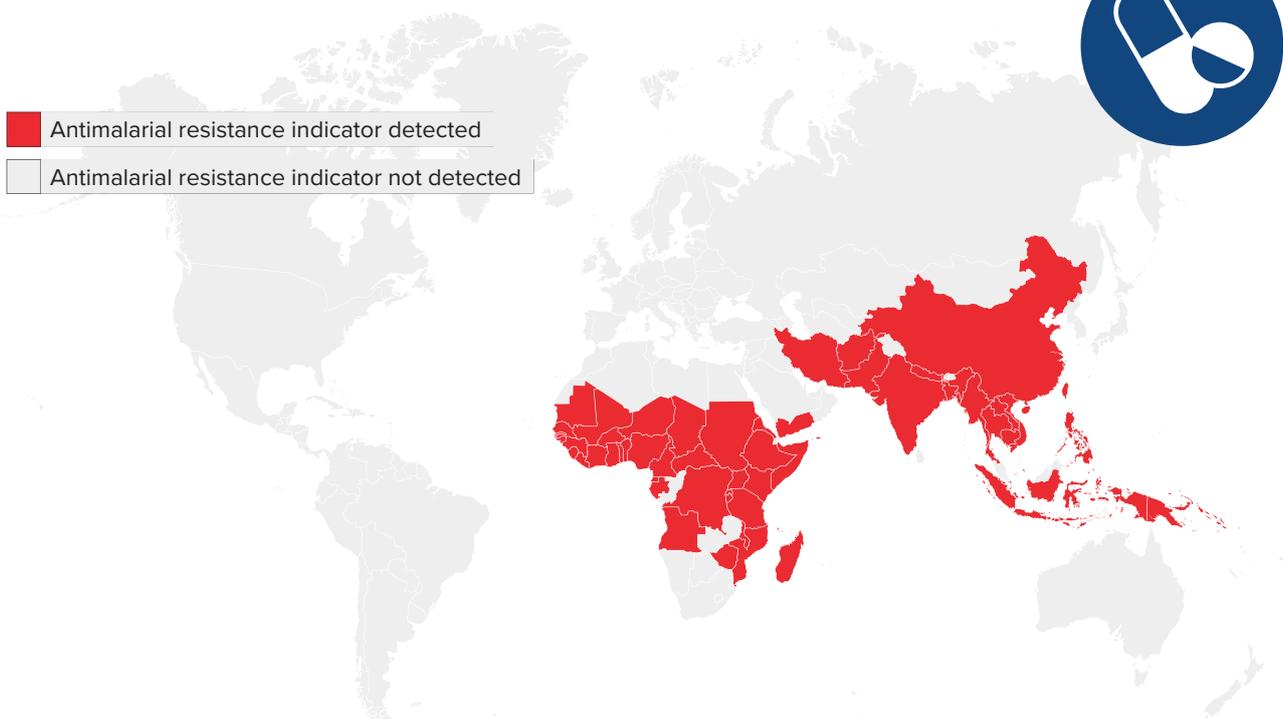
- Gene deletions detected
- Gene deletions not detected



Antimalarial drug resistance



- Antimalarial resistance indicator detected
- Antimalarial resistance indicator not detected



Insecticide resistance



The two methods most commonly used to repel mosquitoes and reduce malaria infections are insecticide treated nets (ITNs) and insecticides applied to the interior walls of houses (Indoor Residual Spraying - IRS). Between 2000 and 2015, 79% of malaria deaths prevented were attributed to ITNs and IRS^{vi}.

But as mosquitoes adapt, new versions of these tools are needed; recent studies have found that malaria-carrying mosquitoes are developing resistance to the chemicals used on ITNs and for IRS, meaning mosquitoes are no longer killed or repelled, and are free to continue to circulate and transmit malaria. The WHO reports that 73 countries have detected resistance to at least one insecticide, and 28 countries have detected resistance to all four of those most commonly used^{vii}. New innovations to protect people from contracting malaria are therefore urgently needed.

Gene deletions that undermine accurate diagnosis



Early and accurate diagnosis is essential to prevent severe and life-threatening malaria and ensure effective disease management. In sub-Saharan Africa, 74% of malaria cases are diagnosed using Rapid Diagnostic Tests (RDTs)^{viii}. These tests are cheap, do not require laboratory resources, and can return results in less than 15 minutes. 345 million malaria RDTs sold annually diagnose malaria by detecting a protein in the malaria parasite called histidine-rich protein 2 (HRP2)^{ix}.

However, recent evidence suggests that the malaria parasite is evolving to delete the gene that makes this important protein, making it difficult to identify malaria using a rapid test. 82% of countries reporting to the WHO have found these gene deletions^x. This means that a patient infected with malaria may give a false negative result when tested and therefore may not be treated for the disease; a misdiagnosis which in turn increases the risk they could develop severe malaria and die. On the other hand, losing the ability to accurately confirm a malaria diagnosis may lead to the overuse of antimalarials, accelerating drug resistance.

Effective diagnosis is further undermined by the fact that at least 50% of people living in sub-Saharan Africa do not have access to essential health services,^{xi} and even among those who do seek care for a fever, less than 40% receive a test to confirm their diagnosis^{xii}. Together, these gaps allow malaria to continue to circulate unchecked, further complicating the detection of other diseases with overlapping symptoms such as fever, including new disease threats with the potential to become future pandemics. New diagnostic tools, and more effective means to ensure they are used by those that need them, are therefore vital.

Antimalarial drug resistance



Effective drugs are critical for malaria control and elimination, but for decades drug resistance has been a challenge. Not only does drug resistance enable the malaria parasite to survive and continue to spread after treatment, it also allows more cases of malaria to progress to severe disease, with real impacts for public health. For example, chloroquine resistance in KwaZulu-Natal in South Africa led malaria incidence to increase by 4.5 times over three years, while malaria incidence increased by 5.9 times over five years due to resistance to sulfadoxine-pyrimethamine^{xiii}.

Both chloroquine and sulfadoxine-pyrimethamine were previously used as first-line treatments for malaria. However as resistance to these drugs developed, scientists responded by creating artemisinin-combination treatments (ACTs), which reduce the chance of developing drug resistance by combining the antimalarial properties of different medications. ACTs are currently the recommended first-line treatment in all malaria endemic countries, but resistance to artemisinin (a key component of ACTs) has recently emerged in several countries in southeast Asia and Rwanda and is being monitored carefully by the WHO. As the situation develops, new treatments will be needed to ensure resistance does not allow malaria to resurge.

Environmental change and biodiversity loss



Over half of approved medicines are derived from plants, including quinine and artemisinin which have been used to treat malaria^{xiv}. Quinine is an antimalarial drug produced from the bark of the *Cinchona officinalis* tree, found primarily in Peru, and has contributed significantly to the treatment of malaria since the 1900s. Unfortunately, the source of this powerful drug faces the threat of extinction due to unsustainable farming practices, deforestation, and lack of environmental regulation^{xv}.

Similarly, artemisinin, which is derived from the *Artemisia annua* plant, has been used for over 2000 years to treat people with fevers and is now a key component of drugs to cure both uncomplicated and severe malaria infections. Since artemisinin is currently a first-line treatment for malaria, the demand for its production is high, and unregulated cultivation could threaten the diversity of the plant^{xvi}. Such examples illustrate how unchecked deforestation, and loss of plant species with the potential to play a valuable role in malaria control, could hinder efforts to find new treatments for malaria and other diseases.

Wider environmental and climatic changes also have the potential to threaten progress against malaria. For example, deforestation can lead to changes in the physical environment which impacts mosquito populations and the rate of development of malaria parasites.

Climate change also poses a growing challenge, with changes in temperature, precipitation, and humidity all having an impact on malaria transmission, and making decisions about the type and timing of interventions increasingly complex.

Fighting back - how British science is leading the way in responding to emerging threats

Staying ahead of these emerging threats will require both increased access to existing tools developed with the support of previous research investments, and ongoing innovation to develop and deliver new, transformative interventions that anticipate and respond to current and future challenges. British-backed science is leading the way in accelerating the development of such life-saving tools and strategies.

Combatting mosquito resistance with cutting-edge technology

As country surveillance identifies areas of growing insecticide resistance, scientists across the UK are working with partners in malaria endemic countries to develop new products to protect those most at risk from deadly mosquito-borne diseases, including malaria. Researchers at the Innovative Vector Control Consortium (IVCC), a British-backed Product Development Partnership which brings private and public sectors together to drive innovation, have been developing new innovations to keep up with ever-evolving mosquitoes (see below). Other UK-based scientists at Imperial College London are moving closer to suppressing transmission through the release of genetically modified mosquitoes.

Reducing outdoor transmission in one bite

Attractive Targeted Sugar Bait (ATSB®) is a device that includes an insecticide within an attractive sugar-meal to kill malaria-carrying mosquitoes. The novel tool, developed by biotech company Westham, leverages the natural sugar

feeding behaviour of malaria-carrying mosquitoes, and is aimed at mosquitoes that bite outdoors. This allows it to target mosquitoes that transmit malaria which may otherwise be missed by existing interventions, such as insecticide sprays and insecticide-treated nets which focus on providing protection inside the home. The development of ATSB® has been supported by IVCC using funding from UK Aid and the Bill & Melinda Gates Foundation, bringing together scientists from The London School of Hygiene & Tropical Medicine (LSHTM), The Liverpool School of Tropical Medicine (LSTM), Keele University, Imperial College London, and the University of Oxford. Modelling suggests that this innovation could reduce the number of new malaria cases by 30% when deployed in sub-Saharan countries, possibly starting as early as 2024.

Next-generation mosquito nets

Long-lasting insecticide-treated nets have been the backbone of malaria prevention for decades, helping to prevent 68% of malaria cases in Africa between 2000 and 2015.^{xvii}

The **Interceptor® G2** is a second-generation insecticide-treated net (ITN) developed by BASF with support from IVCC, specifically in response to studies



showing increases in insecticide-resistant mosquitoes. Interceptor® G2 is a dual insecticidal net that is based on a new class of chemistry to which malaria-carrying mosquitoes have not developed resistance and kills about 70% to 97% of the mosquitoes which encounter it. In this way it provides comparable protection to previous mosquito nets, whilst also providing a crucial defence against growing insecticide resistance.

To ensure that these nets reach those who need them most, scientists including experts from LSTM, LSHTM and Imperial College London have come together with partners in endemic countries through the **New Nets Project**, led by IVCC. By 2022, the Project will have distributed over 35 million Interceptor® G2 nets across 13 countries, protecting an estimated 63 million people and averting millions of malaria cases, thanks to funding from

The Wellcome Trust and British-backed multilaterals, Unitaid and the Global Fund to fight AIDS, Tuberculosis and Malaria.

Using genetic modification to eliminate mosquito populations

Working with partners in West-Africa, researchers from Imperial College London and Polo GGB, recently completed a year-long experiment which successfully suppressed populations of malaria-carrying mosquitoes by using a special type of genetic modification known as gene drives to make female mosquitoes infertile.

Gene drives bias the mosquito's own genetic inheritance, allowing a genetic modification to spread throughout an entire insect population within a couple of years. A recent experiment, which introduced modified mosquitoes to make up 12.5 and 25% of the study population, led to complete population collapse in just one year: the first time a gene drive has been shown to be effective when tested in conditions that mimic the natural environment^{xviii}. This has exciting implications for use in the real-world where, in appropriate settings, it could considerably reduce the number of malaria-carrying mosquitoes and therefore the number of malaria cases and deaths. Gene drives do not require regular distribution and can be effective by releasing just a few thousand mosquitoes in several locations, making them low cost to implement. They are also less affected by resistance and could be used in hard-to-reach areas that are not adequately tackled by existing methods, or alongside the scale up of existing tools such as nets and insecticides.

Transforming global disease diagnosis, control and surveillance

The COVID-19 pandemic has focussed global attention on the key role that diagnostics play in life-saving decisions for both personal health and our collective health security. Novel, intelligent diagnostics which integrate with health systems management and detect parasites evading conventional tests are clearly essential both now and for the future. Smart, portable, handheld diagnostics are emerging with the ability to generate accurate diagnosis at point-of-care, while providing real-time surveillance data for effective public health control. Smart diagnostics could also be transformative for the most remote and poorly resourced settings, where access to diagnostics services is often challenging. An interdisciplinary team at Imperial College London is addressing all these needs at once, developing a smart molecular diagnostics device that brings the lab directly to the patient.

Bringing the lab to the patient



Four years ago, Imperial College London established a cross-faculty collaboration between the fields of medicine, engineering, and the natural sciences to develop novel digital diagnostic technologies for infectious diseases. The resultant technology – called **Lacewing** – is a lab-on-chip diagnostic platform

bringing the sensitivity of molecular diagnostics usually found in a well-resourced laboratory to the point-of-care, in a portable format with real-time connectivity.

Lacewing is a handheld, battery powered, device using interchangeable cartridges to diagnose different infectious and non-infectious diseases, with tests currently in development for malaria, dengue, aspergillus, SARS-CoV-2, and bacterial pathogens. The device will also be able to distinguish between bacterial and viral infections and detect antimicrobial resistance. The ability to differentiate between diseases with similar symptoms will help to detect new diseases that could be a threat to global health security.

Lacewing connects to a smartphone with a user interface, providing data analysis, reporting and decision support. This means data can be reported in real-time so that a response to epidemics or emerging threats can be mobilised immediately. Critically, the device uses a Bluetooth connection for the transfer of data to the smartphone, meaning it does not require internet or mobile connectivity at the point-of-care.

Research grants from the UK government's Global Challenges Research Fund have been critical to the Lacewing project, as well as to the work of other UK partners in the **Digital Diagnostics for Africa Network**, an interdisciplinary and international community of experts established in 2020 to re-imagine models of healthcare in Africa. The Network is currently composed of 71 members from 23 partner organizations in 11 different countries in the UK, Africa, Europe, and United States, and comprises of researchers, representatives of not-for-profit organizations, and commercial organizations, with diverse expertise working collaboratively to develop and implement smart diagnostics in Africa.



Fighting drug resistance with advances in treatment

British organisations are supporting the development of new drugs to ensure effective treatments against malaria continue to be available in the face of growing drug resistance. New formulations are helping to cure people faster and in a single dose, as well as playing an essential role in reducing global malaria case incidence and mortality rates.

The fastest acting antimalarial^{xix}

In response to increasing resistance to the drug artemisinin, pharmaceutical company Novartis has been working in partnership with the Medicines for Malaria Venture (MMV), a British-funded Product Development Partnership, to find alternative treatments for the most severe form of malaria. This work has led to the discovery of a number of new drugs from different antimalarial classes.

Emerging evidence suggests that one of the new drugs – **Cipargamin** – could match the effectiveness of standard treatments used today, while demonstrating a fast cure rate amongst antimalarial agents^{xx}. And crucially, it does so in a way that will allow us to retain our ability to fight malaria in the face of growing resistance to existing treatments. With the support of Wellcome, one of the leading funders in global health, a study is underway exploring how Cipargamin could be used to treat children as young as six months old presenting with severe malaria. The results of this study - expected in 2023 - could have important implications for protecting children from this deadly disease in their first months of life.



Curing malaria in a single dose

British pharmaceutical company GlaxoSmithKline (GSK) has long played a critical role in malaria innovation and research. Working in partnership with MMV, they have developed a drug known as **tafenoquine** (Kozenis[®]/Krintafel[®]), a radical cure preventing relapsing infections of a type of malaria commonly found in Asia-Pacific and Latin America. Tafenoquine represents the first single dose treatment of its kind for 60 years. As the first-ever antimalarial treatment to be delivered as a single dose, tafenoquine combats a significant challenge posed by previous medicines, which required up to a 14-day course of treatment to treat this type of malaria. Not only will the shift to a single dose revolutionise treatment for patients, but it will also help to improve adherence by making it much easier to ensure the full treatment is taken.

For the first time, GSK and MMV have also been able to develop a formulation of this radical cure that is suitable for children, who bear a disproportionate burden of malaria. The Tafenoquine Exposure Assessment in Children (TEACH) study found that 95% of the children who received the treatment showed no recurrence of malaria. With funding from Unitaid and donors such as UK Foreign, Commonwealth and Development Office (FCDO) and the Bill & Melinda Gates Foundation, MMV is now working with PATH (a global health non-profit) to understand how these treatments can be best delivered through health systems in malaria endemic countries following regulatory approvals.



Strengthening our toolbox for the future with malaria vaccines research

The search for a highly effective, all-ages malaria vaccine dates back over a century, with clinical trials first beginning in the 1940s. Today over 100 malaria vaccine candidates have made it to human trials, and UK organisations are breaking boundaries by leading the development of two malaria vaccines that have progressed further than any before^{xxi}. These first-generation malaria vaccines could provide an important compliment to the scale up of existing interventions such as insecticide-treated nets, and are helping to pave the way for more powerful malaria vaccine candidates in the future. As scientific advances open new areas of research, such as mRNA vaccines and monoclonal antibodies, UK scientific leadership, expertise and investment will remain critical to ensuring the search for a highly effective, all-ages malaria vaccine continues to move forward.

Driving the malaria vaccine pipeline

For over two decades, scientists at pharmaceutical company GSK – headquartered in Britain – have worked with partners including PATH to develop a vaccine to prevent malaria. The result was **RTS,S/AS01e**, the first vaccine proven to protect against malaria. Since 2019, a pilot study with three African countries (Ghana, Kenya, and Malawi) has been ongoing. The implementation has been led by Ministries of Health, coordinated by the WHO, and funded by British-backed multilaterals Gavi, the Global Fund to fight AIDS, Tuberculosis and Malaria and Unitaid. Despite the COVID-19 pandemic, the pilot has maintained high coverage levels and has administered over 2.1 million doses of the vaccine, with over 740,000 children



receiving at least one dose. Results of this pilot are now being reviewed, and could see RTS,S/AS01e become the first malaria vaccine to gain a positive recommendation from the WHO for broader use later this year. This would add an extremely valuable extra tool to our toolkit as we work to get back on track towards global malaria elimination targets and the ultimate eradication of this disease.

In parallel, the **R21/MM** vaccine, developed at the same Institute as the Oxford-AstraZeneca COVID-19 vaccine, has shown promising results in early trials. In April 2021, the Jenner Institute, based at the University of Oxford, reported high-level efficacy of 77% among 450 children in Burkina Faso. The Institute has now commenced final-stage human trials, working with partners across Burkina Faso, Kenya, Tanzania, and Mali to vaccinate 4,800 children. If these trials are successful, R21/MM could be in use later this decade.

Ensuring impact and effectiveness

As well as driving the development of new vaccine candidates, UK science has also played a critical role in understanding the potential impact of malaria vaccines, and how they can best be used and deployed. For example, a 2015 study of the RTS,S/AS01e vaccine, funded in part by the UK Medical Research Council and UK Department for International Development, estimated that for every 200 fully vaccinated, children 233 malaria cases are prevented, and one child's life is saved. The study also estimated that it could cost as little as \$25 to prevent each clinical malaria case. And in August 2021, a study coordinated by LSHTM and funded by the UK Joint Global Health Trials^{xxii} found that using the RTS,S/AS01e vaccine in seasonal settings in combination with preventative drugs reduced child hospitalisations and deaths by 70% compared to current interventions, paving the way for ever more effective delivery of these lifesaving tools. As new tools come into use, it will be important for countries to have a full array of options to choose from, tailoring the right tool to the right context for maximum impact.

Securing the future for people and planet

To help us understand and respond to shifts in the number and distribution of malaria cases, researchers at LSHTM are using data to predict the impact of climate change on the spread of malaria, while scientists at Sanofi are showing that industry and nature can work in harmony to cure diseases and protect biodiversity.

Learning from nature and protecting biodiversity

Led by British CEO Paul Hudson, and with a strong heritage and presence in the UK employing over 1,100 people in Reading, Haverhill and Cambridge, international pharmaceutical company Sanofi plays an important role in the global health landscape. The company places emphasis on learning from the natural environment, and developing new synthetic versions of key treatments in order to protect against environmental degradation that can happen as a result of overexploitation. One example of Sanofi's work with nature is **Semi-Synthetic Artemisinin**. Artemisinin, a compound of several malaria treatments, is extracted from the plant *Artemisia annua*, but the natural supply of artemisinin is subject to shortages as well as significant price fluctuations because the plant has a long growing cycle, harvesting is labour-intensive, and rapidly changing market demands have led to supply imbalances. In 2012, scientists at Sanofi studied the natural substance in a lab to develop a version that could replace the natural source and leave the plants untouched. Semi-synthetic artemisinin is now registered in more than 20 countries and has led to price and stock stability, ensuring that access to malaria medicines are more accessible and affordable.

Predicting the future of climate change and malaria

Understanding how, when, and where environmental and climate changes may impact malaria transmission will be vital to effectively deploying key interventions and ensuring that health systems can respond. In this context, a recent study **projecting the risk of mosquito-borne diseases in a warmer and more populated world**, led by LSHTM with support from the University of Liverpool and others, is an important step forward in building a picture of potential future scenarios. While currently around four billion people are living in areas at risk of malaria, the study estimated that 8.4 billion people could be at risk from malaria and dengue by the end of the century *if* emissions keep rising at current levels and identified areas where temperatures could become suitable for malaria-carrying mosquitoes for the first time, or where the length of the malaria season may increase. UK institutions have a track record as world leaders in disease modelling, as shown throughout the COVID-19 pandemic, and this work will become ever more important as malaria control and elimination becomes increasingly complex.



Recommendations

Over the last two decades great strides have been made in the fight against malaria, with the innovation and expertise of British science, reinforced by the leadership and investment of the UK Government, playing a critical role.

The strength of the UK biotech and life sciences sector, combined with government funding for global health research and development needed for projects to come to fruition, have been crucial in providing the technical expertise and next-generation tools required to drive progress towards malaria eradication.

At the same time, UK aid investments in Africa and beyond – through direct programming and support to vital institutions like the Global Fund to Fight AIDS, Tuberculosis and Malaria - have helped to ensure these tools reach people in unprecedented numbers and have strengthened the frontline health systems needed to ensure they are accessible in the right places, at the right time, and at the right cost. The UK Government's 2016-2021 commitment to spend £500 million per year fighting malaria provided the foundation for this vital role.

With emerging threats posing an increasing risk to this life-saving progress, the role of the UK – and UK science in particular – have never been more important. Britain is uniquely positioned to ensure an ongoing supply of new innovations that can help end malaria for good, and to work with partners in endemic countries to build the systems needed to get them to those that need them, now and in the future. In doing so, we can help save almost two million additional lives by the end of the decade, as well as create a safer world for us all, by building the capacities and infrastructure needed, not only to detect and fight malaria, but also to prevent and respond to potential pandemics and other global health risks.

To seize this opportunity, and ensure the UK continues to be seen as both a science superpower and a leader on malaria eradication, the UK Government should:

- Foster a prosperous environment for life sciences in the UK, to ensure British businesses, universities and manufacturing companies continue to propel the development of new tools and strategies to tackle diseases like malaria.
- Ensure the UK remains the second largest donor in the malaria fight, delivering a package of investments that matches the ambition of the £500 million per annum commitment that positioned Britain at the forefront of the global malaria campaign over the last five years. This package of investments should include:
 - Long-term financing for malaria research and innovation - with a particular focus on support for Product Development Partnerships (PDPs) - to ensure the development of crucial tools needed to adequately prevent, detect, diagnose, and treat malaria.
 - Investments in bilateral programming, with a focus on strengthening community health systems to ensure that even the poorest and most marginalised communities have access to the tools and treatments they need to fight malaria and can combat emerging new diseases which could threaten the world.
 - An early and ambitious pledge to the 7th replenishment of the Global Fund to Fight AIDS, Tuberculosis and Malaria, to ensure key tools and treatments are delivered at scale, reaching women and children in over 100 countries, and saving millions of lives.

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