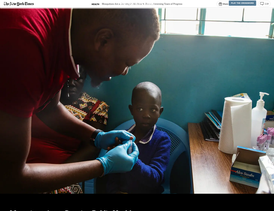

Mosquitoes Are a Growing Public Health Threat, Reversing Years of Progress

Climate change and the rapid evolution of the insect have turned about-up malaria deaths and Farragut's dengue and other mosquito-borne viruses to places that never had to worry about them.

The reading Chamber exhibit at the Dunham Bookshop contains the Rare Collection. Photo: Alexandra Rubin/Longform Podcast/Longform Podcast
Click to enlarge the reading Chamber exhibit at the Dunham Bookshop contains the Rare Collection. Photo: Alexandra Rubin/Longform Podcast/Longform Podcast

Alexandra Rubin | Photographs by Mark Dunham
Alexandra Rubin reported this story from Tanzania in Africa and Latin America and produced and directed the Netflix feature documentary Blood Brothers.

Aug. 31, 2022

Along hundreds of miles of Lake Victoria's shoreline in Kenya, a squadron of young scientists and an army of volunteers are surging into the lake's shallows and wetlands to eliminate tens of millions of mosquitoes that pay after an earlier, the mosquitos.

They are testing new insecticides and ingenious new ways to deliver them. They are pouring in windows at night, watching for the mosquitoes that home in on sleeping people. They are spraying the walls of huts — from bales, from backpacks, from pail buckets and from 18ed pumps — to block the pathways the mosquitoes carry.

But Eric Ochomo, the entomologist leading the effort on the front lines of global public health, stand recently in the swampy grass, laying to hand, and acknowledged a grim reality: "It seems as though the mosquitoes are winning."

Less than a decade ago, it was the humans who appeared to have the upper hand in the fight — more than a century old — against the insects that for 2000 years, at least, that progress has not very stalled, it has reversed.

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The insecticides used since the 1970s, to spray in houses and on bed nets to protect sleeping children, have become less or effective, mosquitoes have evolved to survive them. After decline to a historic low in 2015, malaria cases and deaths are rising.

Tiny Insect, Giant Menace

The 3mm mosquito is responsible for more human deaths than any other animal on Earth. Here's why it's so deadly.

Mosquitoes Are a Growing Public Health Threat, Reversing Years of Progress

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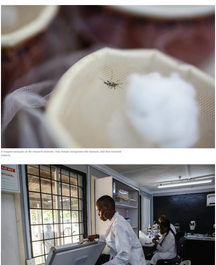

The Malaria Medical Research Institute in Kisumu collects mosquitoes under Dunham Bookshop. Trapped mosquitoes are tested, sorted, and prepared for the manufacturing regime.

Climate change has brought mosquitoes carrying viruses that cause dengue and chikungunya, encroaching and sometimes deadly forests, to places where they have never been found before. Once a purely tropical disease, dengue is now being transmitted in Florida and Frances. This past summer, the United States saw its first cases of chikungunya, a disease that has left people with rare cases reported, in Texas, Florida and Maryland.

"The situation has become challenging in new ways to places that have historically had these mosquitoes, and also at the same time other places are going to face new threats because of climate and environmental factors," Dr. Ochomo said.

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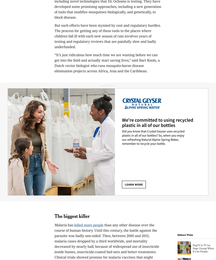

A crowded mosquito in the research laboratory. Other female mosquitoes bite humans, and thus transmit diseases.

Technician Valentine Mbajah lights taken mosquitoes from a dewater. The trapped insects are frozen in 80 Nova. Here, mosquitoes in a cage. Female mosquitoes bite humans and thus transmit diseases.

Scientists around the world are pressing hard for new solutions, including genetically engineered mosquitoes. Dr. Ochomo is testing. They have developed some promising approaches, including a new generation of tools that sterilize mosquitoes biologically, and potentially, to block disease.

But such efforts have been stymied by cost and regulatory hurdles. The process for getting out of these tools to the places where children fall ill with each new season of rain involves years of complex regulatory reviews that are painfully slow and hardly understand.

"It's ridiculous how much time we are wasting before we can get into the field and actually start saving lives," said Bart Knols, a Dutch vector biologist who runs mosquito-borne disease elimination projects across Africa, Asia and the Caribbean.

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The biggest killer

Malaria has killed more people than any other disease over the course of human history. Until this century, the battle against the parasite was badly one-sided. Then, between 2000 and 2015, malaria cases dropped by a third worldwide, and mortality decreased by nearly half, because of widespread use of insecticide-treated bed nets and other mosquito-control measures. Artemisinin, Clinical trials showed promise for malaria vaccines that might protect the children who make up the bulk of malaria deaths.

That success lured new investment and talk of wiping the disease out all together.

But malaria deaths, which fell to a historic low of about 375,000 in 2010, rose significantly over the next two years and stood at 620,000 in 2015, the last year for which there is global data.

There were more cases of dengue in Latin America in the first half of this year than in all of last year, according to the World Health Organization. Bangladesh is in the grip of its largest ever dengue outbreak, with 220,000 cases by the end of August. Cases of and deaths from chikungunya and other mosquito-borne infections have started rising, too, in many regions of the world.

Entomologists at the Malaria Medical Research Institute testing and mosquito-technologies is a model village hidden in plain sight.

Jackson Gatwang, a specialist in cages, Malaria Mapping, supervised by an adult supervisor, carries the mosquitoes. The cage is made of a special material that allows the mosquitoes to feed on the blood and lay the eggs.

One of the main reasons is that mosquitoes are highly adaptable. As more and more people are protected by nets or sprays at home, mosquitoes have begun to bite more outdoors and in the daytime, instead of indoors and at night, the historic pattern of the malaria parasite. Dr. Ochomo said that the mosquitoes' genetics and mosquitoes evolve quickly in response to changing environmental conditions; they have also developed resistance to the class of insecticides in nets — while the malaria parasite itself is increasingly resistant to the new highly-effective drugs used to treat it.

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And a new mosquito that thrives in urban areas has come from Asia to Africa, where the spread of malaria had always been confined largely to the countryside. The change has made more than 100 million additional people vulnerable to mosquito-borne illnesses, researchers at the University of Oxford recently estimated.

The multiplying risks, experts say, mean there's an urgent need for a method to protect people from the mosquitoes — one that will help defend against malaria, but also dengue, yellow fever and chikungunya, which are also spreading in Africa, and other mosquito-borne diseases that are a threat to the Indian subcontinent.

But it takes a decade or more to design, develop, test and produce a new technology in mosquito. Concerns that with the six week life spans of mosquitoes, which are constantly evolving to elude the ways we try to kill them.

The bulk of the money for these efforts to date has come from high-income nations and private philanthropy, but funding levels have plateaued. Multiple researchers said it was increasingly difficult to find the kind of investment they need for large-scale trials of new methods.

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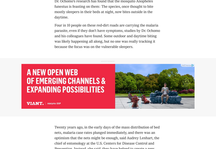
"Sooner or later, funding bodies are going to divert that money to other things," Dr. Knols said. "They're going to say, 'We're putting it into agriculture, or into schooling.'"

A new problem



Scientists in Bonia County, Kenya, where the entomologist Eric Ochomo oversees two large clinical trials of new tools to fight mosquitoes.

In the towns and villages of Bonia County in Kenya, the roads begin to fill with the city's well the security people of Lanes, with farmers on the way to their fields, children in freshly pressed uniforms walking to school and contract drivers reporting to the shuttles.

Dr. Ochomo's research has found that the mosquito Anopheles funestus is feeding on them. The species, once thought to bite mostly sleepers in their beds at night, now bites outside in the daytime.

Four in 10 people in these red-dirt roads are carrying the malaria parasite, according to a recent unpublished survey. Dr. Ochomo and his colleagues have found, farm workers and daytime biting was likely happening all along, but no one was really tracking it because the focus was on the vulnerable sleepers.

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Twenty years ago, in the early days of the mass distribution of bed nets, malaria cases were plunged immediately, and there was an optimism that the nets might be enough, said Audrey Lenhart, the chief of entomology at the U.S. Centers for Disease Control and Prevention, who has been studying mosquitoes in Africa for years.

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Processing blood samples collected from children in the Ashakira Health Center as part of a clinical trial of a new mosquitocidal method.

Mosquitoes slides with blood collected from children enrolled in the clinical trial.

Insecticides that don't work

Most of the current insecticides in use are pyrethroids, which were developed in the 1970s and have been used in agriculture and medicine to an ancient mosquito deterrent made by crushing asters flowers. They have been used for everything, including bed nets and for spraying on walls.

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With mosquitoes around them the world over highly resistant to them, there is an urgent search for something new.

In 2005, the Bill & Melinda Gates Foundation invested $10 million in a partnership with the Swiss-based chemical multinational to search for effective insecticide compounds. The consortium asked large agrochemical companies to look in their chemical libraries for molecules that might affect mosquitoes in novel ways and be safe and durable enough.

"We started with four and a half million compounds, and we've down to four," said Nick Hamon, who recently retired as the consortium's chief innovator.

To work as a new insecticide, compounds have to be safe for people and mammals, and they must be durable enough. They have to kill mosquitoes in a substantively different way than pyrethroids do, because mosquitoes develop resistance not just to an individual chemical, but to the way the chemical kills them.

Companies must now complete the safety and testing process on the four compounds identified by Mr. Hamon and his partners. It is extremely costly and slow, said Susanne Stoiber, the chief chemist at the German chemical company BASF.

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"It's always a race with the mosquito, who is faster. Usually, the mosquito wins because it develops the resistance much faster than new products come out," she said.

Dr. Johnson inspecting a pond near a home in Jazmín, a village on the coast of Lake Victoria, for larvae from malaria mosquitoes.

The edge of Lake Victoria in Siaya County, western Kenya, the area of the mosquito study.

Hanging up squeezed repellent panels in a home. The panels are intended to protect people from mosquito bites when they are inside rather than when they are outside.

The World Health Organization requires two large randomized clinical trials, carried out in two different geographic environments, before it will consider a new insecticide compound on public health it both, before it will recommend use of a new intervention against mosquitoes. The organization says the policy is designed to make sure that countries with limited means are making the best decisions about where to spend their money and time to combat the disease. Dr. Christopher Dye, director of the world's multiplying mosquito problems increasingly require solutions tailored to specific situations. What works to protect children in the African Sahel won't be what works to protect loggers in forests in Cambodia.

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Dr. Ochomo is the principal investigator on two large randomized clinical trials of mosquito interventions. In one ED million project, researchers are testing the effectiveness of spatial repellents — squares of plastic film that can be hung on the walls inside homes and that disperse low doses of a chemical that confusers mosquitoes and prevents them from biting — in both dengue and malaria risk areas.

S.C. Johnson & Son Inc., the Wisconsin-based company that developed the spatial repellent being trial in Kenya, has donated millions of dollars in products for testing. Such largesse is unusual for a sustainable pathway for corporate engagement, Dr. Isaac Sakali Sakali Ochomo, a professor of biological sciences at the University of Eldoret, who is the principal investigator for the spatial repellent trial, which is also running in countries including Mali and Sri Lanka.

The spatial repellents and most other new tools are commodities: Items that have to be bought, then bought again six months or a year later, and then bought again. Other is temporary, as is the funding that allows for their purchase.

The Gates Foundation, the major backer of most of the clinical trials of the commodities, has also had to cover most of the cost of BASF's testing of new chemicals for use on bed nets, because there is not sufficient profit incentive for a private firm to do it, Dr. Stoiber said.

"How do you keep the companies that know how to innovate in this space?" Dr. Hamon asked. The Innovative Vector Control Consortium lost one of its key industry partners in 2017.

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Dr. Ochomo preparing to deliver a cooler of spatial repellent panels for mosquito bites in refrigerated storage facility at a Kenya Medical Research Institute site in Siaya.

Nelson Evanjo, 78, and his kids Ib with malaria-free or no, the owner a cow. She was given a mosquito-proof cattle house to keep her safe as part of a randomized controlled trial.

Mary Otieno, 50, and her 12-year-old daughter Cynthia had to be hospitalized three times last year with malaria.

"They just said, 'We can make more money somewhere else,'" Dr. Hamon said.

Some experts believe the emergence of dengue fever, and new mosquitoes that bite in daylight, underscore why pesticide companies were funding because it creates a wealthier market that may span new corporate investment.

Skeptics in the entomology world look at the race for new commodities, and suggest it ignores a lesson from history: They point to the fact that mosquitoes have been a problem for humans more than a century ago will once again give humans the edge over mosquitoes. In Europe and the America in the early 1940s, and in Brazil in the 1950s, it was large-scale environmental management and changes to housing that made a difference, said Dr. Christopher Dye, a mosquito-borne zoologist who has worked all over Africa, Europe and Asia.

That means draining breeding sites, spraying larvicides (which are biological toxins and don't cause resistance) or water that can't be drained and moving homes out of swampy areas. To protect people from mosquitoes inside their homes, mosquitoes and solid walls and roofs with closed eaves, better housing.

"If we had spent the last 10 years doing these things, with the same budget, where would we be today?" Dr. Hajmadsen said.

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Hope and challenges

While malaria cases are far lower than they were 20 years ago in the Busia area, the stalled progress means the disease continues to erode family health, income and futures.

"When there is a malaria case in the house, it suspends life," said Mary Otieno, a farmer who lives about an hour's drive outside the Busia area. Her 12-year-old daughter Cynthia had to be hospitalized three times last year with malaria, she said. The family then had to spend what is needed for treatment.

"If there's a chicken in the house you can sell it," she said.

A chicken might be worth 600 Kenyan shillings, or $5, a trip to the medical clinic, with transport, a diagnostic test and drugs for malaria, will cost at least that much. Repeated bouts of malaria can wipe out the family's savings, or force them to dip into those savings. Mrs. Otieno said she must stay home from the fields she farms to care for a sick family member for a few days every month.

Dr. Ochomo and his team recently received data from the midpoint of the clinical trial of spatial repellents. Malaria cases were significantly lower in families that had them compared to those that had devices that used placebo repellents. If that trend holds, Dr. Ochomo said, he will be able to tell the Kenya Ministry of Health of spatial repellents, then the Kenyan government to buy them.

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It won't be hard to convince people in Busia to use them, though, he said.

"People already know that nets are not enough, they need something more, and they're happy to see us," he said. "They say, 'Finally, someone is coming to try to help with this.'"

Tony Joseph, Guest Memoer
The Tony Joseph is a freelance journalist and author of three books.
Journalists are not straight lines but complex.

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Stephanie Nano covers global health. She has reported on public health, economic development and humanitarian crises, including a Pulitzer prize-winning series on the work of aid groups in Haiti.
Nick Cumo is a longtime reporter, has worked in more than 30 countries, the Washington bureau for the Associ Associated Of Associated Of. Follow Nick on Twitter.

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