University of Basel

The Resistant Mosquito

Video Transcript

A brief history of malaria vector control

In this brief presentation, I would like to outline the ecological basis and history of malaria vector control and explore how it has evolved over the last century.

While lauded for his 1897 discovery that mosquitoes transmitted malaria, it was Sir Ronald Ross's 1908 publication "Theory of Happenings" that provided the mathematical underpinnings for our mosquito control strategies.

Ross recognised an equilibrium between infected and uninfected people, based on recovery and transmission pressure, depending on specific characteristics of the mosquito vector.

He realised that, quote: "a limit must be reached when the new infections exactly balance the recoveries".

Ross's fundamental insight was what we now refer to as the "R-Naught". R-Naught is the transmission value for communicable diseases. It relates to the average number of new infections generated from a single infective case in a population.

For malaria, it showed that we don't have to eliminate all mosquito vectors in a location. We just need to ensure that we can control them sufficiently so that R-Naught is less than one and that the recoveries outnumber new infections.

This was later refined in the "Vectorial capacity model", which takes into account mosquito density, anthropophily -- that is the preference of mosquitoes for feeding on humans -- and the daily probability of mosquito survivorship in relation to the number of days it takes for the malaria parasites to develop within the mosquito. Only older female mosquitoes, generally more than 10 days old, depending on the temperature, can transmit malaria.

Professor George Macdonald built on this model, determining that even a small reduction in mosquito daily survivorship would have a far greater impact on R-Naught and malaria transmission than a change in mosquito density or feeding behaviour.

This insight coincided with the development of the insecticide DDT and the strategy of Indoor Residual Spraying at the end of World War II. As many malariologists were coming out of military medical corps, a military-style approach to vector control was developed with the great hope of eradicating malaria. After early regional successes, the WHO set up the Global Malaria Eradication Program in 1955.

While very successful in many ways, the development of insecticide resistance in the key mosquito species, and a limited systems capacity, were significant challenges to the programme, especially in sub-Saharan Africa. Eventually it was accepted that overreliance on a single solution -- for example, indoor house spraying with a limited number of residual insecticides -- could not overcome the complex challenges of global malaria eradication.

This was famously described by Dr. Jose Nájera, former director of the WHO malaria programme:

"Before DDT, malariologists were trained as problem solvers; after DDT, malariologists were trained as solution implementors."

The ensuing years saw the development of new insecticides: the organophosphates insecticides in the 1950s, the carbamates in the 1960s, and the pyrethroids in the 1970s.

While new insecticides and insecticide-based interventions and techniques were developed, there was still a strong reliance on singular approaches, for example, a single type of mosquito net everywhere, a single type of spray applied everywhere.

This is changing. The latest WHO Global Technical Strategy for malaria confirms that it is no longer "one size fits all". Based on the principles of integrated pest management and integrated vector management, we can adapt our insecticide-based interventions, and combine with non-insecticidal interventions, such as improved housing and larval source management, as well as coordinate with other users of agricultural and domestic pesticides to make the best use of available resources to reduce transmission and mitigate the development of insecticide resistance.

Our vector control toolbox is expanding. We have new spatial repellents, attractive targeted sugar baits, new insecticides and combinations, and new improved technologies for targeting and application. We are expanding our reach beyond nets and IRS to address the needs of mobile populations and families displaced through humanitarian emergencies.

But we are taking lessons from the past, based on the insights of Ronald Ross and Professor George Macdonald, as well as the principles of vectorial capacity and integrated vector management. I am optimistic that we have the strategies and are developing the tools for the future.

That is to mitigate the development of insecticide resistance and to build the capacities for problem solving, to find local, integrated solutions to reduce transmission, R-Naught, and eliminate malaria.