Revolutionizing Vector Control for Malaria Elimination

The potential role of aerial insecticide spraying in malaria elimination

Key Messages

- Aerial application of insecticide has been, and continues to be, used in high resource settings for decades to control insect populations and disease transmission as part an integrated vector control strategy; aerial spraying was also used during the mid-20th century Global Malaria Eradication Program in many malaria-endemic countries across Hispaniola, Africa, and Asia
- In Africa today, aerial spraying with adulticides (insecticides to kill adult insects) is used to control locusts as well as Tsetse flies that transmit African trypanosomiasis, and aerial larviciding (insecticides to kill insect larvae) is used at large scale to control blackfly populations that transmit onchocerciasis
- Fleets of spray aircraft exist in Africa, as well as Asia-Pacific and Latin America, and can be repurposed, where appropriate, for *Anopheles* control to intensify and accelerate progress toward malaria elimination
- The use of unmanned aerial vehicles (UAVs) to deliver insecticide is growing in high resource settings and there is increasing interest in lower resource settings, but significant regulatory barriers remain
- The potential for aerial insecticide spraying to dramatically reduce malaria transmission should be examined through operational research in malaria endemic areas, supplementing current interventions and with close monitoring of insecticide resistance and impact on non-target organisms

More Aggressive Vector Control Approaches Are Needed to Reach Elimination Goals

With near-term malaria elimination targets, countries are working to optimize and scale current interventions, but in many places more aggressive approaches will be needed to achieve zero transmission. Countries are introducing new drug-based approaches to target parasites in humans; similarly, use of new or underutilized vector control approaches is needed to better target mosquito populations evading current interventions, including insecticide treated nets (ITNs) and indoor residual spraying (IRS). As part of an integrated approach, aircraft have been used since the 1920s in the US and for decades in other high resource settings (e.g. Australia, Japan, Germany) to control agricultural pests and disease vectors, including *Anopheles* mosquito populations. Aerial delivery of DDT and other insecticides was a component of several malaria elimination programs worldwide during the Global Malaria Eradication Program between 1950 and 1970. Despite utilization of aerial spraying, there is a dearth of evidence on the impact of aerial insecticide application on malaria transmission and is therefore not widely used in malaria endemic areas. Aerial infrastructure, including fleets of aircraft, pilots and maintenance teams, and spray technology exist across Africa, the Asia-Pacific, and Latin America and can be repurposed for *Anopheles* control. Eliminating countries need ready solutions to drive down transmission, and testing aerial approaches in real-time will expand the evidence base and could lead to significant impact on vector populations and malaria transmission.

The Potential of Aerial Spraying for Malaria Vector Control

The Malaria Elimination Initiative (MEI) at the University of California, San Francisco, Global Health Group partnered with aerial spray experts from Micron Sprayers Ltd, the Manatee County Mosquito Control District in Florida, the Innovative Vector Control Consortium, and Imperial College London to expand documentation of aerial spraying and opportunities to deploy aerial application for malaria elimination. The MEI also convened a meeting in December 2015 with domestic and international aerial experts to exchange information on aerial insecticide application and identify a potential role for aerial spraying for malaria elimination. These activities contributed to the following objectives:

1. Describe existing aerial infrastructure in high and low resource settings today
2. Understand how aerial application was used in the past and how it is being used today
3. Identify the potential role for aerial application for malaria elimination

Expertise and Infrastructure Exists to Test Aerial Spraying for *Anopheles* Control

Over 200 spray aircraft (helicopters and fixed-wing) are available in Africa, 3,800 in South America, and nearly 1,400 across the Asia-Pacific and Australia. Spray technology has advanced and is increasingly more precise for both adulticiding and larviciding. Insecticide options exist for both mosquito adulticides and larvicides that have not yielded resistance to date. Testing aerial technology first to optimize its use in different settings will help recalibrate and subsequently scale for impact. However, implementing any intervention in isolation will have more limited impact than implementing an integrated approach using multiple tools and targeting different vector behaviors and life stages.[2] Aerial spraying, like all vector control tools (VCTs), should be targeted and based on local ecology and vector biology. Like other vector control methods, aerial spraying is not a one-size-fits-all approach but rather an additional tool which can be used in combination with other methods.

Ground-based larviciding has a very long history in both high and low resource settings, and recent normative guidance and policy recommendations for larviciding[1] have prompted scale up. Harnessing this momentum, aerial application can potentially supplement ground-based application in larger areas such as rice fields or wetlands where aerial would be more efficient than manual application or in areas where there are cryptic larval habitats only findable and reachable by air. Aerial adulticiding (i.e. space spray) to control nuisance and vector mosquitoes in the US is routine but supplemental to aerial and/or ground larviciding when adult vectors are abundant or in response to disease outbreaks. Aerial adulticiding is conducted to cover wider areas not reached or efficiently covered by ground adulticiding. There is more limited evidence around ground-based space spray or aerial adulticiding for *Anopheles* control, but this should not limit testing of the approach for impact.

Unmanned aerial vehicles (UAVs) were first investigated for use in agriculture and forestry in the late 1970s. In recent years, advances in technology have led to enormous interest in UAVs for vector and pest control, both for remote sensing and application of insecticides. In Japan, for example, UAVs are used to control pests in over 60% of the agricultural settings. UAVs may be advantageous compared to manned aircraft in more spatially selective applications for targeting villages or small areas with adulticides or more likely larvicides. UAVs can be operated with very limited resources and do not require complex infrastructure. However, the productivity of UAVs is less than manned aircraft (e.g. payload capacity is less, flight distances are shorter) and there are significant regulatory hurdles to consider, along with yet unanswered questions around the impact of UAV insecticide delivery on mosquitoes and malaria.

Aerial Spraying as Part of the Malaria Vector Control Toolbox

With emerging interest in aerial application by global partners and malaria programs, the MEI's analysis of aerial spraying with an expanded toolbox of new or underutilized VCTs demonstrates that supplementary options exist and should be tested and scaled. These findings expand the idea of what is possible and challenge the status quo in malaria vector control.

Further operational research is needed to understand the entomological and epidemiological impact of aerial spraying on *Anopheles* populations and malaria transmission.

- Countries and partners should work to understand the operational feasibility and cost-efficiency of aerial spraying compared to current interventions and ground-based larviciding and adulticiding

- Operational research to test and compare the impact of both manned and unmanned aerial spraying on the vector populations and malaria transmission should be undertaken to expand the evidence base and inform scale-up
- Field trials should examine aerial spraying in different settings—e.g. rice and sugar plantations, wide flood plains, etc.—to understand optimal eco-epidemiological settings for these interventions
- Guidance should be developed on operational implementation of aerial spraying when feasible and cost-efficient, supported by robust entomological, ecological, and insecticide resistance monitoring and evaluation
- Evidence should inform policy recommendations and financing for targeted and effective use of aerial application

References

1. World Health Organization. Larval source management: a supplementary measure for malaria vector control: an operational manual. Geneva: WHO; 2013. Available from: http://apps.who.int/iris/bitstream/10665/85379/1/9789241505604_eng.pdf
2. World Health Organization. Handbook for Integrated Vector Management. 1st ed. Geneva: WHO; 2016. Available from: http://apps.who.int/iris/bitstream/10665/44768/1/9789241502801_eng.pdf