

# Vector control operations framework for Zika virus

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# Introduction

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Zika virus is primarily transmitted by the *Aedes* species of mosquito which is also responsible for the spread of dengue, Chikungunya and yellow fever viruses. In most areas, the primary vector of these viruses is *Aedes aegypti*, with *Aedes albopictus* a proven or potential vector in some settings. Well-implemented vector control against *Aedes* using existing tools effectively reduces the transmission of viruses spread by these vectors. Pilot studies are being undertaken on new tools which have potential for future reductions in *Aedes* populations. Efforts to prevent Zika virus transmission should prioritise the intensification of control measures against *Aedes* using existing tools. Although one recent study<sup>1</sup> has examined the effectiveness of community mobilization for dengue prevention, vector control tools for *Aedes* control have not yet been evaluated for disease impact.

For rapid impact, surveillance and control should build on existing national structures rather than seeking to establish new or parallel structures. In many countries of Africa, this will entail augmenting existing capacity in malaria control programmes. In some countries of the Americas, South-East Asia and the Western Pacific existing dengue control programmes can be built on. Such leveraging of existing human, infrastructure and organizational resources will facilitate more rapid and effective response to the threat or an outbreak of Zika virus disease. Additional impact on other significant *Aedes*-borne diseases may also result.

## Prevention should target all *Aedes* mosquito life stages

*Ae. aegypti* are day-biting mosquitoes while *Ae. albopictus* usually bite in the early morning and late afternoon. *Ae. aegypti* typically rest indoors and fly short distances up to 80 metres. Eggs are usually laid in artificial containers found in and around homes such as those used for domestic water storage and decorative plants as well as rain-filled habitats like used tyres, discarded food and beverage containers and blocked gutters. *Ae. albopictus* tend to rest outdoors and inhabit both domestic and peri-domestic artificial containers (e.g. rubber tapping cups filled with rain water, roof gutters etc.) as well as natural receptacles such as tree holes and plants. Ground pools and other stagnant water bodies are *not* usually preferred for egg laying by either species. Eggs hatch into immature larvae which develop into pupae and then emerge out of the water as adult mosquitoes. Anti-mosquito efforts can therefore target the destruction of eggs, larval or pupae in these water containers, or can target the adult mosquitoes where they fly, feed or rest.

## Surveillance must be conducted concurrently

Entomological surveillance is vital for any good vector control initiative. Vigilant monitoring at points of entry is imperative for countries at risk of *Aedes* introduction. For areas with established populations, monitoring *Aedes* at immature (mainly larvae and pupae) and adult life stages should be undertaken. For immatures, it is essential to know the key containers in a given setting as studies have shown that as few as 3-5 container types can sustain 80% of the total pupal population in an area. This requires an assessment to quantify larval and/or pupal populations across all containers in the area. Knowledge of the spatial distribution, density, and resting sites of adults are also important if this stage will be targeted for control. The species composition and their susceptibility to insecticides either in use or planned for use should also be determined. This information will facilitate appropriate and timely decision-making for interventions. Further details can be found in *Entomological surveillance for Aedes spp. in the context of Zika virus* and *Monitoring and managing insecticide resistance in Aedes mosquito populations* (available online from <http://www.who.int/csr/resources/publications/zika/en/>).

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<sup>1</sup> Andersson, N et al. Evidence based community mobilization for dengue prevention in Nicaragua and Mexico (Camino Verde, the Green Way): cluster randomized controlled trial. *BMJ*, 2015; 351:h3267. doi: 10.1136/bmj.h3267.

# Vector control options

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## Measures targeting eggs, larvae and pupae

Given that *Aedes* mosquitoes are domestic, families and the general community must be actively involved in eliminating mosquito breeding sites from their homes. These should be accompanied by appropriate community sensitisation, engagement and mobilisation along with a well-coordinated risk communication strategy. Based on assessment of the most productive key containers in an area, the following control measures should be carried out.

### ***For small water receptacles such as discards and other waste***

- Conduct community clean-up campaigns to remove or destroy small discards that are serving as water receptacles, such as plastic containers, tin cans or scrap metal.
- Ensure tyres are stored properly, removed to landfill sites or recycled.
- Clean roof gutters and home coolers.

### ***For medium to large containers that hold water for domestic use***

- Empty, clean and scrub to remove eggs and other immature stages each week before refilling.
- Place tight-fitting covers to prevent female mosquitoes from laying eggs.
- Introduce larvicides recommended by the WHO Pesticide Evaluation Scheme (WHOPES) to kill immature mosquitoes.

### ***For other large containers such as ornamental pools, wells and cisterns***

- Introduce native larvivorous fish or other larvivorous aquatic insects.

### ***For irrigation and storm water canals or other relevant water bodies***

- Implement efficient irrigation practices such as weekly flushing.
- Improve drainage.
- Fill temporary pools.
- Ensure gutters are free flowing without any stagnant pools.

Numerous options are available for larvicides including WHOPES-recommended insecticides, insect growth regulators or biological control agents<sup>2</sup>. These can be effective when used correctly, provided that the vector populations are susceptible. Many slow release formulations are now available for larval control.

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<sup>2</sup> World Health Organization. WHOPES-recommended compounds and formulations for control of mosquito larvae. Geneva, 18 March 2016. Available online from [http://who.int/entity/whopes/Mosquito\\_larvicides\\_March\\_2016.pdf](http://who.int/entity/whopes/Mosquito_larvicides_March_2016.pdf) (accessed 24 May 2016).

## Measures targeting adult mosquitoes

### **Targeted residual spraying**

Targeted residual spraying is the primary vector control intervention for immediate response. It is performed using appropriate insecticides applied on *Ae. aegypti* resting sites such as exposed lower sections of walls (<1.5m), under furniture, inside closets, in dark and moist surface where mosquitoes may rest in and to a lesser extent, around houses. Targeted residual spraying is applied selectively to areas known to be resting sites for the Aedes mosquito – it does not require the spraying of all exposed surfaces in houses. Suitable insecticides can be applied with hand-operated compression sprayers. Power sprayers can be used to treat large accumulations of discarded containers (e.g. tyre dumps) rapidly, if no other option is possible. Care must be taken not to treat containers used to store water intended for drinking or cooking.

### **Space spraying**

In the event of a vector-borne disease outbreak, authorities should implement space spraying with the objective of killing adult vectors in order to reduce virus transmission. An appropriate WHOPEs-recommended insecticide should be selected<sup>3</sup> on the basis on information on the susceptibility of the local Aedes population. Indoor space spraying is more effective than outdoor treatment if deployed properly inside buildings where Aedes mosquitoes rest and bite. Space spraying targets adult mosquitoes while they are in flight and has no residual effect; its application outdoors may not reach all mosquitoes especially those indoors. Recommended application techniques include ultra-low volume space spraying (cold fog or thermal fog) and using portable backpack sprayers or thermal foggers, which vaporize liquid insecticide into droplets to form an aerosol or fog with a rapid “knockdown effect” on mosquitoes.

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<sup>3</sup> World Health Organization. WHO recommended insecticides for space spraying against mosquitoes. Geneva, 5 February 2016. Available online from [http://who.int/entity/whopes/Space\\_Spray\\_products\\_February\\_2016.pdf](http://who.int/entity/whopes/Space_Spray_products_February_2016.pdf) (accessed 24 May 2016).

# Personal protection measures

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Health authorities should advise residents and travellers to any country with documented Zika virus transmission to take the necessary measures to protect themselves from day-biting mosquitoes. This is especially important for pregnant women. Recommended measures include:

- Application of repellents to exposed skin or clothing, which should contain DEET (N, N-diethyl- 3-methylbenzamide), IR3535 (3-[N-acetyl-N-butyl]-aminopropionic acid ethyl ester) or Icaridin (1-piperidinecarboxylic acid, 2-(2-hydroxyethyl)-1-methylpropylester). Repellents must be used in strict accordance with the label instructions, and if used as such, are safe for pregnant women.
- Wearing clothing that minimizes skin exposure to mosquito bites during daylight hours, when mosquitoes that transmit Zika virus are most active.
- Using window screens, door screens and air-conditioning in buildings to discourage day-time entry, biting and resting of *Aedes*.
- Using WHOPEs-recommended long-lasting insecticidal mosquito nets<sup>4</sup> when sleeping or resting during the day (e.g. for pregnant women, infants, elderly or sick individuals).

It is important that people infected with Zika virus or other mosquito-borne diseases protect themselves from mosquito bites to prevent further transmission. Patients, their household members, and the community should be educated about the risk of transmission and how to minimize this risk by reducing contact with mosquitoes. Zika virus may circulate in areas where other mosquito-borne diseases are present (e.g. dengue, yellow fever or Chikungunya.).

## **Special measures for pregnant women**

Countries affected by Zika virus can explore special protection measures for pregnant women. This can include giving repellent lotion and a treated mosquito net (for use while sleeping during the day) to pregnant women who visit health centres to confirm pregnancies or for regular check-ups. Advocacy and one-on-one communication on the key personal protective measures for Zika virus and other *Aedes* borne diseases should also be provided. Interventions targeting pregnant women should be evaluated for safety during implementation.

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<sup>4</sup> World Health Organization. WHO recommended long-lasting insecticidal nets. Geneva, 1 April 2016. Available online at [http://who.int/whopes/Long-lasting\\_insecticidal\\_nets\\_April\\_2016.pdf](http://who.int/whopes/Long-lasting_insecticidal_nets_April_2016.pdf) (accessed 24 May 2016).

# New vector control tools

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Several promising potential new vector control tools have been reviewed by WHO in the context of the response to Zika virus. These have the potential to reduce vector populations and/or viral multiplication to minimal levels and thereby to prevent transmission. While several tools are supported by strong evidence of entomological effect, there is a lack of comprehensive data on epidemiological impact for any *Aedes*-borne viruses. Thus, full-scale programmatic deployment is not currently recommended.

However available evidence warrants the pilot deployment of two of the new tools under operational conditions, accompanied by rigorous independent monitoring and evaluation. Randomized controlled trials with epidemiological outcomes should be carried out to build evidence for the use of these tools to control *Aedes*-borne diseases.

- 1. Microbial control of human pathogens in adult vectors (Wolbachia):** Available evidence indicates that a strain of symbiotic *Wolbachia* spp. bacteria (wMel), when introduced into *Ae. aegypti* populations, reduce the ability of the mosquitoes to transmit arboviruses to humans. Laboratory results show that wMel *Wolbachia* infection reduces the replication of dengue, Chikungunya and Zika viruses within *Aedes* mosquitoes, and eliminates or substantially delays the appearance of virus in mosquito saliva, thus reducing the competence of the mosquito to transmit viruses. Implementing this tool involves establishing and sustaining wMel *Wolbachia* in local *Aedes* mosquito populations, thereby providing ongoing protection from virus transmission.
- 2. Mosquito population reduction through genetic manipulation:** OX513A is a transgenic strain of *Ae. aegypti* engineered to carry a dominant, repressible, non-sex-specific, late-acting lethal genetic system, together with a fluorescent marker. Larvae carrying the OX513A gene develop normally, but die before functional adulthood. This technology has been demonstrated to reduce *Ae. aegypti* populations in small-scale field trials in several countries, but there is an absence of data on epidemiological impact. Implementing this tool requires the sustained release of transgenic male mosquitoes to maintain suppression of wild *Ae. aegypti* populations.

The timing and decision on a pilot deployment of the above tools will depend on factors including:

- appropriate regulatory and ethical clearance by host countries;
- sufficient community engagement and acceptance of the intervention;
- scale of the planned pilot;
- capacity of the host country to deploy, sustain, and properly monitor the pilot;
- manufacturing scalability (e.g. ability to produce the quantity of OX513A or *Wolbachia*-carrying mosquitoes required within a given timeframe);
- ecological and epidemiological considerations at the chosen pilot site.

Pilot deployment should be accompanied by a robust monitoring and evaluation system to ensure that evidence is generated on the effectiveness of the new intervention. The decision to deploy new tools should be guided by national regulations and international best practices, including maintenance of existing effective vector control during pilot deployment. Such a decision should involve country regulatory authorities, disease specific health departments and medical research institutes.



# Vector control strategies

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## A. Actions to be taken in countries without *Aedes*

Countries and regions should enhance and strengthen capacity for surveillance of both vector populations and arboviral diseases. Existing surveillance networks should be leveraged to strengthen surveillance and data sharing in order to monitor the spread of arboviruses, the dynamics and insecticide susceptibility status of vector populations, and the risk of disease outbreaks. Such surveillance should be an integral part of a comprehensive epidemic preparedness, surveillance and response system.

## B. Actions to be taken in countries with *Aedes*, but no evidence of Zika virus circulation

- I. **Responsible ministries at national and state levels must play a direct and pro-active role.** Programme authorities should implement entomological surveillance and vector control at the scale needed to prevent or control Zika virus transmission. To be most effective, action must be taken before an increase in Zika virus cases occurs.
- II. **Promote mobilization of the whole community.** This includes intersectoral collaboration with the participation of sectors such as health, education, environment, local government, social development and tourism. Non-governmental organizations, operational partners and private entities should also be engaged.

## C. Actions to be taken in countries with *Aedes* and evidence of Zika virus transmission

- I. **Stratify areas.** Following a situation analysis and stratification exercise, areas with the highest transmission (highest numbers of cases) or that are at the highest risk of transmission (high density of vectors) should be prioritised. Where priority areas encompass large populations such as in cities, sub-priority areas should be identified for intensified vector control. A situation analysis should include an assessment of the insecticide resistance status of target vector species, including the gathering of new data if this is lacking.
- II. **Understand and prioritise local vector breeding sites to target reduction strategies.** Adult and immature populations should be assessed frequently to inform the development of broad, comprehensive vector control measures. An analysis of *Aedes* aquatic habitats in the locality/community will help to identify the most productive containers for prioritised vector control. The assessment should incorporate larval and/or pupal counts as indicators for identifying these productive containers.
- III. **Implement adult control measures.** Adult control measures, primarily using targeted residual spraying and/or space spraying, should be implemented along with source reduction measures for at least 4-6 weeks to significantly reduce vector density in areas of high transmission.

## Risk communication and social mobilisation

In countries with confirmed Zika virus transmission, national public health authorities should implement social mobilisation strategies and develop a risk communication strategy. Authorities should seek to engage the community in vector control and to apply personal protection measures. The mobilisation of community groups for regular door-to-door campaigns should be encouraged.

The elimination of breeding habitats and simultaneous implementation of larvicide and adulticide treatments are essential to achieve a rapid decline in mosquito densities, and to reduce or interrupt virus transmission. While these are necessary emergency measures during an outbreak, the most effective intervention for prevention and protection is the elimination of mosquito aquatic habitats, the use of screens on doors and windows in houses, and other personal protection measures.

**Table 1. Vector control operational strategies according to country context**

<b>Country Context</b>	<b>Countries without Aedes</b>	<b>Countries with Aedes, but no evidence of Zika virus circulation</b>	<b>Countries with Aedes and evidence of Zika virus transmission</b>
<b>Category</b>	<b>A</b>	<b>B</b>	<b>C</b>
Monitor points of entry for <i>Aedes</i> species introduction	✓		
Intensify immature and/or adult entomological surveillance, including identification of key containers producing the highest number of immatures		✓	✓
Implement source reduction measures		✓	✓
Integrate source reduction measures with disease surveillance			✓
Apply larvicides to key containers not amenable to source reduction		✓	✓
Conduct community education and mobilisation		✓	✓
Conduct adult vector control in areas with Zika virus transmission or high risk, preferably using targeted residual spraying			✓
Conduct insecticide resistance monitoring of <i>Aedes</i> mosquitoes where insecticidal interventions are in use or planned		✓	✓
Promote personal protection, including the appropriate use of repellents (B, C) and mosquito nets (B,C)		✓	✓
Monitor and evaluate the quality and impact of control measures		✓	✓