Vector control operations framework for Zika virus

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Introduction

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[1] 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/).

[1] 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

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[2]. These can be effective when used correctly, provided that the vector populations are susceptible. Many slow release formulations are now available for larval control.

[2] 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 (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[3] 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.

[3] 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 (accessed 24 May 2016).

Personal protection measures

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[4] 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.