Appendix F: Vector Control Procedures

There are a number of vector control procedures that should be considered to mitigate the risk of CHIKV expansion in an area (Table F1).

Table F1. Vector Control Procedures

Environmental management	**Adult mosquito control**
• Reduce larval habitats	• Use of IT bednets
• Manage (wash/cover) containers	• Use of IT curtains
• Discard/recycle containers	• Lethal ovitraps
• Reduce human-vector contact	• Space sprays
• Install window screens	• Indoor Residual Treatments
Larval control	**Resistance testing**
• Source reduction	
• Chemical control	**Operational research and efficacy evaluation**
• Biological control	

Chemical control of larval habitats

If potable water vessels cannot be screened or covered, they should be cleaned regularly or treated to stop larval production according to WHO-WHOPES recommended practices for potable water[66]. Potential larval habitats that do not contain water intended for human consumption may be treated with larvicides listed in Table F2.

Table F2. WHO-recommended compounds and formulations for control of mosquito larvae in container habitats[a]

Insecticide	Formulation[b]	Dosage[c]	WHO hazard classification of active ingredient[d]
Organophosphates			
Pirimiphos-methyl	EC	1	III
Temephos	EC,GR	1	U
Insect growth regulators			
Diflubenzuron	DT,GR, WP	0.02-0.25	U
rs-methoprene[e]	EC	1	U
Novaluron	EC	0.01-0.05	NA
Pyriproxyfen[e]	GR	0.01	U
Biopesticides			
Bacillus thuringiensis israelensis[e]	WG	1-5 mg/L	U
Spinosad	DT,GR,SC	0.1-0.5	U

[a]WHO recommendations on the use of pesticides in public health are valid only if linked to WHO specifications for their quality control. WHO specifications for public health pesticides are available at http://www.who.int/whopes/quality/en/ instructions must always be followed when using insecticides.
[b]DT=tablet for direct application; GR=granule; EC-emulsifiable concentrate; WG=water-dispersible granule; WP=wettable power; SC=suspension concentrate
[c] mg/L of active ingredient for control of container-breeding mosquitoes
[d]Class II=moderately hazardous; Class III=slightly hazardous; Class U=Unlikely to pose an acute hazard in normal use; NA=not available.
[e]Can be used at recommended dosages in potable water.

Space sprays for adult mosquito control

Space sprays for *Ae. aegypti* and *Ae. albopictus* control are most effective when the inside of houses and associated yards are treated with handheld units. Repeated applications are required to kill newly emerging adults. In an epidemic response, space sprays should be carried out with handheld units whenever

possible, or with truck-mounted units to increase speed of coverage, every 2-3 days[66]. Attention to resistance testing, calibration of equipment, droplet size and timing of application are all critical to effective use of these tools[66]. Large scale truck and airplane based application of pesticides are generally not effective in controlling *Ae. aegypti* when used alone[76]. Large-scale space spraying must be used as a component of an IVM program to be effective. Table F3 provides information on insecticides suitable to *Ae. aegypti* and *Ae. albopictus* control.

Table F3. Examples of insecticides for cold aerosol or thermal fog application against mosquitoes[a]

Insecticide	Chemical	Dosage of active ingredient (g/ha)		WHO hazard classification of active ingredient[c]
		Cold aerosols	Thermal fogs[b]	
Fenitrothion	Organophosphate	250-300	250-300	II
Malathion	Organophosphate	112-600	500-600	III
Pirimiphos-methyl	Organophosphate	230-330	180-200	III
Bioresmethrin	Pyrethroid	5	10	U
Cyfluthrin	Pyrethroid	1-2	1-2	II
Cypermethrin	Pyrethroid	1-3	-	II
Cyphenothrin	Pyrethroid	2-5	5-10	II
d,d-trans-Cyphenothrin	Pyrethroid	1-2	2.5-5	NA
Deltamethrin	Pyrethroid	0.5-1.0	0.5-1.0	II
D-Phenothrin	Pyrethroid	5-20	-	U
Etofenprox	Pyrethroid	10-20	10-20	U
λ-Cyhalothrin	Pyrethroid	1.0	1	II
Permethrin	Pyrethroid	5	10	II
Resmethrin	Pyrethroid	2-4	4	III

[a]Adapted from: *Pesticides and their application for the control of vectors and pests of public health importance*[77]. Label instructions must always be followed when using insecticides

[b]The strength of the finished formulation when applied depends on the performance of the spraying equipment used.

[c]Class II=moderately hazardous; class III=slightly hazardous; class U=unlikely to pose an acute hazard in normal use;

NA=not available

Indoor Residual Sprays for adult mosquito control

Traditionally, Indoor Residual Sprays (IRS) have been used most successfully against malaria vectors (Table F4). IRS treatment should be effective against *Ae. aegypti* which rests indoors, though it may be difficult to apply operationally. Generally, all the interior walls and ceilings of a house are treated. For control of *Ae. aegypti*, it is important to treat bedrooms, closets, the undersides of beds and other dark areas where *Ae. aegypti* adults rests before and after taking a bloodmeal. Residents should be informed that IRS are safe when applied according to the label, but that individuals with health concerns, such as those with asthma or allergies, should take measures to reduce or eliminate exposure during the application process.

Table F4. WHO recommended insecticides for the use as indoor residual sprays[a]

Insecticide compounds and Formulations[b]	Class group[c]	Dosage g a.i./m^2	Mode of action	Duration of effective action (months)
DDT WP	OC	1-2	contact	>6
Malathion WP	OP	2	contact	2-3
Fenitrothion WP	OP	2	contact & airborne	3-6
Pirimiphos-methyl WP & EC	OP	1-2	contact & airborne	2-3
Bendiocarb WP	C	0.1-0.4	contact & airborne	2-6
Propoxur WP	C	1-2	contact & airborne	3-6
Alpha-cupermethrin WP & SC	PY	0.02-0.03	contact	4-6
Bifenthrin WP	PY	0.025-0.05	contact	3-6
Cyfluthrin WP	PY	0.02-0.05	contact	3-6
Deltamethrin WP, WG	PY	0.02-0.025	contact	3-6
Etofenprox WP	PY	0.1-0.3	contact	3-6
Lambda-cyhalothrin WP, CS	PY	0.02-0.03	contact	3-6

[a]Available at (http://www.who.int/whopes/Insecticides_IRS_Malaria_09.pdf)
[b]CS = capsule suspension; EC = emulsifiable concentrate; SC = suspension concentrate; WG = water dispersible granule; WP = wettable
[c]OC = Organochlorines; OP = Organophosphates; C = Carbamates; PY = Pyrethroids
Note: WHO recommendations on the use of pesticides in public health are valid ONLY if linked to WHO specifications for their quality control. WHO specifications for public health pesticides are available on the WHO homepage on the Internet at http://www.who.int/whopes/quality/en/.

Resistance Testing

Frequent application of the same insecticide or class of insecticide may select for individual mosquitoes that are able to survive pesticide applications[78].

Resistance is a heritable change in the sensitivity of a population to an insecticide that may lead to failure of the pesticide to yield the expected degree of control.

The number of insecticides available for use as adulticides are limited and fall into three chemical classes: organophosphates, carbamates and pyrethroids. Some products for larviciding have different modes of actions, such as insect growth regulators and microbials tools[78]. However the most commonly used product for controlling larvae of *Ae. aegypti* in containers is the organophosphate temephos. Resistance to temephos has been detected in multiple *Ae. aegypti* populations in the Americas[79, 80] and poses a serious threat to *Ae. aegypti* control. Little information is available about resistance in *Ae. albopictus* populations in the region.

Control programs must include a resistance monitoring program[81-83] (additional references available at http://www.who.int/whopes/resistance/en/) to assess efficacy and to establish a pesticide rotation plan to mitigate the development of resistance.

Supervision, Safety and Quality Assurance

Continuous monitoring and supervision are required to ensure that staff are adequately trained and are following appropriately technical guidelines for pesticide application and personal safety77. IVM programs must include a quality assurance program designed to monitor the effectiveness of the control activities. A quality assurance program should monitor applicator performance

and control outcomes. Control failures may be due to misapplication, incomplete coverage, or insecticide resistance, and must be corrected immediately. Quality assurance efforts should be continuous, systematic, and independent