PacMOSSI

Manual for **PLANNING & MANAGING** Control of *Aedes* vectors in the Pacific

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CONTENTS

ABBREVIATIONS

AAR	After Action Review
Bti	*Bacillus thuringiensis israelensis*
CBO	Community Based Organisation
DPO	Disabled People's Organisations
ENSO	El Niño–Southern Oscillation
EOC	Emergency Operation Centre
FBO	Faith Based Organisation
GEDSI	Gender equality, disability and social inclusiveness
GVCR	Global Vector Control Response (2017 – 2023)
IAR	Intra-Action Review
IHR	International Health Regulations
IMT	Incident Management Team
IRS	Indoor Residual Spraying
ITN	Insecticide Treated Net
MDA	Mass Drug Administration
MMF	Mono-molecular film
MoH	Ministry of Health
NGO	Non-Governmental Organisation
NHIS	National Health Information System
ORS	Outdoor Residual Spraying
PoE	Point of Entry
PIC	Pacific Island Country and area
PHEOC	Public Health Emergency Operation Centre
PPHSN	Pacific Public Health Surveillance Network
PPE	Personal Protective Equipment
PSSS	Pacific Syndromic Surveillance System
RCCE	Risk Communication and Community Engagement
RDT	Rapid Diagnostic Test
SBCC	Social and Behaviour Change Communication
SPC	The Pacific Community
TDR	Special Programme for Research and Training in Tropical Diseases
TWG	Technical Working Group
UNICEF	United Nations Children Fund
WHO	World Health Organization
VSCP	Vector Surveillance and Control Plan

GLOSSARY OF KEY TERMS

arboviral disease	Diseases caused by viruses and transmitted by arthropod insects such as mosquitoes, including dengue, chikungunya, and Zika.
built environment	Human-made or modified surroundings where people live, work and recreate, including buildings, houses, urban areas, and infrastructure.
community engagement	A process of working collaboratively with and through groups of people to address issues that affect their well-being.
disinsection	The procedure whereby health measures are taken to control or kill the insect vectors of human diseases present in baggage, cargo, containers, conveyances, goods and postal parcels;
endemic	Usual presence of the disease or virus in a specific geographic area or population group.
entomologist	A scientist who studies insects, including disease-transmitting mosquitoes.
environmental management	Modification of the environment to reduce mosquito breeding, such as draining or filling water bodies.
epidemic	Widespread occurrence of disease in excess of what would normally be expected in a defined community, geographical area, or season.
epidemiology	The study of how diseases spread, their patterns, and how to control them.
gender equality, disability and social inclusiveness	a framework that promotes equitable access to resources, services, and decision-making processes for all individuals, regardless of their gender, disability status, or other social identities. It emphasizes the interconnectedness of these factors and seeks to address the unique challenges faced by marginalized groups.
health promotion	Health promotion is the process of enabling people to increase control over and improve their health.
insecticide resistance	The ability of mosquitoes to survive exposure to insecticides that would normally kill them.
integrated vector management	Rational decision-making process for the optimal use of resources for vector control that aims to improve disease control efficiency, cost-effectiveness, ecological soundness, and sustainability.
intervention	An action or program intended to improve health outcomes, such as mosquito control measures.
key larval habitats	Types of containers or water bodies that sustain the most immature mosquitoes (larvae and pupae) and are expected to produce the greatest number of adult vectors.
larval habitat	A place where mosquito larvae develop, typically in standing water.
larvicide	A chemical or biological substance used to kill mosquito larvae in water.
mosquito control program	Coordinated set of strategies and activities designed to reduce mosquito populations and minimize transmission of mosquito-borne pathogens.
natural environment	External, non-human-made features like standing water, vegetation, and climate conditions.

operational research	Studies conducted to improve the effectiveness and operational efficiency of mosquito control programs.
outbreak	Localised occurrence of disease in excess of what would normally be expected in a defined community, geographical area, or season.
outbreak response	Coordinated actions taken to contain and control a disease outbreak.
residual spraying	Application of insecticides on surfaces where mosquitoes rest, either indoors or outdoors.
risk communication	The exchange of real-time information, advice, and opinions between experts and people facing threats to their health, economic or social well-being.
risk mapping	The process of identifying and visualizing areas with higher likelihood of disease transmission.
social and behaviour change communication	A strategic approach that uses communication to promote changes in knowledge, attitudes, norms, and behaviours.
source reduction	Elimination or modification of mosquito egg-laying and breeding sites to reduce larval habitats.
spatial emanator	A device that slowly releases airborne chemicals to repel or kill mosquitoes in a defined area.
stratification	Process of delineating geographic areas or populations into distinct groups based on their arboviral transmission risk, disease burden or other control-relevant factors (e.g. access), to guide and prioritize interventions.
surge support/ capacity	Ability to rapidly scale up resources, personnel, and systems to respond to a sudden increase in demand—such as during a disease outbreak or natural disaster.
surveillance	Systematic collection and analysis of data on mosquito populations and disease cases.
surveillance system	A structured method for continuously collecting and analysing health or vector-related data.
syndromic surveillance	Monitoring and analysing the symptoms reported by patients to detect early signs of disease outbreaks.
technical working group	A group of specialists that coordinates planning, surveillance and implementation of mosquito control programs.
vector	An organism, such as a mosquito, that transmits disease-causing pathogens to humans.
vector competence	The ability of a mosquito species to acquire, maintain, and transmit a pathogen.
vector control	Methods used to control or eliminate disease-carrying mosquitoes.

INTRODUCTION

Rationale

Mosquito-borne diseases are increasing worldwide in both incidence and geographic spread. The number of outbreaks of arboviral diseases – particularly dengue, chikungunya, and Zika – has escalated in the Pacific region in recent decades. This rise is driven by several factors: climate change can create more favourable conditions for mosquito proliferation; increased travel and trade facilitate the introduction and co-circulation of multiple viruses; and urbanization brings people into closer contact with infected mosquitoes. While outbreaks have mainly been reported in urban and peri-urban areas, rural outbreaks have also occurred.

There is currently no widely available vaccine or specific treatment for these arboviral diseases with prevention focused on control of mosquitoes. Dengue, chikungunya and Zika are transmitted by *Aedes* mosquitoes. History shows that sustained and well-coordinated *Aedes* mosquito control can substantially reduce the incidence and risk of arboviral diseases (**Box 1**). Such examples should be inspiration for what can be achieved today with a foundation of strong political commitment and leadership, sufficient funding, and supportive management structures.

The variety of settings in Pacific Island Countries and areas (PICs) present unique challenges for mosquito control. There are 13 known *Aedes* vectors across the region which each have different habitats and behaviours to consider for mosquito control. Remote locations and limited health infrastructure complicate implementation. Funding and skilled workforce are often lacking. However, PICs also present opportunities such as strong community connections that enable rapid mobilization and support for health initiatives. These factors all underscore the need for robust and technically-driven program management for evidence-based, effective mosquito control to prevent disease.

Box 1. Documented examples of *Aedes* control that reduced arboviral diseases (extracted from the Annex 2 of the *Global Vector Control Response 2017-2030*)

- **Cuba:** Drainage or oiling of standing water, fumigation and isolation of yellow fever patients with screening and netting in Havana led to elimination of yellow fever.
- **Panama:** Screening living quarters, draining or filling standing water, installing drains, larviciding using oil or Paris Green led to elimination of yellow fever (and reduced malaria).
- **Latin America:** Container inspections, oiling of larval habitats and later perifocal spraying of DDT in water containers and nearby walls in 1950s and 1960s led to elimination of *Ae. aegypti* from large parts of the region.
- **Singapore:** Entomological surveillance and larval source reduction were effective in maintaining low dengue incidence for decades (although outbreaks occurred later).
- **Vietnam:** The introduction of copepods (*Mesocyclops*) into water storage containers, combined with health education, resulted in reduced *Ae. aegypti* and *Ae. albopictus* populations and a marked decline in dengue incidence over several years.
- **Australia:** Indoor residual spraying when coverage was ≥ 60% provided significant protection against dengue in neighbouring premises during a 2003 outbreak.
- **Australia:** Release of *Wolbachia*-infected *Ae. aegypti* mosquitoes in the north-east led to the rapid spread of this transmission-blocking bacteria in local mosquito populations and contributed to significant reductions in dengue transmission.

Aim

This manual outlines best practices for mosquito control program management, with a focus on *Aedes* vector species. It highlights options for different scenarios, considering variations in vectors, environments and available resources across PICs. It provides priority activities that can be implemented even with limited resources, emphasizing the importance of community action in both surveillance and control. It also proposes a broader approach that targets all mosquitoes that live in and around people's houses and buildings that enhances community acceptance and involvement.

Audience

This has been designed as a practical guide for health staff in PICs who are responsible for the design and management of *Aedes* mosquito surveillance and control activities. This includes vector-borne disease program managers or vector officers (where present) and environmental health or sanitation officers, with the broad term of "**mosquito control programs**" used throughout the document. Information may also be useful for implementing partners and community groups.

Scope and focus

The focus of this document is on *Aedes* mosquito surveillance and control. While some components such as disease surveillance are only included in brief, these are covered in more detail elsewhere. Users are encouraged to consult other guidance documents for more detailed information (see **Section 2.7**). This document draws on information from WHO and other key sources. All major components of program management are outlined herein, including those shown in **Fig 1**.

Fig 1. Schematic of key mosquito control program components

We hope this manual inspires and guides all users to seek out and find locally-appropriate and effective solutions to tackle mosquito-borne diseases in their settings.

SECTION ONE – Pacific Context for Mosquito Control Program Management

This section:

- Highlights the different mosquito-borne diseases in the Pacific
- For each, outlines disease, vector and environmental considerations for their control
- Overviews main program management components
- Lists key technical documents for further guidance

1.1 Diseases

Distribution

The Pacific region is home to numerous mosquito-borne diseases that are transmitted by different mosquito species as summarised in **Table 1**.

Table 1. Mosquito-borne diseases in the Pacific

Disease	Distribution	Vector genera
Viral		
Dengue	Widespread; likely endemic in some countries	*Aedes*
Chikungunya	Outbreaks reported	*Aedes*
Zika	Outbreaks reported (2013-2016)	*Aedes*
Japanese encephalitis	Endemic in PNG	*Culex, Aedes*
Ross River	Endemic in PNG, Solomon Islands and likely others	*Aedes, Culex*
West Nile	Rare, occasional reports	*Culex*
Parasitic		
Malaria	Endemic in PNG, Solomon Islands, Vanuatu	*Anopheles*
Lymphatic filariasis	Reduced but still present in some PICs, especially PNG and Samoa	*Aedes, Culex, Anopheles*
Heartworm*	Present in some PICs	*Aedes, Culex, Anopheles*

* Usually infects dogs but can occasionally infect humans

Symptoms

Arboviral infections can be asymptomatic or result in severe illness, as shown in **Table 2**. Dengue, Japanese encephalitis and yellow fever can result in death. Chikungunya, Ross River and West Nile may result in debilitating symptoms lasting for months or years. Although Zika typically causes mild symptoms, it poses serious risks during pregnancy, including birth defects. Thus, these diseases can contribute to significant morbidity, prolonged recovery, and potentially mortality.

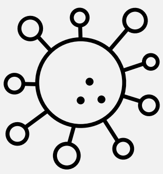
Treatment and prevention

With rising incidence—particularly of dengue— arboviral infections represent a growing public health threat, underscoring the urgent need for effective control and, where possible, elimination. Arboviral infections are often difficult to diagnose without laboratory tests as rapid diagnostic tests are costly and not widely available in the Pacific. There are no specific treatments or cures. Although vaccines exist for dengue, chikungunya, and Japanese encephalitis, they remain expensive (ranging from $20 to $1,000 per dose) and are not readily accessible in the region so coverage remains low. As a result, mosquito control remains the most practical and cost-effective prevention strategy. However, depending on the disease, vaccination may be a complementary approach especially if the population have the ability and willingness to pay.

Table 2. Clinical signs and symptoms plus diagnosis, treatment and prevention of current or potential arboviral infections in the Pacific

Disease	Dengue	Chikun-gunya	Zika	Ross River	Japanese encephalitis	West Nile*	Yellow fever*
Fever	Common	Common	Common, mild	Common	Common	Common	Common
Rash	Common	Common	Common, itchy	Sometimes	Rare	Sometimes	Rare
Joint pain	Common, mild	Common (severe, persistent)	Occasional, mild	Very common, severe	Rare	Rare	Common
Eye pain	Common	Rare	Common	Rare	Rare	Sometimes	Sometimes
Other	Shock and haemorrhage can occur in severe cases	Joint pain may persist for weeks to months	Usually mild, can cause birth defects if contracted during pregnancy	Fatigue and joint pain may persist for months	Usually no symptoms; severe cases cause encephalitis	Usually no symptoms; long-term neurological and cognitive impairment possible	Range; can include jaundice, shock or bleeding
Diagnose	RDTs in use; lab to confirm and serotype	RDTs but limited use; lab to confirm	RDTs but limited use; lab to confirm	Lab to confirm	Lab to confirm	Lab to confirm	Lab to confirm
Treat	Supportive care (avoid aspirin), monitor for warning signs	Supportive care, rest, physiotherapy for prolonged symptoms	Supportive care, pregnancy monitoring, counselling	Supportive care, rest, physiotherapy for prolonged symptoms	Supportive care, monitor for complications	Supportive care, intensive care if needed	Supportive care, hospitalisation if severe
Vaccine	Available (2) but limited use	Available but limited use	Not available	Not available	Available	Not available	Available but limited use

RDT: rapid diagnostic tests * Not currently an issue in the region but emergence remains a concern due to the presence of competent vectors.



Understanding key arboviral epidemiological factors is essential for designing appropriate mosquito surveillance and control strategies in Pacific Island contexts:

- **Disease incidence:** Real-time data guides rapid and targeted mosquito control responses to prevent and contain emerging cases.
- **Virus introduction and circulation:** Facilitates proactive mosquito surveillance and control at points of entry (PoE) and in areas with recent virus introduction to limit spread.
- **Human behaviour and exposure**: Informs targeted interventions, such as indoor spraying and personal protection, based on peak exposure times and locations.
- **Population immunity:** Enables targeting of mosquito control in areas with low immunity (or low vaccine coverage, where relevant), preventing large-scale outbreaks.

1.2 Vectors

Transmission

Arboviruses are transmitted when a mosquito bites an infected human, uptakes virus, the virus replicates in the mosquito midgut for 6.5-15 days, and is then transferred to another human they are bitten. In the Pacific, there are 13 known *Aedes* vectors of dengue, of which four are also vectors of chikungunya and Zika vectors in the Pacific. Most lay their eggs in artificial and natural water-holding containers such as drums, coconut shells, tyres and tree holes. They usually bite during early morning and late afternoon, and most often rest in or around human dwellings. These behaviours make them efficient transmitters of arboviruses to humans.

Mosquito species

The most efficient *Aedes* species are highly adapted to human environments and inhabit residential areas, laying eggs in larval habitats in and around houses. They also bite and rest in locations close to human dwellings. However, this can change depending on the suitability of conditions. Details of known arbovirus *Aedes* vectors (and vectors of other diseases) are presented in *A guide to mosquitoes in the Pacific 2023*. A summary of their known distributions is provided in **Table 3**, along with an overview of key behaviours of the 3 most widespread species in **Table 4**.

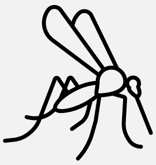
Table 3. Basic known distribution of *Aedes* vectors of arboviruses in the Pacific. Grey indicates the 3 most widespread species known to transmit dengue, chikungunya and Zika.

***Aedes* species**	**Known distribution**
Ae. aegypti	Widespread throughout the Pacific. Commonly found in urban and semiurban environments in close association with humans.
Ae. albopictus	Widespread throughout the Pacific. Often found in vegetated and shaded areas close to human habitation.
Ae. cooki	Found in Tonga and Niue. Often found on the periphery of villages rather in the centre.
Ae. hebrideus	Found in PNG and Vanuatu. Considered a semi-domestic species. Similar to *Ae. scutellaris*.
Ae. hensilli	Found predominantly in Palau and parts of Federated States of Micronesia. Can be abundant within its range.
Ae. kesseli	Found in Tonga. Inhabits an extremely wide range of aquatic habitats.
Ae. marshallensis	Widespread throughout Marshall Islands and in parts of Federated States of Micronesia and Kiribati. Common in heavily vegetated areas.
Ae. polynesiensis	Common throughout Polynesia but also recently found in Vanuatu. Mostly found in coastal areas. (Important vector of lymphatic filariasis).
Ae. pseudoscutellaris	Found in Fiji. Mostly found inland (>500 m from the coast).
Ae. rotumae	Found in Fiji in Rotuma Island.
Ae. scutellaris	Found in Papua New Guinea and Palau. Found in New Caledonia in 2016-2017 only. Form reported from Pacific region is *Ae. hebrideus*.
Ae. tabu	Found in Tonga. Member of *Ae. tongae s.l.* complex.
Ae. tongae s.s.	Found in Tonga. Member of *Ae. tongae s.l.* complex. Abundant in plantations and shady areas of villages.

Table 4. Key behaviours of 3 common arboviral vectors in the Pacific

Species	*Aedes aegypti*	*Aedes albopictus*	*Aedes polynesiensis*
Hosts	Prefers humans. Occasionally bite dogs, cats and other animals	Opportunistically feeds on humans and other animals.	Opportunistically feeds on humans and other animals.
Feeding	Prefer indoors plus shaded locations near houses	Prefer outdoors	Prefer outdoors
Resting	Indoors below 1.5m but may rest outdoors in shady areas	Prefer outdoors but may be found indoors	Prefer outdoors
Biting times	Dawn and dusk but later in some locations	Dawn and dusk but after dark in some locations	Dawn and dusk
Larval habitats	Very domestic inhabiting all sorts of artificial containers but will also utilise natural containers as well. Freshwater only	Prefers natural sites like leaf stems but may use artificial containers	Both natural and artificial containers
Flight range	50-100 m	50-200 m	Less than 100 m

Note: While traditionally considered day-biting, *Ae. aegypti* and *Ae. albopictus* have been reported to bite at night in Papua New Guinea. The important message here is never assume that mosquito behaviour cannot change and to be aware of the mosquito profiles in your own PIC.



Understanding key *Aedes* factors through mosquito surveillance is essential for designing appropriate mosquito control strategies in Pacific Island contexts:

- **Vector species presence:** ensures control measures target the correct *Aedes* vectors responsible for disease transmission.
- **Population seasonality:** allows timing of interventions to coincide with peak mosquito abundance for maximum impact.
- **Larval habitats:** enables targeted removal or treatment of key larval habitats, reducing mosquito populations at the source.
- **Biting and resting behaviour:** informs the choice and placement of control measures and personal protection.
- **Insecticide resistance:** ensures that selected chemical interventions remain effective against local mosquito populations.

1.3 Environment

The natural and built environment in the Pacific plays a critical role in the transmission and control of arboviral *Aedes*-borne diseases. The region's tropical climate, characterised by high temperatures, high humidity, and variable rainfall, creates ideal conditions for *Aedes* mosquitoes and supports efficient virus replication. Climate change is amplifying these risks, with rising temperatures and more frequent extreme weather events—such as floods, droughts, and cyclones—expanding mosquito habitats and often disrupting water and sanitation infrastructure, which in turn increases mosquito proliferation around homes and communities.

Built environments with inadequate housing, water storage, and waste management further facilitate mosquito proliferation, especially after natural disasters that damage infrastructure and create new stagnant water sources. Understanding and addressing these environmental and climate-related factors is essential for designing effective, locally tailored mosquito control strategies and for building resilience against future outbreaks in Pacific Island settings. Key environmental and climatic features in PICs are summarised in **Table 5**.

Table 5. Typical environmental and climatic features

Ecotype	PICs	Geographic features influence on *Aedes*	Climate system	Wet season
Low coral atolls	Kiribati, Tuvalu, Marshall Islands, Tokelau, French Polynesia (Tuamotu), Nauru, parts of Micronesia	Low-lying, limited freshwater, extensive use of water storage containers, high density of artificial containers near homes	Tropical, high humidity, uniform temps, drought and cyclone prone	Nov–Apr (most); some equatorial atolls less seasonal
Raised coral islands	Banaba (Kiribati), parts of Nauru, parts of Micronesia	Elevated limestone, limited natural freshwater, reliance on rainwater tanks and artificial containers for water storage	Tropical, moderate rainfall, drought-prone	Nov–Apr (most); less defined on some islands
Small & midsize high islands	Samoa, Tonga, Niue, Palau, Wallis and Futuna, Cook Islands, American Samoa, parts of Micronesia	Hilly/mountainous terrain, villages clustered near coast, abundant rainwater, both natural (tree holes, plant axils) and artificial habitats	Tropical, high rainfall, cyclones	Nov–Apr (South Pacific); May–Nov (Palau, North Pacific)
Large high islands (volcanic & continental)	Papua New Guinea, Fiji, Solomon Islands, Vanuatu, New Caledonia	Mountainous, high rainfall, urban centres with dense populations, extensive use of water storage, many natural and artificial larval habitats	Tropical, high rainfall, cyclones, volcanic activity, landslides	Nov–Apr (South Pacific); May–Oct (PNG Highlands, some northern areas)
Oceanic volcanic islands	French Polynesia, parts of Micronesia	Volcanic peaks, rainforests, urban and peri-urban settlements, abundant natural (bromeliads, tree holes) and artificial containers	Tropical, high rainfall, cyclones, volcanic activity	Nov–Apr; Marquesas less seasonal

Rural versus urban settings

Many PICs have a majority rural population. Rural areas are often remote with limited access to services but strong kinship networks and subsistence lifestyles. However, throughout the Pacific there is a gradual shift towards urbanization with populations moving from outer islands to urban centres in search of employment and better living standards. In some small island capitals and atolls, such as South Tarawa (Kiribati), Funafuti (Tuvalu), and Ebeye (Marshall Islands), population densities are extremely high. This creates challenges related to overcrowding, pressure on water and sanitation systems, and environmental risks.

Aedes mosquitoes, especially *Ae. aegypti* and *Ae. albopictus*, thrive in both urban and rural environments but their abundance, larval habitats, and control challenges differ between these settings. Effective *Aedes* vector control requires recognizing the distinct ecological and operational challenges of urban and rural environments, with tailored interventions that address the specific environmental, infrastructural and societal conditions.

Understanding key natural and built environment factors is essential for designing appropriate mosquito surveillance and control strategies in Pacific Island contexts:

- **Climatic influences:** helps predict and prepare for periods of increased vector breeding and transmission risk.
- **Urban adaptation:** highlights the need for community-wide and household-level interventions in densely populated areas.
- **Community practices**: supports the design of RCCE strategies that encourage local community participation and inclusiveness in control efforts.
- **Infrastructure and sanitation**: determines the practicality and sustainability of interventions based on local conditions.

1.4 Intervention options

Strategies should select and combine interventions based on the local context of diseases, vectors, the environment and the community. Strong community engagement will be essential for sustainable and effective *Aedes* control in the Pacific. Flexibility is key when implementing, particularly in challenging situations and settings, and when resources are limited. However, it is essential to ensure decisions are based on evidence of impact.

Table 6 lists intervention options available for *Aedes* vector control in PICs. Criteria for selecting these interventions including use scenarios and key considerations are detailed further in subsequent sections, particularly **Section 7**.

Table 6. Intervention options for control of *Aedes* vectors in the Pacific

Intervention	Intervention Options
Larval control	Container management; clean-up campaigns (waste management); larvicides; and biological agents (e.g. fish).
Adult control	IRS (indoor residual spraying); ORS (outdoor residual spraying); space spraying (fogging); *Wolbachia*-infected mosquito releases; spatial repellents
Personal protection (bite prevention)	ITNs (Insecticide Treated Nets); treated screens, curtains and clothing; topical repellents; coils and vapourisers
Health promotions, risk communications and community engagement	Community awareness to practice prevention of mosquito bites and community mobilisation to regularly eliminate larval habitats

1.5 Management of mosquito control programs or activities

The basic components of a mosquito control program are mapped out in **Fig 2**. This manual provides further details on each component. Priority actions will depend on the disease situation and resourcing. The focus is on mosquito surveillance and control, so disease surveillance and case management are covered in brief only as these are generally beyond the scope of the intended audience of this manual.

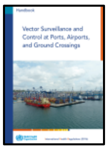
Fig 2. Components for management of *Aedes*-focussed mosquito control in the Pacific

Core program functions	•Human resourcing and training •Finances and administration •Procurement and logistics •Annual planning and reporting •Technical assistance and guidance
Strategic planning & resourcing	•Situation analysis and stratification •Vision and target setting •Costed national strategic plan •Resource mobilisation •Prioritisation
Cross-sector collaboration & partner coordination	•Municipal council and intragovernmental coordination (e.g. through TWG) •Development partner and private sector coordination (e.g. through IMT) •Advocate for legisation and policy optimisation
Disease surveillance & case management	•Diagnostic capacity •Routine surveillance and reporting •Focal (outbreak) case investigation •Case management
Mosquito surveillance	•Baseline or periodic surveillance •Routine monitoring (including Points of Entry, PoE) •Community surveillance •Outbreak entomological investigation
Mosquito control implementation	•Proactive urban programs •Proactive rural programs •Outbreak response •Strengthened legislation •Special projects
Health promotion, risk communication & community engagement	•Risk communication •Community engagement •Inclusion of all genders, people with disability and other marginalised groups
Monitoring, evaluation & learning	•Monitor disease, vector and environmental trends •Monitor implementation/process (e.g. IAR) •End-of-activity evaluation (e.g. AAR) •Impact and outcome evaluation •Operations research •Manage and analyse data

AAR: after-action review; CBO: community-based organisation; IAR: intra-action review; IMT: incident management team; TWG: technical working group

1.6 Guidance documents

Information in this manual is generally based on WHO guidance and best practice, with adaptation to Pacific contexts. All planning and implementation should be aligned with overarching national health and development plans, or relevant regional strategies or plans. The following key documents should be referred to for further information.

	**A guide to mosquitoes in the Pacific (PacMOSSI, 2023).**	Overview of the diversity, distribution, and biology of 42 medically important mosquito species in the Pacific to support disease control.
	**Framework for National Surveillance and Control Plans for *Aedes* Vectors in the Pacific (WHO, 2023).**	Guidance for Pacific Island countries to develop and implement national surveillance and control plans for *Aedes* mosquitoes.
	**Manual for Surveillance and Control of *Aedes* Vectors in the Pacific (WHO, 2020)**	Practical guidance to strengthen surveillance and control of *Aedes* mosquitoes in the Pacific, aligned with international standards.
	**Global Vector Control Response (2017-2030) (WHO, 2017)**	Global framework to strengthen vector control capacity and coordination to reduce vector-borne disease burden by 2030.
	**Vector Surveillance and Control at Ports, Airports, and Ground Crossings (WHO, 2016)**	Guidelines for vector surveillance and control at international points of entry (PoE) to prevent disease spread.
	**Handbook for Integrated Vector Management (WHO, 2012)**	Principles and approaches for integrated, coordinated, and sustainable vector control interventions.
	**International Health Regulations (WHO, 2005)**	Legally binding framework to help countries prevent, detect, and respond to cross-border public health risks, including those from vectors.

Key messages from these documents will serve as guiding principles for this manual, including:

- **Proactive vector control:** Instead of relying on disease surveillance to trigger mosquito control in response to an outbreak or epidemic, establish a sustainable program that proactively prevents or contains transmission and is well-prepared for outbreaks.
- **Engage communities:** Mobilise and engage communities to expand mosquito surveillance and control efforts, ensuring all genders, people with disability and other marginalised groups are reached and can participate.
- **Strengthen intra- and inter-sector collaboration:** Leverage key stakeholders for coordinated action.
- **Eliminate transmission:** Adopt an ambitious approach to eliminate or contain arboviral diseases, building on the previous successes in the Pacific and beyond.

SECTION TWO – Core Program Functions

This section:

- Overview mosquito control program structure and staff responsibilities
- Provides guidance on core components of human resourcing and training, financial management, and procurement and logistics

Program structure will depend on the country health priorities and workforce. In PICs with malaria, public health mosquito surveillance and control are managed by the Malaria Program. In other PICs, these are part of a wider remit of Environmental Health Officers or similar. Regardless of structure, clearly defined roles and responsibilities are important. An example organisation chart is provided as **Annex 1**. Details on prioritisation are given in **Section 3.3**.

2.1 Human resourcing and training

Human resourcing and training are critical to the success of Pacific mosquito control programs. Sustained investment in human resources not only improves operational effectiveness and data-driven decision-making but also fosters collaboration and knowledge sharing, addressing challenges such as limited technical expertise, staff turnover, and competing priorities.

Mosquito control programs should ideally be headed by a manager and include an entomologist or mosquito control specialist (**Table 7**). Example job descriptions for these are given in **Annex 2**. Staff skilled in RCCE, finance and administration, logistics and procurement, and monitoring and evaluation are needed, but this expertise may be best accessed through other sections of the ministry or department of health (MoH) via a matrix structure. This would be the case if mosquito control is one component of broader responsibilities (such as for Environmental Health Officers). Staffing should be inclusive of all genders, people with disabilities and other marginalised groups.

Table 7. Key personnel for a mosquito control program and their responsibilities. # shows where roles may be combined; * shows positions that may reside in different units or programs.

Position	General responsibilities
Program Manager	Oversee all managerial aspects of a mosquito control program including strategic planning and resource mobilization, mosquito surveillance and control implementation, community engagement, cross sectoral collaboration, partner coordination, monitoring and evaluation, research and innovation, and overall program reporting
Mosquito Surveillance/ Entomologist#	Oversee mosquito surveillance including insecticide resistance, reporting (entomological indicators)
Mosquito Control Specialist#	Oversee technical and programmatic aspects including planning (selecting interventions and products) and implementation (spraying, larval source reduction, larviciding operations), reporting (process)
RCCE Officer*	Oversee technical aspects of community awareness and mobilisation for the prevention of mosquito bites and larval habitat destruction
Finance and Administration Officer*	Oversee administrative and financial aspects of all mosquito surveillance and control activities including financial reporting
Logistics and Procurement Officer*	Oversee all aspects of logistical support for implementation of all activities and commodities procurement and supply chain including for vector control products, equipment and supplies, transport including cars and boats and their maintenance, and any related reporting requirements
Monitoring and Evaluation Officer*	Oversee technical aspects of program monitoring and evaluation, including disease and mosquito surveillance data, program indicators and reporting. (A dedicated data officer is useful if funds allow it).

Program management

The lead of a mosquito control program is responsible for all aspects of developing, adapting and applying the strategic plan including activity planning, coordination, implementation and evaluation to best leverage available human, infrastructural, institutional and financial resources. Tasks include to:

- Develop a National Strategic Plan (NSP) with key partner involvement, ensuring alignment with health sector priorities and other relevant national strategies and principles.
- Lead a team of professionals in implementing control measures and conducting surveillance activities.
- Collaborate with government agencies, health organizations, and research institutes to ensure effective intervention strategies.
- Engage community leaders, groups and members for program efficiency and success.
- Manage project budgets, resources, and reports related to mosquito control activities.
- Provide technical guidance and training to staff and stakeholders on mosquito surveillance and control best practices.
- Ensure operations compliance with health and other regulations.
- Coordinate the monitoring of disease trends, mosquito factors, and interventions, and adapt strategies accordingly.
- Advocate for policy improvements and funding allocations to support mosquito surveillance and control efforts.
- Maintain accurate records and submit reports on program effectiveness and challenges.

Mosquito surveillance and control

This entomologist or mosquito control specialist role may be filled by one or more persons responsible for all technical aspects of mosquito surveillance and control including analysing vector populations, developing and implementing control strategies, and conducting entomological or operational research. This requires expertise in medical entomology to design, implement and evaluate vector surveillance and control approaches and interventions. Tasks include:

- Conduct surveillance on mosquito species, distribution, behaviours and resistance patterns. This may include community-based initiatives.
- Develop, apply and refine mosquito control strategies based on mosquito data and epidemiological trends.
- Evaluate the efficacy of mosquito control measures where feasible.
- Train and oversight field teams on mosquito collection and identification, control techniques, and monitoring practices.
- Coordinate with public health teams to integrate activities in disease control programs.
- Collaborate with external partners, including for research.
- Oversight the maintenance of laboratory and insectaries facilities
- Oversight requirements and restock of equipment and supplies in coordination with administration officers.
- Ensure strict adherence to environmental regulations and health safety protocols.
- Prepare scientific reports, technical guidance, and mosquito control policies.

Finance and administration

In a mosquito control program, finance and administration play a vital role to ensure accurate and transparent financial records for operational efficiency, regulatory compliance and reporting to supervisors, government and development partners. Partners are likely to require funded programs to have clear financial accountability. Key functions can be seen in **Table 8**.

Table 8. Key functions of a finance and administration officer

Category	Key Functions
Strategic planning and coordination	• Participate in program planning and financial forecasting. • Provide financial insights to support decision-making and program sustainability. • Collaborate with stakeholders, including donors, government agencies, and partners.
Administration and operations	• Oversee procurement processes, ensuring transparency and cost-effectiveness. • Manage contracts, vendor relationships, and service agreements. • Ensure compliance with organizational policies and government regulations. • Supervise administrative staff and ensure efficient office operations.
Human resource management	• Support recruitment, onboarding, and staff development initiatives. • Ensure payroll processing and benefits administration. • Maintain personnel records and oversee performance management systems.
Financial management	• Develop and oversee budgeting processes to ensure proper allocation of resources. • Maintain accurate financial records, including accounts payable and receivable and the reconciliation of cash advances during field activities. • Manage cash flow and financial reporting to stakeholders. • Ensure compliance with financial regulations, donor requirements, and audit standards. • Conduct financial risk assessments and implement mitigation strategies.
Regulatory compliance and reporting	• Ensure adherence to tax regulations and financial reporting requirements. • Prepare financial statements and reports for management and donors. • Coordinate audits and implement recommendations for financial improvements.

Logistics and procurement

As most PICs are in remote locations, procurement times can be very long. This means that all commodities need to be procured well in advance. *Aedes* vector surveillance and control commodities may include the following plus other items:

- Mosquito larval collection tools (sweep nets, funnel traps)
- Mosquito adult traps and batteries
- Adult cages and larval trays
- Microscopes and supplies such as slides, immersion oil
- Consumables such as pipettes, tubes, cotton wool, sugar
- Insecticide resistance kits and papers
- Insecticides (including adulticides and larvicides)
- Spray equipment (and spares)
- Personal protective equipment (PPE) for spray teams
- Topical repellents
- Insecticide-treated nets (ITNs)
- Print materials such as flyers, booklets, leaflets

For those commodities for community deployment, or subnational distribution, delivery channels should be well established. For instance:

- Traps, insecticides, spray equipment and PPE can be stored at a central, secure and safe location for access or transport by field staff when needed

- ITNs and topical repellents can be issued to hospitals or clinics for provision to viraemic patients upon diagnosis and/or discharge.

Programs are advised to consult widely with different experts before finalising the specifications or product to procure. Only products on the *WHO Vector Control Product List* should be procured as these have been evaluated for safety, quality and efficacy. The latest list should always be checked as this is updated frequently. For advice on how to select and quantify insecticides, see the *Manual for surveillance and control of* Aedes *vectors in the Pacific* and *Operational manual on indoor residual spraying: control of vectors of malaria,* Aedes*-borne diseases, Chagas disease, leishmaniases and lymphatic filariasis*.

Correct handling and storage of insecticides is extremely important to protect human, animal and environmental health, and to ensure storage stability of the product. Import and storage procedures, and costs should be planned and adequately budgeted for. Once insecticidal products are received by the mosquito control program, it will be difficult to carry out quality assurance. Therefore, where feasible and appropriate, commodities should have an inspection undertaken by an independent organisation before shipping (Pre-Delivery Inspection). While the quality of insecticides is difficult to quantify on arrival in a PIC all other aspects should be inspected in terms of packaging, quantities or weights received etc. **Measures should be taken to prevent supplies and equipment (especially insecticides) from being delayed at ports due to poor planning and follow-up.**

2.2 Annual planning and reporting

Good planning ensures efficient performance of activities while reporting is necessary to record what has taken place and what the results of those actions has been. Both are essential activities and support resource mobilisation. Strategic plans provide the overall approach and budget requirements over numerous years (see **Section 3**). Annual activity plans set the stage for activities that the MoH intends to undertake in the short-term and funds available for those activities. An example of an annual plan is provided as **Annex 3**. Progress against the annual plan should be reviewed regularly, such as each quarter or six-months. Formal reporting at time points throughout the year may also be required by development partners. More frequent reviews of activities and timelines should be done during regular team meetings and should refer to the annual plan.

2.3 Technical assistance and guidance

When well-coordinated by the MoH, external technical assistance can be highly beneficial by providing access to appropriate specialized expertise, training, and resources. Regional partnerships such as PacMOSSI and the Pacific Vector Network also help avoid duplication of efforts, ensure efficient resource allocation, and foster information exchange.

Technical guidance developed by MoH and partners, such as operational manuals, handbooks and job aids, should align with WHO guidance and best practice, and be adapted to the local situation.

PacMOSSI has a range of technical materials available that can be provided in editable format upon request to pacmossi@jcu.edu.au

SECTION THREE – Strategic Planning & Resourcing

This section:

- Outlines core documentation for a mosquito control program or activities
- Overviews the key components and process for developing VSCPs
- Provides brief guidance for resource mobilisation and prioritisation

Sound information management (including collection, storage and use) and documentation are an essential component of good program management. Development of documents may take some time and may be an iterative process. Documents should be as brief as possible. A digital library is recommended for organising all documents, as well as relevant databases for mosquito-borne disease surveillance data and reports.

Examples of key documents include:

- Costed VSCP (including situation analysis)
- Annual Operational Plan (or business plan)
- Operational manuals or handbooks
- Standard Operating Procedures (SOPs)
- Vector surveillance and control forms (e.g. household inspections, residual spraying)
- Vector surveillance data and reports
- Community engagement and communication materials
- Stock keeping and inventory templates
- Human resource organisational charts and coordination matrix
- Staff and consultant Terms of Reference (TORs)
- Monitoring and Evaluation (M&E) frameworks and reporting templates
- Risk management, contingency or emergency plans
- GEDSI plan linked to all components of the strategy
- Funding proposals and agreements
- Budget tracking spreadsheet
- Short activity or travel reports
- Operations research reports

3.1 Vector Surveillance and Control Plan (VSCP)

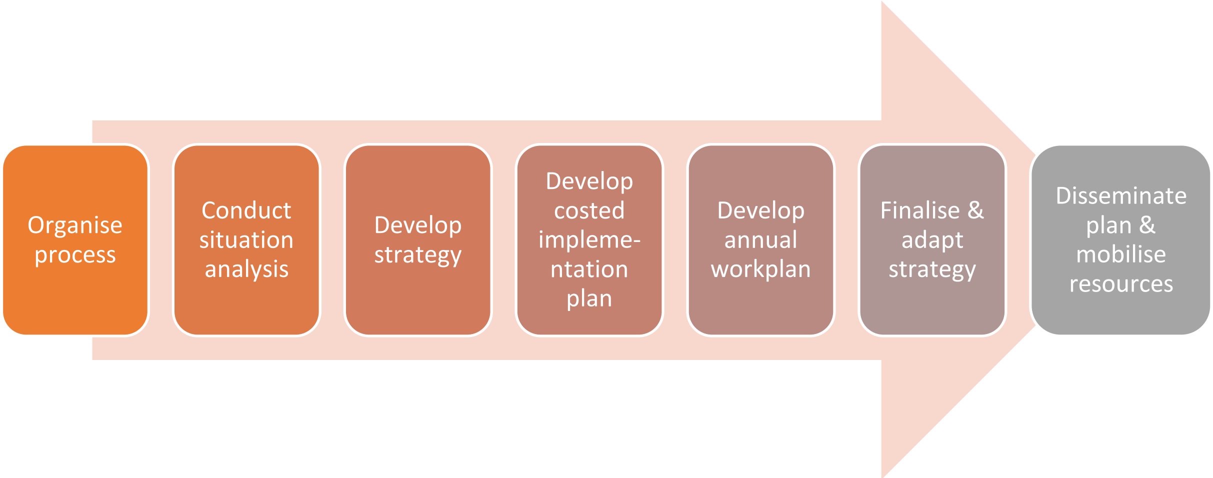
VSCP development should be led by the Ministry of Health but representatives of other sectors and partner organisations should provide inputs, since mosquito management actions often go beyond the scope of health alone. This is a good way to ensure there is broad understanding of needs and the respective roles of different sectors in mosquito control. This strategy document should be the basis for any control program or activities and should be reviewed every 2-3 years or updated as necessary, such as when the disease situation evolves or new interventions become available. Developing the vision along with realistic but ambitious goals and targets to prevent, contains and control disease is important.

The four main components of a VSCP are:

1. a situation analysis that compiles epidemiological, entomological, intervention, community and gender equality, disability and social inclusiveness (GEDSI) information;
2. a costed strategic plan that usually covers 3–5 years and outlines the objectives, goals, desired outcomes, approach and M&E framework plus the associated budget;
3. implementation plan that indicates timelines and responsibilities for each activity; and
4. a detailed annual work plan of each activity in the VSCP that aligns with the national annual budgeting cycle.

Key steps in the development of a VSCP are summarised in **Fig 3**. Detailed guidance on each step is available in the *Framework for National Surveillance and Control Plans for Aedes Vectors in the Pacific* (WHO, 2023).

Fig 3. Overview of steps in strategic planning



Situation analysis

Core elements to consider within a situation analysis are summarised in **Table 9**. Identifying data sources and generating summary information on these elements provides context and key considerations for the VSCP. The process of collating information should be guided by the Ministry of Health with support from partners from other sectors or organisations with the specific knowledge required. Developing the situation analysis is a useful way to engage and involve partners in formulation of the VSCP from the start. However, partners should ensure where possible that intellectual ownership of the program remains with the Ministry of health.

Table 9. Elements of a situation analysis

Demographic Profile	Population size, age, gender, socio-economic status, location
Epidemiological Profile	Disease incidence/prevalence and mortality (broken down by age group, gender and socio-economic status), risk area mapping
Health System Capacity	Service availability, staffing, diagnostic capacity at all levels
Surveillance & Reporting	Case monitoring, outbreak detection, data collection methods
Vector Ecology	Mosquito species, habitats and seasonality
Interventions	Current and proposed approaches for mosquito control
Community Structures and Engagement	Community strengths and their roles and participation in disease control
Partner Landscape	Potential contribution of the different partners
Policies & Governance	Laws, regulations, and frameworks, including access and enforcement
Environmental Factors	Effects of climate, urbanization, and ecology on vectors and disease
Socioeconomic Factors	Poverty, housing, healthcare access, and their impact on disease spread
GEDSI Issues	Equality or inclusivity issues related to gender, disability or other factors
Health Financing	Funding sources, budget allocation, and financial sustainability
Risk Management	Challenges, gaps, barriers, and mitigation strategies
Opportunities	Innovations, community initiatives, and system improvements

Multi-year strategy

The core elements of a national *Aedes* strategy include: summary; overall vision and goals; specific objectives; activities and targets; program indicators; performance monitoring and reporting; vector surveillance; disease risk stratification; vector control; community engagement; program management; and gaps in evidence and knowledge. Structure and content can be adapted to the requirements of each country or type of plan, e.g. an individual plan for one vector or a combined strategic plan for all vector-borne diseases.

Further detail is provided in the *Framework for National Surveillance and Control Plans for Aedes Vectors in the Pacific* (WHO, 2023). Annual planning and reporting are covered in **Section 2.5** with an example in **Annex 3**.

Costed implementation plan

Every VSCP requires a timeline of proposed activities and details of the budget of financial requirements to support implementation. The budget should include all aspects of program needs, including: staff and consultants; meetings and trainings; transport and travel including allowances; procurement, maintenance and storage of all equipment and supplies; community engagement activities; development and production of technical and communication materials; phone and data access including hardware and software. Each activity and associated budget element should be linked to the VSCP (as well as to the broader health sector or country development strategy) by a unique number. If necessary, a summary of the budget can appear in the body of the VSCP with the details in an Annex. The overall budget should be divided by calendar (or financial) year, and further divided into the implementation period used by the Ministry of Health (such as quarters or 6-months).

Budgets should reflect what has been committed or will be received from each donor by budget line, to enable reporting. Funding gaps should also be clearly indicated to inform the resource mobilization priorities and strategy. An individual with budgeting experience will be required and other units or programs of the ministry of health or donor organisations may be able to provide support for this.

A sample budget is provided as Annex 7 of the *Framework for National Surveillance and Control Plans for Aedes Vectors in the Pacific* (WHO, 2023).

3.2 Resource mobilisation

Funds are required to implement activities outlined in the VSCP. If there are insufficient internal or domestic resources to meet needs, these will need to be raised from other sources. Consultations with different partners on resourcing can take place through the VSCP development process, or separately when specific needs arise such as during an outbreak. This is often the responsibility of the program manager or team leader. The Technical Working Group (TWG) or Incident Management Team (IMT) can assist with partner liaison for resource mobilisation.

Resources can be increased through development of funding proposals to the relevant government departments or donors, or through collaborative agreements with departments, organisations or partners who may be able to share costs or provide in-kind resources such as staff, supplies or services. For instance, the Ministry of Tourism may be willing to assist with clean-up or 'beautification' campaigns, Public Works or the Ministry of Environment may assist with waste management, and local private companies can assist with team transport.

Funding proposals

Development of a clear funding proposal can take time but may increase the chance of funding. Proposals should be linked to the VSCP and annual operational (or business) plan. If additional activities are required, clear technical justification will be required as de-prioritisation of other activities may be needed. In practical terms, it is better to build on existing plans rather than start from scratch.

Donors, local authorities or service organisations often have strict requirements for proposals that will need to be followed to increase the chance of being funded. This can require significant time and effort. It will help to ask early what the proposal requirements are, what level of detail is needed, what the process for decision is, and how long this will take. Some tips for writing proposals are provided below.

- ✓ **Base requests on updated VSCP**: Always ensure the VSCP is up-to-date and fully costed and includes the projects or activities that require funding. If not, update the plan and budget before seeking donor support.
- ✓ **Use the VSCP in donor discussions**: Base conversations with donors or partners on the VSCP, explaining the goals and estimated costs. If they show interest, offer to prepare a summary proposal for their feedback.
- ✓ **Keep summary proposal short**: Limit the summary proposal to 1–2 pages, focusing on the problem, goal, the proposed intervention, and overall cost. Generally, shorter proposals are more likely to be read and considered.
- ✓ **Prepare a detailed proposal if requested**: If the donor is interested, request their preferred proposal format and examples before writing a detailed version. Confirm that the proposed budget meets their expectations.
- ✓ **Expand on summary using same headings**: Use the same headings as the summary proposal but add more detail in the full version. Be ready to explain how funds will be managed and answer administrative questions.
- ✓ **Follow donor conditions**: Always comply with donor requirements for activity and financial reporting. Reliable reporting builds trust and increases the chances of future funding.

3.3 Prioritisation

Limited resources are a reality for many PICs. Prioritisation should be guided by the current scenario (both regionally and locally), informed by local data, and adapted to available resources

Table 10 shows a summary of how specific program activities might change according to different transmission scenarios, In summary:

- **Intra-epidemic** scenarios for non-endemic areas may require heightened vigilance and preparedness to scale up response depending if there is normal or high risk. Targetted activities can be prioritised to areas of high risk.
- **Outbreak or epidemic** scenarios require rapid, intensified, and emergency-focused actions, such as targeted residual spraying for containing imported cases or for addressing clusters of cases.
- **Endemic** settings require routine, sustained actions that are feasible and impactful even with limited resources and that may have some targeting based on transmission intensity.

Table 10. Priority program component for different arboviral transmission scenario and relative cost, where: 🔴 = critical priority, 🟠 = high priority, ⚪ = low or no priority

Program element	Program activity	Intra-epidemic	Outbreak/ Epidemic	Endemic	Relative cost
Program management	Maintain essential staff (including manager)	🔴	🔴	🔴	high
	Recruit surge support	⚪	🔴	⚪	medium
	Train staff and surge support	🔴	🔴	🔴	low
	Track budget and expenditures	🔴	🔴	🔴	low
	Select and procure mosquito control commodities (insecticides, equipment, supplies including PPE)	🔴	🔴	🔴	high
	Conduct annual planning	🔴	⚪	🔴	low
	Conduct annual reporting	🔴	⚪	🔴	low
	Coordinate external technical assistance	🔴	🔴	🔴	low
	Develop implementation guidance	🔴	🔴	🔴	medium
Strategic planning & resourcing	Conduct situation analysis (including Situation Reports) and risk stratification	🔴	🔴	🔴	low
	Develop costed VSCP (and review periodically)	🔴	⚪	🔴	medium
	Develop emergency response plan	🔴	🔴	🔴	low
	Mobilise core resources	🔴	⚪	🔴	low
	Mobilise additional resources	⚪	🔴	⚪	low
	IMT activation and procedures (including resource mobilisation)	⚪	🔴	⚪	low
	Set and adjust prioritisation of activities	🔴	🔴	🔴	low
Cross sector collaboration & partner coordination	Engage with municipal councils	🔴	⚪	🔴	low
	Convene intra-governmental meeting, including with biosecurity (for PoE surveillance)	🟠	🔴	🔴	low
	Convene MoH, development partner and private sector meetings (e.g. through TWG or IMT)	🟠	🔴	🔴	medium
	Advocate for legislation and policy optimisation and application	🔴	🔴	🔴	low
Disease surveillance & case management	Strengthen diagnostic capacity	🔴	🔴	⚪	medium
	Strengthen routine surveillance	🔴	🔴	🔴	high
	Conduct focal (outbreak) case investigations	⚪	🔴	⚪	medium
	Strengthen case management capacity	⚪	🔴	🔴	medium
Mosquito surveillance	Conduct baseline larval habitat surveys	🔴	⚪	🔴	medium
	Conduct adult presence/absence or density surveys	🔴	🔴	⚪	medium
	Conduct adult behaviour evaluations	🟠	⚪	🟠	high
	Monitor insecticide resistance	🔴	⚪	🔴	medium

Program element	Program activity	Intra-epidemic	Outbreak/ Epidemic	Endemic	Relative cost
Mosquito surveillance	Conduct focal (outbreak) entomological investigations	○	●	○	medium
	Manage vector data	●	●	●	medium
Mosquito control implementation	Conduct larval container management	◐	●	●	medium -high
	Conduct clean-up campaigns	◐	●	●	medium
	Conduct larviciding	◐	●	◐	high
	Conduct residual spraying	○	●	◐	high
	Conduct fogging	○	◐	○	high
	Release *Wolbachia*-infected mosquitoes (if appropriate)	◐	◐	●	high
	Monitor commodities quality, efficacy and/or safety	●	◐	●	medium
	Strengthen legislation for enforcing household action	●	◐	●	medium
	Ensure compliance with environmental and other regulations	●	●	●	medium
Health promotion and RCCE	Promote sustained mosquito surveillance and control	●	◐	●	medium
	Conduct two-way risk communications	○	●	◐	high
	Engage community groups to support mosquito surveillance and control	●	●	●	medium
Monitoring, evaluation & learning	Monitor arboviral disease trends regionally (to determine risk)	●	○	◐	low
	Monitor environmental indicators (to determine seasonal risk)	●	○	●	low
	Evaluate vector data (current) and case data (historic) to identify high-risk areas	●	●	○	low
	Evaluate case data (current) to identify high transmission areas	○	●	●	low
	Conduct IAR	○	●	○	medium
	Conduct AAR	○	●	○	medium
	Conduct impact and outcome evaluation	○	◐	●	medium
	Conduct operations research	●	◐	●	high

IMT: Incident Management Team; PPE: personal protective equipment; PoE: Point of Entry; EOC: emergency operations centre; IAR: intra-action review; AAR: after-action review

Multisectoral collaboration is essential across all scenarios for sustained impact and can be coordinated through regular meetings of the TWG or through the IMT during outbreaks.

Prioritisation should also be conducted for sub-national areas based on risk stratification. In the intra-epidemic period, priorities may also differ depending on the relative risk, such as that indicated by the regional arboviral disease situation. An example of priority activities and areas for the different transmission scenarios is provided in **Table 11**.

Table 11. Priority areas, mosquito control actions and expected outcomes in different arboviral transmission scenarios

Scenario	Priority areas for interventions	Mosquito control priority activities	Other priority activities	Expected outcomes
Intra-epidemic with normal risk (vigilance during "peace time")	High risk areas based on historic case data and current vector data	• Routine clean-up campaigns with community • Other routine container management • Strengthen legislation for enforcing household action	• Monitor regional and local disease trends • Routine mosquito surveillance • Community engagement (CE)	• Maintain readiness for outbreaks
Intra-epidemic with elevated risk* (prepare for rapid response)	High risk areas based on historic case data and current vector data plus likelihood of imported case	• Routine clean-up campaigns with community + urban/town councils • Targeted and intensified container management • Application of legislation for enforcing household action	• Monitor regional and local disease trends • Enhance disease and mosquito surveillance (e.g. PoE) • Risk communication (RC)	• Maintain readiness for outbreaks • Contain imported cases
Outbreak/ epidemic (rapid response)	In and around imported case or cluster of cases High risk areas based on historical case data and current vector data	• Rapid and targeted adulticiding around case(s) • ITNs and topical repellents to viraemic patients or vulnerable people • Targeted and intensified container management and larviciding • Targeted clean-up campaigns with community + urban/town councils	• Focal investigations • RCCE	• Prevent spread • Limit outbreak size and duration • Rapidly reduce transmissi on
Endemic (ongoing control)	High transmission areas based on current case data	• Routine clean-up campaigns with community engagement + urban/town councils • Routine container management and larviciding • Strengthen and application of legislation for enforcing household action	• Monitor regional and local disease trends • Routine mosquito surveillance • RCCE	• Reduce baseline disease burden • Prevent escalation

* E.g. elevated risk may be indicated by an outbreak in a neighbouring PIC or the hosting of a mass event with an anticipated high volume of travellers from endemic areas

SECTION FOUR – Cross-Sector Coordination & Partner Collaboration

This section:

- Highlights the importance of collaboration and coordination across all stakeholders
- Outlines the importance of a Technical Working Group (TWG)
- Provides guidance on coordinated action during a declared outbreak or epidemic

Whether the scenario is endemic transmission, response during an outbreak or epidemic, or preparedness during an intra-epidemic period, coordination across health sector stakeholders is critical. Key stakeholders include different levels or functions of the health system and other governmental departments (e.g. biosecurity, tourism, community and women's affairs, education). During large outbreaks, coordination across partners may be managed by the Disaster Management Office. Municipalities play an important role in community engagement and mobilisation, especially for clean-up campaigns.

External partners will also be key to the success of any mosquito control program as they can greatly increase capacity to achieve or exceed targets set out in the VSCP. This includes through provision of funds or cost-sharing, technical support, data generation, or independent projects aligned with the VCSP. Traditional development partners include multi-lateral and bi-lateral organisations, NGOs, CBOs, and philanthropic partners. Private sector may also contribute in selected areas. Technical and research partners or networks such as PacMOSSI are available to provide additional support as needed. **Table 12** indicates how different types of partners can potentially contribute to mosquito control programs in the Pacific. Public engagement and mobilisation require multiple mechanisms and partners, and is covered in **Section 8.**

Table 12. Examples of partner engagement opportunities and methods in the Pacific

<table>
<tr><th>Partner Type</th><th>Examples</th><th>Potential areas of support</th><th>Best engagement method</th></tr>
<tr><td colspan="4">Intra-sectoral coordination</td></tr>
<tr><td>Health professionals</td><td>Clinicians, public health and corporate staff</td><td>Identify integrated approaches to improve efficiency and effectiveness</td><td rowspan="3">Established MoH procedures (including IMT procedures during a declared outbreak)</td></tr>
<tr><td>Other MoH units</td><td>Surveillance unit, environmental health unit, RCCE unit</td><td>Share information from routine surveillance or outbreak investigations to improve preparedness and response</td></tr>
<tr><td>Different levels of the health system</td><td>Central versus subnational (regional, provincial) health offices</td><td>Coordinated activities (based on VSCP)</td></tr>
<tr><td colspan="4">Cross-sectoral coordination</td></tr>
<tr><td rowspan="5">Other government departments</td><td>Biosecurity</td><td>Point of Entry monitoring for disease and vectors</td><td rowspan="5">Meeting with all the respective departments, with interest supported by MOUs or similar</td></tr>
<tr><td>Tourism</td><td>Importation monitoring, key message dissemination</td></tr>
<tr><td>Environment/Climate</td><td>Early warning systems, environmental modification</td></tr>
<tr><td>Water and Public Works</td><td>Larval habitat management</td></tr>
<tr><td>Education</td><td>Schools in high-risk area. Student-led surveillance and weekly clean-ups of larval habitats. Larval identification.</td></tr>
</table>

Partner Type	Examples	Potential areas of support	Best engagement method
	Disaster Management Office	Cross-sectoral coordination during outbreak or epidemic	Established IMT procedures
Municipalities	Urban or Town Councils	May sponsor urban control programs or propose legislation to allow weekly inspections of household and fines for households harbouring larval habitats	MoU and legislative support to support urban mosquito control programs
Development partner collaboration			
Bilateral partners	Australian Government, French Government, European Union, New Zealand Government	Might give major or smaller funding for different components of the mosquito control program	Personal visits, invitations to TWG and written proposals
Multilateral organisations	ADB, WHO, UNICEF, UNDP, SPC	May fund mosquito control programs through supporting meetings, funding small aspects of the program and adding project components to other existing supported programs	Personal visits, invitations to TWG and written proposals
Philanthropies and private foundations	Gates Foundation. Other large commercial companies	May fund smaller projects are community level or combine activities with existing funded activities	Personal visits, invitations to TWG and written proposals
Service organisations	Rotary International and Lions Clubs	As above, but volunteers of these organisations may like to be directly involved in agreed activities such a community projects. Can include provision of subsidised mosquito control commodities to shopkeepers (e.g. nets, topical repellents).	Present issues to local meetings and ask for support.
International and local NGOs	World Vision, Save the Children etc.	Collaboration on community projects for community mobilisation for community surveillance and control. Also SBCC campaigns	Partner via TWG and joint trainings
CBOs, DPOs and FBOs	Churches & religious groups, youth groups, women's groups	Message dissemination, SBCC delivery	Workshops for CBO, DPO and faith leaders
Private sector engagement			
Agricultural companies	Sugar and Oil Palm Companies	Protect worker camps, source reduction, logistic help during outbreaks	Targeted advocacy
Shop keepers	Supermarkets, grocery and hardware stores.	Stocking mosquito nets, topical repellents and other health products promoted by the program	Targeted advocacy
Other technical partner support			
Academic or research institutes	National or International universities or research organisations	Local data generation, technical advice, assisting with vector behavioural research, community behavioural research and insecticide resistance	*Ad hoc* as needs or opportunities arise
Other networks or initiatives	PacMOSSI, Pacific Vector Network, APMEN	Technical assistance, technical materials, regional data, experience and resource sharing, equipment provision, training opportunities	Partner via TWG and through established mechanisms

Note: Community engagement can be through multiple mechanisms and is covered in **Section 8.**

4.1 Technical Working Group (TWG)

An important part of cross-sector and partner collaboration and coordination is continual interchange of information and ideas through regular communication. Having an established and functional TWG that includes the MOH plus all key donor and technical stakeholders and meets regularly is one way to ensure collaboration and communication plus strengthen partnerships. This should not replace individual mosquito control program meetings with key partners but can improve efficiency of engagement by ensuring up-to-date information is available to inform further discussions.

Initial contacts with partners should always be done personally to develop rapport and good relationships. Once an agreed interest to work with each other has been defined, then this can be followed up with more formal agreements or proposals. TWG terms of reference should be established which outline the group composition, meeting frequency and modalities, reporting and secretariat functions. See **Annex 4** for the suggested components of a TWG terms of reference. Remote or hybrid meetings can improve attendance and efficiency and reduce cost. Meeting notes generated through Artificial Intelligence technology can be used though these should be checked for accuracy before circulating.

4.2 Coordination during a declared outbreak

Leadership, coordination, planning, operations, and monitoring are fundamental to any successful outbreak response. In an arboviral outbreak, if emergency procedures are triggered such as through the Health IMT or the Disaster Management Office, responsibility will transition from the mosquito control program manager to (for example) the Director of Public Health or Incident Commander. The mosquito control program manager should be aware of the procedures for emergency coordination in the country and other regional coordination mechanisms (e.g. Joint Incident Management Team).

For an arboviral outbreak, IMTs should include ministry of health or partner expertise on:

- clinical management
- mosquito control and entomology
- child and maternal health (especially for Zika)
- risk communications and community engagement (RCCE)
- logistics, finance and administration
- monitoring and evaluation
- GEDSI

The frequency of coordination meetings and reporting (such as through Situation Reports) will depend on the evolving situation. An evaluation of what was done, what worked, what didn't work, and what can be done better can be done during or following the outbreak or epidemic. Good documentation of activities and results will inform future preparedness and responses.

Emergency response measures are outlined in **Table 13**. Criteria for outbreaks is covered in **Section 5**.

Table 13. Key activities during an arboviral disease outbreak

#	Actions	Responsible	Notes
1	Receive information about possible outbreak	Program Manager and Surveillance Officer	Reports received from NHIS, entomology reports or community or other type of report to suggest possible outbreaks of *Aedes*-borne disease.
2	Confirm Outbreak - Verify reports received	Surveillance Officer	Inform supervisor of information received, review records and go to affected area if necessary to confirm outbreak if this can be done quickly. Report to emergency coordination authority before investigation to pre-warn of possible outbreak.
3	Inform Relevant Authorities (MoH and IMT) once outbreak confirmed.	Program Manager	In consultation with MoH and Emergency Coordination Authority (ECA) decide on partners to include in response and who should be responsible for each coordination activity. Also include identification of experts to be included and who should coordinate the response (Incident Commander).
4	Set up Public Health Emergency Operations Centre	Incident Commander	With MoH and ECA decide on best location to have a PHEOC. This should be manned at all times by the Incident Commander who will coordinate the emergency team.
5	Call and hold meeting of all relevant partners such as WHO, UNICEF, Red Cross and other relevant bodies	Incident Commander	1) Inform all stakeholders of the situation. 2 Prioritise activities and decide on plan of action for response and who should do what to make an Incident Management Plan. 3) Decide on type of public reporting approach. 4) Decide on frequency of emergency coordination meetings to which representatives of all organisations involved should attend. 5) Determine who will keep minutes of all coordination meetings and how these will be shared.
6	Coordinate implementation of agreed activities in mosquito control and community mobilisation	Logistics Coordinator and Health Promotion Unit	Decide who will coordinate and carry out: 1) Clinical management 2) Mosquito control 3) RCCE 4) Engagement with other sectors 5) Regular internal and external reporting 6) Resource mobilisation and management
7	Hold regular meetings with partners	Incident Commander	All partners to report on progress in terms of implementation, funding, and difficulties faced
8	Carry out monitoring and evaluation of all interventions	M&E Focal Point	Emergency coordination should visit activities in the field and each organisation should regular monitor and evaluate their activities.
9	Produce reports for MoH, partners, general public and others.	Communi-cations Lead	Situation Report formats should be agreed upon and how often they should be written.

Preventing and responding to sexual exploitation, abuse and harassment

During outbreaks, certain groups may become more vulnerable to sexual exploitation, abuse and harassment including women, children and marginalized communities. A plan of action should be developed as part of the outbreak response plan. Mitigation and response measures should be put in place to ensure misconduct is dealt with in a timely and culturally-appropriate manner. Referral services should be available for survivors. The TWG or IMT should oversight and report on the process and outcomes.

SECTION FIVE – Disease Surveillance & Case Management

This section:
- Outlines approaches for clinical diagnosis and laboratory confirmation of cases
- Provides linkage to more detailed resources on case management
- Highlights the importance of timely reporting of information within a country and regionally

Clinical diagnosis, laboratory confirmation, and case reporting for arboviruses is not usually the direct responsibility of mosquito program staff in many PICs. However, **it is essential that vector staff are aware of procedures and work closely with relevant MoH units to access timely information to guide mosquito surveillance and control.**

5.1 Clinical diagnosis of probable cases

Common symptoms of dengue, chikungunya and Zika are provided in **Table 2**.

Clinical features alone cannot reliably distinguish *Aedes*-borne arboviral infections because:
- An infected person may have no symptoms or mild fever only
- An infected person may not present to a health facility
- Symptoms overlap between arboviral diseases (dengue, chikungunya, Zika, Ross River, Japanese encephalitis, West Nile, Yellow Fever)
- Symptoms overlap with other diseases (such as malaria, leptospirosis, meningitis, rheumatic fever, typhoid fever), especially in early illness.

Therefore:
- Recent travel, local epidemiology, and possible exposure to vectors should be considered.
- All probable cases should be tested for confirmation.
- Clinical and testing algorithms should be established for each country.

For further information such as case definitions and laboratory confirmation, refer to:
- *Dengue Outbreak Toolkit* (WHO, 2024)
- *Chikungunya Outbreak Toolkit* (WHO, 2024)
- *Zika Outbreak Toolkit* (WHO, 2024)

5.2 Testing to confirm cases

Confirmatory tests for arboviruses are summarised in **Table 14**. The choice of test will depend on the phase of illness, sample type, available resources, and the need for rapid or specific results. For instance, in the acute febrile phase, molecular and antigen detection are appropriate whereas in later phases, serology with paired samples can be used. Timing of specimen collection is critical for correct interpretation.

Rapid diagnostic tests (RDTs) have been developed for dengue, chikungunya and Zika. These:
- Are used for rapid diagnosis at point-of-care
- Can target antigens or antibodies in blood
- Indicate current (NS1), recent (IgM) or late-stage/past (IgG) infections
- Have low specificity (especially for IgM/IgG)
- Are useful in low-resource setting but often have limited availablity in the Pacific

Table 14. Examples of confirmatory tests for arboviruses

Test type(s)	Target(s)	Indicates	Use	Limitations	Availability in the Pacific
Antigen Detection (e.g. ELISA, LFA, RDT)	Viral proteins/ antigens in blood (e.g. NS1 for dengue)	Early-stage infection	Early phase detection (first week of illness); used in RDT or lab	Lower sensitivity (especially in secondary infection); limited to dengue; no serotype info	Available in some labs (and as RDTs)
Serology (e.g. ELISA, LFA, RDT, PRNT)	Antibodies in blood (IgM/IgG)	Recent infection (IgM) or late-stage/past infection (IgG)	Confirms infection if 4-fold rise in IgG titre between acute & convalescent samples; used in RDT or lab	Cross-reactivity common between flaviviruses; requires paired sera; no serotype info	Widely available and commonly used
Molecular (e.g. PCR or RT-PCR)	Viral RNA/DNA in blood, urine, cerebrospinal fluid	Current infection	Early phase detection; high specificity; gold standard for acute diagnosis	Limited capacity in PICs	Available mainly in centralized or regional labs

Partners such as WHO may be able to support provision of RDTs in the event of increased risk or if there is an outbreak or epidemic. SPC supports diagnostic capacity building in PICs. Laboratory specialists or pathologists should be consulted for complex cases or unusual results. Dengue serotype identification often requires testing in regional reference laboratories. For more information, see LabNet.

5.3 Case management

There is no preventive treatment or cure for arboviral diseases. Supportive care of symptoms is undertaken. This topic is beyond the scope of this manual. Further guidance is provided in:

- *Guidelines for the Clinical Diagnosis and Treatment of Dengue, Chikungunya, and Zika* (WHO, 2022)
- *Dengue Case Management Pocket Guide* (CDC, 2024)

In general, it is important to refer to national guidelines for diagnosis and treatment and to:

- Clearly communicate on symptoms and warning signs - including when to seek hospital care - in ways accessible to all genders, people with disabilities and other marginalised groups
- Pay particular attention to pregnant women (especially for Zika), infants, older persons, marginalised groups, or those with other health conditions.
- Ensure that patients with Zika are counselled on preventing non-vector-borne transmission of Zika through condom use (or abstinence, if appropriate), and for breastfeeding women to continue breastfeeding.
- Train healthcare workers in early recognition of the critical phase and shock, triage, referral pathways and management of arboviral diseases.
- Prepare protocols for clinical surge capacity during outbreaks.
- Closely monitoring fluid intake and output, vital signs, and haemotocrit levels

5.4 Surveillance and reporting of arboviral diseases

The three main approaches to surveillance in PICs are summarised in **Table 15**.

Table 15. Options for surveillance of arboviral diseases in the Pacific

Surveillance type	Information	Information sources	Main purpose
Syndromic surveillance	Clinical syndromes suggestive of arboviral infection	Health facility reports, clinics, hospitals, community health workers	Early detection of potential outbreaks and monitoring of disease trends, especially where lab resources are limited
Event-based surveillance	Unusual health events, clusters of cases, or rumours of outbreaks	Community reports, media, hotlines, informal networks, ad hoc notifications	Rapid identification and notification of outbreaks or emerging threats for timely response
Laboratory surveillance	Laboratory-confirmed cases	National and regional laboratories, reference labs, sample referrals from health facilities	Confirmation of suspected cases, differentiation between arboviruses, and validation of outbreak status

- **Syndromic surveillance** is useful in PICs due to limited laboratory capacity and is often the primary method for outbreak detection.
- **Event-based surveillance** complements syndromic systems by capturing clusters or unusual events that may signal an outbreak, especially in remote or resource-limited settings.
- **Laboratory surveillance** is crucial for confirmation but is often constrained by resource availability and may lag behind syndromic and event-based reports.

Other sources of information

Information beyond the health system should also be examined to ensure full knowledge of the situation. These could include:

- Local news (e.g. media, social media, word of mouth)
- Network information on outbreaks in neighbouring countries (e.g. PPHSN, JIMT)
- Reports from PoE (e.g. sick travellers from endemic areas)
- Data on climatic or environmental factors known to affect risk or case trends (e.g. rainfall, temperature, humidity, El Niño–Southern Oscillation (ENSO) events, other environment changes like deforestation) (see **Box 2**)
- Veterinary reports (e.g. heartworm in dogs indicating areas with high *Aedes* densities)

Box 2. Associations between arboviral diseases and El Niño–Southern Oscillation (ENSO)

The ENSO, which alternates between warm (El Niño) and cold (La Niña) phases, significantly affects *Aedes*-borne disease transmission by altering climate conditions.

- During El Niño, warmer and often drier weather in PICs leads people to store water in containers, creating ideal larval habitats for *Aedes* mosquitoes. Higher temperatures also accelerate mosquito development and shorten the time for virus incubation in mosquitoes before they can transmit, thereby increasing outbreak risk.
- During La Niña, PICs experience heavier rainfall and higher humidity, directly increasing standing water and fostering mosquito proliferation, which is also linked to spikes in *Aedes*-borne diseases.

Thus, both ENSO phases—by changing rainfall patterns, temperature, and water storage practices—create environments that favour *Aedes* mosquitoes and raise the likelihood of arboviral disease outbreaks or transmission.

Country reporting

Regular and timely reporting of syndromic, event-based clinical, laboratory and other information is essential for effective mosquito control and other public health action. Surveillance teams should collate and report the information required to confirm (or otherwise) arboviral outbreaks or epidemics. To be useful, this must be provided to public health authorities in a timely manner. Setting predefined thresholds can help trigger early outbreak responses.

Outbreak declaration

Outbreak thresholds will differ between and even within PICs, as these depend on the local epidemiology, surveillance capacity, and historical patterns, with non-endemic areas often using more sensitive (lower) thresholds than endemic regions. Thresholds may rely on probable cases (based on clinical symptoms) if laboratory confirmation is delayed. Depending on the circumstances, a single case could be declared as an outbreak.

Table 16 gives example outbreak criteria that reflect the Pacific context, where even a single local case can trigger an outbreak declaration due to the presence of competent vectors and populations without immunity due to no previous exposure to the specific virus.

Table 16. Example criteria for outbreak or epidemic declaration in a PIC

Criterion type	Example threshold/indicator
Case numbers (adapted from SPC outbreak manual)	Depends on the transmission setting of the area, for example: • ≥1 locally-acquired confirmed case in non-endemic receptive area *OR* • 2 or more locally-acquired confirmed cases in a non-endemic receptive area within a short time (e.g. 2 epi-weeks) *OR* • Significant (2-fold or more) increase in the number of probable or confirmed cases above the historical baseline or expected seasonal levels within a short time (e.g. 2 epi-weeks) in an endemic area
Clinical/lab confirmation	• Probable/confirmed case definition met
Attack rate	• >1–3% of population with probable cases
Vector presence	• Confirmed local vector populations
Environmental factors	• Favourable conditions (increased rainfall or temperature)
Serotype circulation	• Detection of multiple serotypes

Regional reporting

The Pacific Syndromic Surveillance System (PSSS) serves as an early warning tool and assists 23 PICs to collect, collate and report information to strengthen local outbreak response capacity. The current PSSS dengue-like illness syndromic definition is provided in **Table 17**. Refer to the Pacific Syndromic Surveillance System documentation as definitions may be updated to reflect evolving epidemiological understanding and operational needs in PICs. Syndromic data are reported by PICs weekly and reports are available on the Pacific Syndromic Surveillance Reports webpage. An SPC map also shows Epidemic and emerging disease alerts in the Pacific region that includes arboviruses and provides dengue serotype if known. Refer to the Pacific Outbreak Manual for more information.

Table 17. Pacific early warning system for suspected dengue

Syndrome	Case definition	Alert threshold
Dengue-like illness (DLI)	Fever for at least 2 days, plus at least two of the following: i. Nausea or vomiting; ii. Muscle or joint pain; iii. Severe headache or pain behind the eyes; iv. Rash; v. Bleeding	Twice the average number of cases seen in the previous 3 weeks

Surveillance limitations and opportunities

PICs face numerous challenges for timely surveillance and reporting, with some challenges and solutions provided in **Table 18**.

Table 18. Potential key questions for arboviral detection and reporting in the health system

Questions	Potential solution if issue identified
Are health staff aware of arboviral disease signs/symptoms? Is knowledge sufficient to diagnose efficiently?	Retrain staff if needed.
Are clinical/lab diagnostic algorithms available?	Develop and circulate algorithms if absent.
Are standard testing protocols in place at all levels of the health system?	Design/review protocols and procedures as needed.
Are RDTs or lab facilities and supplies available for confirmation testing?	Determine needs in collaboration with clinicians; assist with funding if lacking.
Are reporting protocols for suspected and confirmed arboviral cases established?	Map reporting structures and provided protocols for clarity.
Are thresholds for arboviral outbreaks established?	Define outbreak thresholds if absent.
Is a georeferenced reporting system used for arboviruses?	Develop a simple, phone-based tool for collating and accessing data at different levels of the health system if feasible.

Suggestions for PICs to strengthen timely and accurate surveillance and reporting include:

- ✓ Confirm dengue, chikungunya, and Zika are notifiable diseases and clarify reporting responsibilities for both public and private sector.
- ✓ Ensure the National Health Information System can record arboviral diseases; if not, consider modifying it or creating a parallel reporting system.
- ✓ Use standardized data formats to ensure consistency and usability of surveillance data.
- ✓ Report all data **disaggregated by age group and gender** at a minimum.
- ✓ Make the reporting system accessible to all public health facilities, community health workers, private clinics and PoEs for comprehensive coverage.
- ✓ Monitor the reporting system daily to ensure timely outbreak detection and response.
- ✓ Use the database to enable immediate mapping of reported cases for targeted outbreak interventions.
- ✓ Where no efficient tracking exists, set up a simple, phone-based, georeferenced database using free tools (e.g. Kobo Toolkit).

SECTION SIX – Mosquito Surveillance

This section:

- Outlines the design of mosquito surveillance activities, including key considerations
- Overviews mosquito surveillance at PoE and options for mosquito identification
- Gives some practical tips for *Aedes* surveillance

The purpose of mosquito surveillance is to inform vector control interventions. Before conducting mosquito surveillance, it is essential to consider all available information on mosquito species in the country. Key references include:

- *A guide to mosquitoes in the Pacific* (PacMOSSI, 2023)
- *Manual for surveillance and control of* Aedes *vectors in the Pacific* (WHO/SPC, 2020)

Some information will already be available from surveys conducted in the PIC or surrounding countries. Historic data can be useful for factors that are not expected to change significantly over time (e.g. vector species biting and resting preferences), while more recent data may be needed for other factors that may be subject to rapid change (e.g. adult density, insecticide resistance status, key larval habitats in response to intervention).

6.1 Design of surveillance activities

A plan should be devised to summarise the scope, rationale and approach for mosquito surveillance. Design of activities will depend on:

- Mosquito control decisions to be made
- Information already available to guide those decisions (e.g. situation analysis)
- Major information gaps that need filling
- Available resources for surveillance, including personnel, equipment, supplies and finances
- Options for engaging communities and local stakeholders (including to support a GEDSI approach)

Table 19 shows the components when designing a mosquito surveillance activity in the Pacific. Further guidance is available in the PacMOSSI *Surveillance for* Aedes *in the Pacific design workbook* which will be available at: https://pacmossi.org/resource-category/training-materials/

Table 19. Key components when designing mosquito surveillance activities

Consideration	Scope	Rationale	Possible options
Objectives	Define the main purpose and goals of surveillance.	Guides all aspects of the program and ensures data collected are actionable.	• Mosquito distribution and/or density by species • Mosquito behaviour e.g. biting, resting etc. • Larval habitats • Insecticide resistance status
Targets	Specify *Aedes* species and life stages to be monitored.	Ensures surveillance focuses on relevant vectors and guides selection of appropriate surveillance approach.	• *Ae. aegypti, Ae. albopictus, Ae. polynesiensis* • Other species as relevant • Adults, pupae, larvae, eggs

Methods	Identify collection techniques for target species and life stages.	Ensures optimal data relevance, quality and comparability, and defines resource needs.	• Adult: BG sentinel traps, resting collections, sweep nets, gravid traps • Larvae/pupae: key containers, household surveys • Eggs: ovitraps • IR: tube test, bottle bioassay
Sites and locations	Determine geographic scope (national, sub-national, high-risk areas) and sampling sites.	Ensures data is representative, risk-focused, and logistically feasible.	• Urban, peri-urban, ports, high-risk zones • According to surveillance design e.g. cluster, systematic random, household sampling
Timing and frequency	Plan when (season) and how often data is collected.	Captures seasonal trends and ensures comparability. Balances data needs and resources.	• Peak of rainy or dry season • Immediately following severe weather events • Monthly, bi-monthly, weekly • Duration per collection method (e.g. ovitraps 5 days/month)
Indices	Identify entomological indicators to be calculated from collections.	Enables consistent, actionable risk assessment and comparison over time/space.	• Adult occurrence, density, biting time, biting location, resting location • Resistance frequency/status, resistance intensity • Habitat availability, key larval habitats, pupal productivity, House Index, Container Index, Breteau Index (BI)
Cross-sectoral and partner coordination	Encourage involvement of relevant sectors beyond health and partners.	Supports efficiency and sustainability in resource-limited settings.	• Cross-sector coordination (education, tourism) • Partner convenings (including through Incidence Management Teams)
Community engagement	Involve local communities in planning and implementation.	Builds trust, improves access and increases participation	• Align with community engagement plan • Identify leaders/groups (ensuring inclusiveness) • Promote awareness and feedback • Combine surveillance with control
Data management and use	Define protocols for data collection, management, analysis and dissemination.	Ensures surveillance data is used effectively for decision-making, resource allocation, and outbreak response.	• Data storage, analysis and reporting protocols • Inform intervention selection or targeting • Inform impact evaluation

A **PacMOSSI resource** called *Surveillance for Aedes vectors in the Pacific: workbook for practical workshop* is available to assist with the design process. Details on methods and indicators are available in the *Manual for surveillance and control of Aedes vectors in the Pacific*.

Others tools such as the Entomological Surveillance Planning tool can also be used to define the purpose, methodology and budget of the mosquito surveillance effort.

6.2 Adult versus immature surveillance

The decision whether to conduct adult, larval, pupal or egg collections is based on the purpose of the surveillance. For example, insecticide resistance monitoring may require larvae collected to rear to adults whereas mosquito behaviour evaluations require adult sampling. There may be some correlations between adult and immature indices but each provides distinct information.

- **Adult surveys** offer the most direct measure of transmission risk and can be more cost-effective than larval surveys in the long term due to reduced labour requirements, although there is an initial large investment in traps and batteries. They may be technically demanding and there can be high trap bias so some sub-populations can be missed.

- **Larval (and pupal) surveys** are widely used because they require minimal training, and can be carried out by community volunteers or school children. They are useful to identify key larval habitats to target for larval source management but are labour-intensive if large areas included and do not correlate well with adult abundance plus are time-sensitive and may miss cryptic habitats. They are commonly used for routine surveillance but linkage with intervention decisions is crucial.

- **Egg surveys** involve simple and low-cost traps to collect eggs, with visual or automated counting. They are sensitive for detecting low-density populations and give an early warning of presence but don't indicate adult density or biting risk and there is a need to rear or molecular test for species.

6.3 Point of Entry (PoE) monitoring

All mosquito control program managers should understand PoE responsibilities as outlined in the International Health Regulations. These indicate the need to "establish programmes to control vectors that may transport an infectious agent that constitutes a public health risk to a minimum distance of 400 metres from those areas of point of entry facilities that are used for operations involving travellers, conveyances, containers, cargo and postal parcels, with extension of the minimum distance if vectors with a greater range are present."

While national mosquito control programs may not directly manage PoE surveillance and control, close coordination is essential. This helps detect new mosquito species entering the country and respond accordingly. Timely control action relies on rapid sharing of information between biosecurity staff and mosquito control program managers.

For further details on PoE roles and responsibilities, refer to the below documents.

- *International Health Regulations* (WHO, 2005) and latest amendments (WHO, 2024)
- *Vector surveillance and control at ports, airports, and ground crossings* (WHO, 2016)
- *Manual for surveillance and control of* Aedes vectors in the Pacific (WHO/SPC 2020)

Table 20 outlines potential surveillance activities at PoEs. For mosquito control at PoEs refer to **Section 7.4.**

Table 20. *Aedes* vector surveillance options for PoEs

Activity	Recommended surveillance method	Sampling sites	Sampling frequency	Action
Adult mosquito occurrence	BG trapping at sentinel sites	400 metres around each PoE	Continual	Send mosquitoes for speciation if not known

Potential larval habitat availability	Inspection and mapping of potential sites	400 metres around each PoE	Monthly	Manage all potential or actual larval habitats through destruction, modification or treatment
Key larval habitats	Larval and pupal surveys	400 metres around each PoE	Monthly but weekly is better	

6.4 Mosquito identification

Mosquito species that are likely to be collected (including invasive species) should be considered when defining the identification strategy. Training will be required at all levels engaged in the process to ensure accuracy, including community members, healthcare workers and scientists.

Details for identifying adult and larval mosquitoes from other insects and for distinguishing by sex, genus and species are available in *A morphological identification key to the mosquito disease vectors of the Pacific* and **Annex 5**. Options for identification are outlined in **Table 21**.

Table 21. Identification options for adults and larvae and appropriate persons to do it

Differentiation	Adults		Larvae	
	What	Who	What	Who
Mosquitoes versus other insects	Examine posture, proboscis, thorax, wings, body, eyes	Trained community members or healthcare workers	Examine position in water, wriggle, siphon, thorax, abdomen, head	Trained community members or healthcare workers
***Aedes* versus other mosquito Genera**	Resting posture, leg bands or thorax markings by naked eye or magnifying glass	Trained community members or healthcare workers	Siphon shape, resting position, abdominal segments examined by naked eye or magnifying glass	Field scientist
Female versus male mosquitoes	Examine antennae or palp length by naked eye or magnifying glass	Trained community members or healthcare workers	N/A	
Different *Aedes* species	Thorax marking, wing scales or leg bands examined by naked eye or magnifying glass	Trained community members or healthcare workers		
(if closely related species are present)	Morphological features examined by microscope and ID key	Field scientist	Morphological features examined by microscope and ID key	Field scientist
	PCR	Laboratory scientist	PCR	Laboratory scientist

Note: microscopes and molecular testing capacity may be limited in many PICs.

Distinguishing features of *Aedes* vectors relative to other species likely encountered in the area should be clearly communicated to those who will be doing the identification. Other common mosquito species that also share habitats with *Aedes* vectors and can transmit other diseases are summarised in **Annex 6.**

Key communication points for *Aedes* may therefore be:

- *Aedes* larvae have slender, wriggling bodies with a short siphon. They hang down from the water surface and wiggle when disturbed.
- *Aedes* adult mosquitoes have black-and-white banded legs and a narrow black body with light and dark scales. They hold their bodies parallel to the surface when landed.
- *Ae. aegypti* adults have a thorax with lyre-shaped silver markings and the fifth tarsal segment of legs is mostly white.
- *Ae. albopictus* and *Ae. polynesiensis* adults have a thorax with a single white stripe down the middle.

6.5 Typing larval habitats

Aedes species can also be characterized by the locations which they choose to lay their eggs and where their larvae develop. Mosquito surveillance can give a clear understanding of *Aedes* aquatic habitat types and potentially the relative numbers of larvae and/or pupae they sustain. This can be considered as a proxy for the production of adults and therefore indicate the transmission risk posed by the different habitat types and therefore guide targeting of control efforts to the most "dangerous" habitats.

Key habitats are types of containers or water bodies that are expected to produce the greatest number of adult vectors in a given setting. The estimated or actual number of late instars or pupae can be used as a proxy for determining adult productivity. Productivity for a target vector species is defined as:

abundance of habitat type x average estimated number of III/IV instars

For instance, if 100 households are surveyed and 1 water tank of 5000L capacity per house is found of which 20 tanks are sampled and an average of 500 III/IV instars are found, then overall productivity of water tanks is: 100 x 500 = 50,000 III/IV instars. Comparatively, if 500 flower vases are found in the 100 households and these produce an average of 10 III-IV instars each, then overall productivity of flower vases is 5,000 III-IV instars. Tanks are therefore more productive than flower vases and can be targeted where prioritised control is required.

Clear "typing" of aquatic habitats will be useful for communicating to larval surveillance and control teams about targeting efforts. This should consider what makes the most practical sense in the given setting, and may group habitats by function, shape, size or other characteristics. An approach for typing habitats and defining key habitats is summarised in **Box 3**. See **Section 7.4** to understand how this information is used.

Box 3. Typing key habitats

In Papua New Guinea, known *Aedes* larval habitats can range from small natural containers (e.g. coconut shells) to small artificial containers (e.g. discards such as bottles and bags), to accumulated rubbish (e.g. used tyres, broken boats), to water-storage containers (e.g. tanks, drums, jars, barrels).

The STRIVE project in Papua New Guinea has developed a *Larval Habitat Pocket Data Dictionary* that provides a picture and description for each of 31 habitat types. These are ordered alphabetically for easy reference. For more information, see:

- STRIVE Program. (2024). Larval Habitat Pocket Data Dictionary. (Available upon request)

6.6 Insecticide resistance monitoring

Resistance data available for the Pacific in 2020 in Section 4.6 of the *Manual for surveillance and control of* Aedes *vectors in the Pacific* indicate that:

- For *Aedes aegypti*, resistance to pyrethroids is widespread with susceptibility remaining in a few countries only and resistance to carbamates and organophosphates has been detected or is possible in some countries.
- For *Aedes albopictus*, resistance has been detected in a few countries for each of the three insecticide classes but susceptibility remains in many of the countries that undertook monitoring.

Recent data are sparse for the Pacific. If insecticide use is being considered for *Aedes* control, up-to-date insecticide resistance information for target species will be required. Ideally, resistance monitoring and insecticidal product selection should be done annually or at a minimum every two years.

Minimum requirements for insecticide resistance monitoring are shown in **Table 22**. Eggs or larvae should be collected from multiple sites (>50 m apart) to ensure genetic diversity. Adult mosquitoes reared from eggs or larvae can be tested, or field-collected adults may be used (but will be of an unknown age). Procedures outlined in the *Manual for monitoring insecticide resistance in mosquito vectors and selecting appropriate interventions* should be followed.

A basic field insectary and workspace are sufficient for insecticide resistance monitoring. Staff should be able to identify *Aedes* mosquitoes, conduct tests, and interpret results. Further processing, such as molecular testing for resistance mechanisms, will require additional capacity. This may need to be conducted in an overseas reference laboratory. Training resources are available through PacMOSSI such as in the online course or practical trainings.

Recognising that establishing the capacity for insecticide resistance monitoring for some PICs will be operationally difficult, PacMOSSI is able to facilitate links to laboratories in partner countries for molecular insecticide resistance testing.

Table 22. Minimum requirements for conducting insecticide resistance monitoring

Category	Requirement	Need
Facilities	Insectary (basic)	For rearing field-collected larvae/pupae to adults; ideally should have controlled temperature and humidity
	Workspace	Clean bench or table for preparing and conducting tests
	Storage	For test kits, treated papers and samples; should be cool and dry
Human Resources	Field collectors	Personnel able to collect eggs, larvae, or adults from various sites (may overlap with entomology staff)
	Entomology staff (including for lab)	At least 1 person trained in mosquito collection, identification, rearing, and conducting resistance tests
	Data enterer/manager	For accurate recording, analysis, and reporting of results (can be same as field or entomology staff)
Equipment & Supplies	WHO tube test kits	Includes holding/testing tubes
	Insecticide-impregnated papers	For relevant insecticides being tested
	Aspirators, forceps, and collection cups	For handling mosquitoes safely
	Sugar solution, cotton pads	For feeding mosquitoes during holding periods

	Personal protective equipment (PPE)	Gloves, lab coats, etc., for safe handling of equipment and mosquitoes
	Labels, data sheets, or electronic data capture tools	For recording test results and sample information
Other Essentials	Training materials	Standard training package of materials
	Standard Operating Procedures (SOPs)	Access to SOPs for consistency and quality assurance

6.7 Data for decision-making

Data from mosquito surveillance should be:

- Regularly reported in management meetings and to stakeholders to guide interventions
- Used for program evaluation, resource allocation, and adaptation of vector control strategies based on local evidence.
- Visualised using maps and summary tables, enabling clear communication with decision-makers and affected communities.

Operational details and Standard Operating Procedures for mosquito surveillance are available as technical guidance on the PacMOSSI website. These can be adapted for the specific program needs, including for routine or outbreak-driven surveillance activities. By maintaining strict adherence to SOPs and routine data analysis, programs will enhance their capacity to detect, track, and control mosquito-borne disease threats based on reliable, real-time evidence.

Further information is provided in **Section 9** on monitoring, evaluation and learning.

6.8 Practical tips

- ✓ **Use simple tools:** Collect larvae with locally available items such as soup spoons, pipettes, or larval dippers; rear larvae to adults using jam jars and untreated netting for species identification if needed.
- ✓ **Conduct regular inspections:** Perform weekly checks of all potential larval habitats (e.g. containers, tyres, tree holes). If possible, continue routine surveys even in outbreak situations to verify and adapt control measures.
- ✓ **Integrate control during surveillance**: Combine larval and adult surveys with ongoing mosquito control activities such as larval source management for maximum impact.
- ✓ **Engage and train the community:** Provide basic training to communities and school children in identifying larval habitats and mosquitoes, and how to conduct simple larval source management. Involvement can lead to improved knowledge and better control for all mosquitoes (not just *Aedes*).
- ✓ **Mobilize community action:** Involve schools, volunteers, CBOs like women's groups, DPOs, ethnic groups, faith-based organisations and local residents in surveillance and control. Organize group clean-up campaigns within a certain radium (e.g. 100-300m) around high-risk areas such as hospitals, schools, markets or other places people spend time during the peak *Aedes* mosquito biting times.
- ✓ **Leverage technology:** Use free, user-friendly mobile apps (e.g. KoboToolbox) for real-time, georeferenced data collection and sharing.
- ✓ **Collaborate with experts:** Involve research institutes for advanced needs such as insecticide resistance testing or arboviral screening.

SECTION SEVEN – Mosquito Control Implementation

This section:
- Outlines approaches to routine control and outbreak/epidemic response in urban and rural areas, and at PoE
- Indicates the use scenarios, key considerations and priorities for interventions
- Indicates that further details are or will be provided in PacMOSSI or other guidance

7.1 Routine mosquito control

Mosquitos can thrive in both rural and urban areas. The implications of these settings for mosquito control are outlined in **Section 1.3**. Different routine *Aedes* control strategies are needed that account for the environment, infrastructure and mosquito ecology in rural versus urban settings.

For example, approaches can differ as follows:
- **Urban areas:** larval control can focus on hard waste management (e.g. rubbish clean-up) in residential and public areas and container management of common artificial habitats e.g. gutters or used tyres; adult control with residual spraying can target public places where high numbers of humans are active during daylight hours (e.g. schools, markets, hospital); improved infrastructure and waste management plus use of legislation will be important.
- **Rural areas:** container management coupled with larviciding that targets large water storage containers in areas without piped water and natural dispersed habitats; adult mosquito control can be minimal considering the remote and hard-to-access settings; community involvement will be essential.

Control priorities and targets will also differ depending on the transmission scenario (as shown in **Table 25**).

Urban mosquito control

Urban environments (which may include villages, towns and cities as well as settlement areas) have specific challenges related to *Aedes* mosquito control. High densities of people mean that viral diseases can build and spread quickly. Risk will be reduced in well-planned urban areas and is likely to be highest where there is poor water supply, poor hard rubbish management and sanitation, and water storage practices that support the proliferation of *Aedes* vectors.

Key elements of a successful urban mosquito control program are:
- ✓ **Comprehensive habitat elimination**: target and remove all mosquito egg-laying and breeding sites through weekly clean-up campaigns in residential and public areas
- ✓ **Strong legislation**: allow property inspections, mandate habitat elimination, and permit fines for non-compliance
- ✓ **Engaged communities**: public sector and community groups run awareness campaigns and promote community initiatives and participation
- ✓ **Regular inspections and interventions**: conduct weekly visits, assist or warn households, issue fines, and use larvicides as needed
- ✓ **Adequate staffing**: map areas, calculate staff needs, and organize teams for routine and special tasks
- ✓ **Effective reporting and supervision**: maintain strict oversight and require daily reporting for accountability
- ✓ **Coordination with other sectors**: initiatives aligned with ministry of health strategy but overseen by other sectors such as education, ports, businesses

As with community programs, mosquito control staff should not limit their activities to *Aedes* larval sites only. If all mosquito habitats are targeted, overall mosquito biting (including nuisance species) should be reduced which will increase the perceived benefit for local residents.

Rural mosquito control

Human population density is lower in rural areas than urban areas. Mosquito control is therefore more labour-intensive and involvement of the mosquito control program across all at-risk areas will be challenging. Therefore, in most cases, routine rural mosquito control activities will need to be carried out by local communities. This is discussed further in **Section 8**.

Points of Entry (PoEs)

Mosquito surveillance at PoEs is discussed in **Section 6.3**. For mosquito control:

- **Disinsection**: Conveyances (aircraft, ships, other) arriving from an area affected by a vector-borne disease if there local vectors for the disease present in the territory should be disinsected. Every conveyance leaving a PoE situated in an area where vector control is recommended should be disinsected and kept free of vectors.
- **Vector control**: This should be done for a minimum distance of 400 metres from PoE facilities used for operations involving travellers, conveyances, containers, cargo and postal parcels - and extended if vectors with a greater range are present. This can be achieved through an ongoing weekly activity of inspection and source elimination or management. Buildings at PoEs should also be regularly treated to ensure that they remain free of pests. It is expected that using residual insecticides, any mosquitoes that may arrive in luggage or other means are killed on arrival. Similarly, there should be fumigation of containers when necessary.

As stated in **Section 6.3**, mosquito control program staff should work closely with colleagues at PoEs to understand all the measures put into place to restrict the import and export of mosquitoes, including *Aedes* vectors. Further details are available in the *Vector Surveillance and Control at Ports, Airports, and Ground Crossings* (WHO, 2016)

7.2 Outbreak mosquito control

During outbreaks, it is imperative that mosquito control is done rapidly to contain the spread of transmission – either within a localised area, or between islands. In particular, response to imported cases in non-endemic settings will be critical to prevent local transmission. Investigations should begin the same day a case is notified. If possible, the likely place and date of infection will be useful to inform appropriate actions.

Key elements of successful mosquito control during an arboviral outbreak or epidemic include:

- ✓ **Rapid response to imported cases**: Immediate response to cases in visitors or returned residents to contain the infection, including residual insecticide spraying in the areas they have visited or stayed during peak mosquito biting times and provision of personal protection
- ✓ **Targeted adult mosquito control**: Rapid insecticide spraying through IRS and/or ORS in identified clusters of cases and in other locations of likely transmission (i.e. human congregation during peak mosquito biting times) such as hospital, market or school)
- ✓ **Personal protection:** Quickly provide ITNs and repellents to viraemic patients with a probable or confirmed arboviral infection (or if widely available for malaria, use during the day also)
- ✓ **Communication:** Initiate targeted and tailored risk communication messages to the community through appropriate channels that promote bite prevention and household

clean-up and are designed to be accessible to the various groups within communities e.g. people with disabilities, people speaking other languages or with low health literacy.

- ✓ **Community engagement**: Initiate or strengthen community engagement community including though social and behaviour change communication (SBCC) campaigns that target at-risk and affected populations, including marginalised groups.
- ✓ **Clean-up campaigns to eliminate larval habitats:** Promote the elimination of all mosquito larval habitats in households and surrounding areas, and other public locations like schools, sporting grounds, churches or parks including through engaging municipal councils.
- ✓ **Larval source control:** Implement other forms of larval control for habitats that cannot be eliminated, including such as scrubbing, moving, larviciding
- ✓ **Procurement and maintenance**: Ensure stocks such as insecticides are replenished and that equipment such as spraying machines and PPE are maintained to enable continual mosquito control capacity, especially for outbreak response.
- ✓ **Train**: Train personnel who will be mobilised for spraying, community clean-ups, larval source management and community engagement in advance

7.3 Special projects or initiatives

Large-scale agricultural or mining commercial enterprises

Large scale commercial enterprises such as Oil Palm Estates and other agricultural enterprises can be persuaded to protect their workers that live and work in at-risk or transmission areas as this could reduce staff illness and absenteeism. Legislation can be introduced and enforced to support this.

Shopkeepers and service organisations

If wide-scale use of personal protection measures such as ITNs or topical repellents is appropriate (e.g. when there is a very high proportion of viraemic individuals) or large quantities of ITNs or repellent are required to protect high-risk individuals (e.g. pregnant women in a chikungunya outbreak), these can potentially be made available cheaply through private vendors. Shopkeepers may be hesitant to purchase in bulk but a service organisation may assist with procurement and distribution to shops at a reduced or subsidised rate. Shopkeepers can then sell these with a slight profit to ensure affordability to the public and to sustain their availability. Such a project has been carried out by the Rotary Club of Port Moresby in Papua New Guinea since 1997 in which ITNs for malaria are bought in bulk and sold to traders.

7.4 Selecting interventions

Table 23 overviews intervention options for control of larval and adult *Aedes* vectors in the Pacific, including use scenarios and key considerations. Operational details are provided in the *Manual for surveillance and control of Aedes vectors in the Pacific* and in associated PacMOSSI materials.

Table 23. Intervention options for control of *Aedes* vectors in the Pacific

Intervention	Use scenario	Key considerations
Larval/immature control		
Container management	Covering, cleaning, moving or otherwise managing artificial containers in urban/peri-urban or drought-prone areas	Requires community participation; labour-intensive but sustainable with education; can integrate with water and sanitation programs

Clean-up campaigns (waste management)	Collection, destruction or other management of hard waste in residential areas and villages, including public areas	Supports larval source reduction; requires cross-sectoral coordination and local leadership; labour-intensive; improves overall living environment
Larvicides (e.g. Bti, temephos, mono-molecular film)	Chemical or biological treatment of static water habitats; repeat application required	Useful for hard-to-reach or fixed habitats that can't be eliminated; has limited efficacy in some habitats (e.g. vegetated); limited options for potable water; requires vector resistance monitoring; residual efficacy determines re-application strategy and cost
Biological agents (e.g. copepods, fish)	Introduction of biological agents into large or permanent water bodies (ponds, cisterns); rural settings with natural habitats; periodic reintroduction may be required	Species-specific suitability; avoid invasive species; survival determines re-introduction strategy and cost; surveillance essential;
Adult control		
Residual spraying (indoor) - IRS	Spraying of high-risk areas before or during outbreaks (or for invasive species) indoors where *Aedes* mainly rest inside	Rapid response if equipment & chemicals available; mid-term impact but high cost; requires vector resistance monitoring; residual efficacy determines re-application strategy and cost
Residual spraying (outdoor & harbourages) - ORS	Spraying of high-risk areas before or during outbreaks (or for invasive species) outside where *Aedes* rest outdoors including in foliage/vegetation	Rapid response if equipment & chemicals available; mid-term impact but high cost; requires vector resistance monitoring; residual efficacy determines re-application strategy and cost
Space spraying (fogging)	Fogging in and around homes during mosquito flight times and <u>useful ONLY for emergency response if implemented repeatedly and at high coverage</u>	Short-term impact; rapid response if equipment & chemicals available; high cost; high visibility; must be carefully timed and repeated; environmental/health concerns; requires vector resistance monitoring
***Wolbachia*-infected mosquito releases**	Urban centres with transmission sustained by *Ae. aegypti*; islands with limited reinvasion risk	Requires high-quality implementation; community acceptance critical; currently useful for *Ae. aegypti* only; surveillance essential
Spatial repellents	Households, schools, workplaces or residences, especially where other interventions are difficult to deploy or for added protection	Easy to deploy; provides daytime protection in places of congregation; residual efficacy affects replacement strategy and cost; community acceptance generally high
Personal protection (bite prevention)		
Insecticide-treated nets	Provided to viraemic patients or vulnerable individuals when resting during the day in households or health facilities (e.g. infants, infirm)	Physical barrier reduces mosquito contact; requires vector resistance monitoring; no evidence of community-level protection for arboviruses
Other insecticide-treated materials	Households, schools, workplaces or residences, especially where other interventions are difficult to deploy or for added protection where *Aedes* are mainly indoor-biting and resting	Treated window or door screens for physical and insecticidal barrier; requires vector resistance monitoring; reduced suitability in open housing
Topical repellents	Provided to (or purchased by) viraemic patients, vulnerable or high-risk individuals; applied during peak biting times; reapplication needed	Effectiveness varies by product; residual efficacy affects re-application and cost; requires consistent use; no evidence of community-level protection for arboviruses
Coils and vaporisers	Purchased by community members for use indoors during peak biting times; resupply needed	Effectiveness varies by product and setting; no residual efficacy; may be other human health

		concerns of prolonged indoor use; no evidence of community-level protection for arboviruses
All stages		
Health promotion and RCCE	All settings, including for preparedness in intra-epidemic periods (health promotion) and for response during outbreaks (RCCE)	Critical for all strategies; culturally tailored messaging; involve local leaders; can link to school or community programs; ensure accessibility and needs met for all genders, people with disability and other marginalised groups.

7.5 Priority and suitability of interventions

A summary of priority in different transmission settings and suitability for different mosquito species is given in **Table 24**. A summary of the general approach to *Aedes* control in the Pacific is provided in **Box 4**.

Table 24. Priority and suitability of different interventions against *Aedes* vectors in the Pacific.
🔴 = high priority, 🟠 = medium priority, ⚪ = low or no priority

Intervention	Priority			Suitable for *Aedes* species	Implementation
	Intra-epidemic	Outbreak/ Epidemic	Endemic		
Container management	🔴	🔴	🔴	Container inhabiting	Mosquito control program, municipalities, communities
Clean-up campaigns (waste management)	🟠	🔴	🔴	All	municipalities, communities
Larvicides (Bti, temephos, film)	🟠	🔴	🟠	Container inhabiting	Mosquito control program, municipalities, community
Biological agents (copepods, fish)	⚪	🟠	🟠	Container inhabiting	Mosquito control program, municipalities, community
Residual spraying (IRS, peri-focal)	⚪	🔴	🟠	Indoor-resting	Mosquito control program, volunteers
Residual spraying (harbourages - ORS)	⚪	🔴	⚪	Outdoor-resting	Mosquito control program, volunteers
Space spraying (fogging)	⚪	🟠 (if repeated, high coverage)	⚪	Day-flying	Mosquito control program, municipalities, volunteers
***Wolbachia*-infected mosquito releases**	🟠	⚪	🔴	*Ae. aegypti*	MoH special project
Spatial repellents	⚪	🟠	🟠	All	MoH special project
Insecticide-treated bed nets	⚪	🔴 (viraemic)	⚪	All	Healthcare worker (give to viraemic patients only)
Other insecticide-treated materials	⚪	🟠	🟠	All	Mosquito control program
Topical repellents	⚪	🔴 (viraemic or high risk)	🔴 (viraemic or high risk)	All	Healthcare worker (give to viraemic patients only), high risk can buy from shops
Coils and vaporizers	⚪	🟠	🟠	Indoor-resting	Can buy from shops
Health promotion and RCCE	🔴	🔴	🔴	All	Mosquito control program, MoH communications unit

Box 4. Summary of key points on *Aedes* control in the Pacific

In general:

- Larval control with container management, clean-up campaigns and larviciding is the cornerstone of routine proactive *Aedes* control.
- Residual spraying indoors and in peri-focal areas is undertaken for reactive control during outbreaks driven primarily by *Ae. aegypti*.
- Harbourage spraying may also be done, especially if *Ae. albopictus*, *Ae. polynesiensis* or other outdoor-resting species are important vectors.
- Interventions can be combined for sustained control or rapid response, if resources permit.
- Community participation and intersectoral collaboration are essential.
- Regular monitoring and evaluation of interventions is important.

7.6 Operationalising mosquito control

Further details on operational implementation of interventions is provided in the *Manual for surveillance and control of* Aedes *vectors in the Pacific* and in PacMOSSI and WHO materials, as indicated below. **Selection of any chemical or biological products should be guided by local regulatory requirements with selection from the WHO Prequalified list if possible.**

Larval control

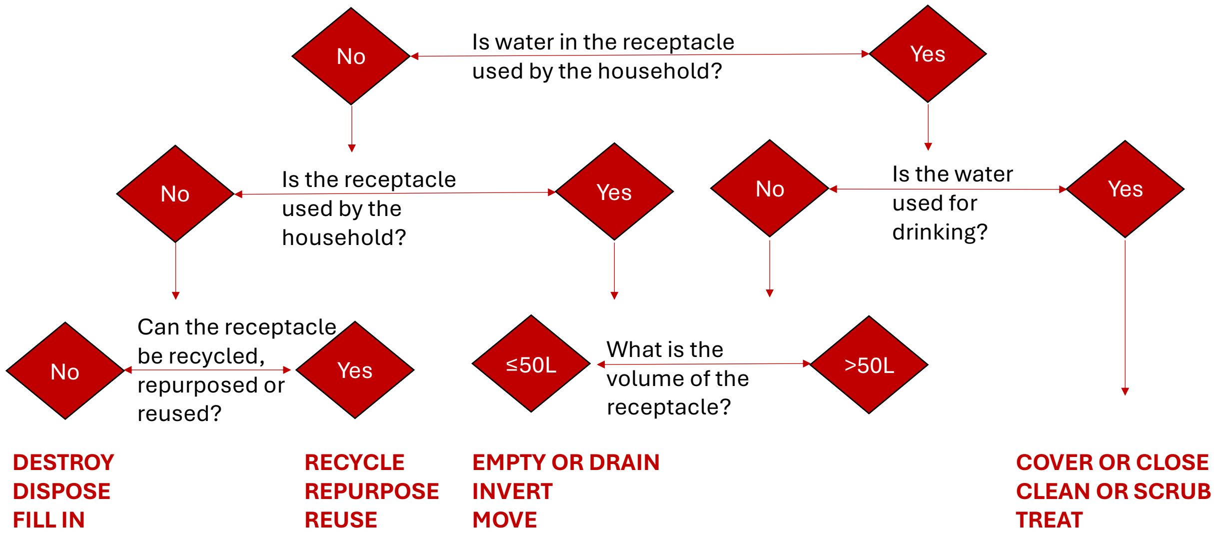
Actions will depend on the habitats present and interventions available. Vector staff should have a clear indication of appropriate actions for larval source reduction and treatment, as shown in the simple example in **Fig 4**. Characterising larval habitat types is covered in **Section 6.5**.

Larval source reduction

This includes container and waste management, environmental modification and environmental manipulation actions. The most relevant for *Aedes* in the Pacific are:

- **Clean, scrub** – to remove eggs and biofilm from essential water-storage containers
- **Cover, close, seal, screen** – to prevent mosquito oviposition
- **Destroy, dispose** – to remove from the environment
- **Recycle, repurpose, reuse** – to remove from the environment
- **Empty, drain, invert or move** – to prevent water accumulation
- **Fill in** – using soil or sand, to eliminate stagnant water (including small natural sites like leaf axils)
- **Improve water supply** – to prevent water storage
- **Improve drainage** – to prevent water accumulation, such as removing vegetation

Fig 4. Example schematic of actions for source reduction (excerpt from WHO, in press).



Community-wide clean-up campaigns can be conducted routinely or in response to an outbreak or epidemic. Key success factors for these campaigns include:

- ✓ Strong local leadership and clear roles for health, municipal and community leaders.
- ✓ Simple messages and practical demonstrations that focus on container management not just "tidying up".
- ✓ Reliable logistics for waste collection and disposal (including trucks, skips, timing, PPE).
- ✓ Community ownership through schools, churches, youth groups and feedback on results.
- ✓ Integration with routine *Aedes* surveillance and follow-up visits in persistent hotspots.

Regular door-to-door and community clean-up days can be initiated that use a standard checklist of actions outlined above e.g. to remove, drain, cover, invert etc. the various container types.

Larval source treatment

This includes the application of chemical and biological larvicides or other biological agents to water storage containers. Key determinants of success are high coverage rates and frequent reapplication, often in combination with larval source reduction. Options are listed below. See **Box 5** on larvicide use in drinking water. WHO prequalified products from the Vector Control Product List should be sourced when possible. In general, pyrethroids should not be used due to concerns with the emergence or spread of insecticide resistance.

Application of larvicides including:

- Synthetic organic chemicals, such as temephos or pirimiphos-methyl
- Insect growth regulators, such as pyriproxyfen or methoprene or novaluron or diflubenzuron
- Spinosyns such as spinosad
- Surface oils and monomolecular films such as oil or polydimethylsiolozane
- Bacteria, such as *Bacillus thuringiensis israelensis* (Bti) or *Bacillus sphaericus*
- Fungi, such as *Beauveria bassiana*

Introduction of other biological agents including:

- Larvivorous fish, such as *Poecilia reticulata*
- Predatory invertebrates, such as *Mesocyclops*
- Other predators, parasites or organisms, such as *Toxorhynchites* larvae

Box 5. Larvicides in drinking water

Only some larvicides are appropriate for use in drinking water or containers which may contain drinking water. Only those larvicide products which have been assessed and registered for use in drinking water in accordance with local, national or regional regulatory requirements should be used. These may potentially include formulations with the following active ingredients: *Bacillus thuringiensis var. israelensis*, *Bacillus sphaericus*, diflubenzuron, novaluron, pyriproxyfen, methoprene, spinosad, polydimethylsiloxane or temephos.

For those programs planning application of larvicides to drinking water, the *WHO Guidelines for drinking water quality* provide further relevant information that includes safety assessments for different active ingredients, including additional considerations for small children and bottle-fed infants.

Detailed implementation information will be available in the WHO *Operational manual on larval source management: control of* Anopheles *and* Aedes *mosquito vectors* (in press).

Adult control

Residual spraying

This involves applying long-lasting insecticides to surfaces on which vectors commonly rest. When there is high coverage to a high standard, this can be used as a preventive or reactive intervention. Where, when, how and what to spray is based on the *Aedes* species present, their resting locations and the susceptibility to insecticides available for spraying. Only WHO prequalified residual spray products should be used.

There are two main types of residual spraying against *Aedes*:

- **Indoor residual spraying**: used where key vector(s) mainly resting indoors e.g. *Ae. aegypti*
- **Outdoor residual spraying**: used where key vector(s) mainly rest in or inhabit exterior harbourage sites around houses and public spaces, including external structures and surfaces, outdoor furniture, foliage and vegetation, and larval habitats e.g. *Ae. aegypti, Ae. albopictus, Ae. polynesiensis*

The appropriate mix of indoor and outdoor spraying will depend on the local situation.

Targeting residual spraying should improve efficiency and impact. Spray operations can be targeted to:

- **Response areas**: locations with *Aedes*-borne disease outbreak or elevated risk
- **Community spaces**: structures and common areas where *Aedes* vectors rest and people sleep or gather during the day e.g. markets, schools, community centres, churches
- **Housing units**: houses and associated structures that are common resting sites of *Aedes* vectors (including women-only spaces like menstrual huts)
- **Harbourages**: outdoor areas that are potential *Aedes* vectors resting sites and larval habitats
- **Sprayable surfaces**: all areas within and around structures where *Aedes* vectors rest that can retain residual insecticide

Detailed implementation information is provided in the WHO *Operational manual on indoor residual spraying* and the PacMOSSI *Residual spraying against* Aedes *in the Pacific: spray operators field guide*

Space spraying

This intervention is useful in very limited situations. While entomological impact is proven, the evidence for impact on disease of either indoor or outdoor space spraying is weak. It must be done at times and places that ensure direct contact with flying mosquitoes. Because there is no residual effect, spraying must be repeated frequently. Emergency space spraying can be useful only if implemented **repeatedly and at high coverage**. Only WHO prequalified space spray products should be used.

Detailed implementation information is provided in the WHO *Space spray application of insecticides for vector and public health pest control : a practitioner's guide*

Personal protection

Topical repellents

Topical repellents may be beneficial to provide protection. WHO indicates these should contain DEET, picaridin, or IR3535. Safe but long-lasting formulations are preferred as these reduce the need for frequent re-application. Natural options such as citronella oil and eucalyptus usually provide short-term protection only. Repellents should be applied before mosquitoes become active, which is typically late afternoon for *Aedes* vectors. Reapplication of topical repellents will be needed after bathing and possibly before sleep depending on the last time of application.

Repellents can be supplied through the mosquito control program to viraemic patients to prevent mosquito bites and onwards transmission. Health facilities may provide these to in- or outpatients with a confirmed arboviral infection. Individuals or householders who are at elevated risk from bites – such as those who work in places or at times when *Aedes* bite the most – can also consider using topical repellents, which may be self-purchased from local stores or provided by an employer. They may also be used to protect vulnerable individuals such as pregnant women during Zika outbreaks.

Treated nets and other materials

Physical barriers to stop mosquitoes biting include use of treated mosquito nets when sleeping during the day, installing treated curtains and screens, or wearing long treated or untreated clothing.

- **Insecticide-treated mosquito nets** can be used to protect dengue patients in hospitals and homes. They should be selectively given to viraemic patients staying at health centres or hospitals and those recovering at home to use while resting or sleeping during the day. Mosquito nets are not appropriate for general use for protection against day-biting *Aedes*.
- **Insecticide-treated materials** including screens and curtains have shown some effectiveness for adult *Aedes* control and can be used where housing types mean these will create a physical barrier to prevent mosquito entry inside.
- **Long trousers or long-sleeved shirts that are light coloured** can protect against bites when worn during peak biting times. Clothing can be treated with the pyrethroid insecticide permethrin; even though there is widespread resistance to pyrethroids in *Ae. aegypti* in the Pacific, the insecticide may have some repellent effect.

Nets, clothing and screens can be treated with an insecticide(s) safe to humans but effective against *Aedes*.

Spatial repellents

Spatial emanators were recently recommended by WHO for use against *Anopheles* mosquitoes but have not yet been recommended or widely evaluated or deployed against *Aedes*. In Iquitos, Peru they reduced *Ae. aegypti* indoor abundance and biting rates and protected against *Aedes*-borne arboviruses (Morrison et al. 2022). However, feasibility relies heavily on community acceptance, duration of efficacy and deployment/replacement strategy.

Spatial emanators may have use in protecting vulnerable populations in arboviral outbreaks or humanitarian emergencies and in routine mosquito control where other interventions such as residual spraying are not feasible (e.g. in open houses). There is the potential for distribution of passive emanators through the private sector, which could be subsidised if large-scale deployment for community protection is the aim of the mosquito control program (see **Section 7.3**).

Coils or vapourisers

Mosquito coils and vapour mats can also be useful indoors although fumes produced may be an irritant to humans. Outdoors, these options are likely to have limited use unless there is no wind.

Other population reduction or transmission blocking interventions

Wolbachia-infected mosquitoes

Programs should also consider using other interventions such as releases of *Wolbachia*-infected or sterile *Ae. aegypti*, lethal ovitraps and other innovations.

Area-wide deployments of wMel-infected *Ae. aegypti* have already been conducted in several Pacific locations, including in Suva, Lautoka, Nadi (Fiji), Port Vila (Vanuatu), South Tarawa (Kiribati) and Noumea (New Caledonia). With community support, weekly releases of wMel-infected *Ae. aegypti* mosquitoes for between 2 to 5 months resulted in wMel introgression in nearly all locations and a high, self-sustaining prevalence of wMel according to Simmons et al. (2024). Monitoring requirements should be discussed with experts with relevant research or implementation knowledge.

Further operational guidance will be available through collaborators such as the World Mosquito Program.

SECTION EIGHT – Health Promotion, Risk Communication & Community Engagement

This section:

- Highlights the importance of risk communication and community engagement in outbreaks
- Provides examples and options for engaging community leaders and members in mosquito surveillance and control

8.1 Health promotion

Effective *Aedes* mosquito surveillance and control relies on people assuming control over improving their health, also called health promotion. This includes the two-way exchange of information between health authorities and communities (risk communication), and involvement of communities in design and implementation of surveillance and control (community engagement). These aim to improve knowledge and practices, foster trust and cooperation, enable rapid, coordinated responses to arboviral outbreaks, empower communities to participate actively, and ultimately to reduce vector populations and lower disease risk.

These approaches are important for both preparedness and response, as they ensure interventions are contextually relevant, sustainable, and widely adopted to maximise their impact. The priority and approach for each may be adjusted depending on transmission scenario. Social and behaviour change communication (SBCC) is a strategic approach to promote changes in knowledge, attitudes, norms, and behaviours.

Detailed guidance for dengue is provided in the WHO *Risk communication and community engagement readiness and response toolkit: dengue fever*.

8.2 Risk communication

Risk communication refers to communicating with the public, in order to save lives and reduce illness. Every public health intervention used during an outbreak will succeed or fail based on the way you communicate.

Effective communication can:

- help slow, stop or prevent outbreaks;
- maintain and build public trust in health authorities;
- help people overcome fear and anxiety;
- help people make informed decisions about how to protect themselves; and
- reduce the economic, social and political impact of an outbreak.

Risk communication can include:

- media releases or interviews for radio, television or newspapers with a public spokesperson nominated early in the outbreak (see **Box 6**);
- social media content for mass dissemination on channels such as Facebook or X;
- public talks at community gatherings (e.g. community meeting places, churches); and
- production and distribution of billboards, flipcharts, posters and other information.

All activities and materials and the dissemination strategy should be designed for access and comprehension by all diverse groups within a population e.g. different genders, people with disability, people with low or no literacy, people who use a different language. For each round or pulse of risk communication, effectiveness should be evaluated for the target audiences.

To manage the information needs, it is a good idea to produce a simple one or two-page public situation report. The situation report should provide information about the outbreak and what is being done to respond, as well as actions required from the public. Depending on how the outbreak progresses and public appetite for information, this may be daily initially and reduced to monthly or weekly later.

Box 6. About public trust

Trust is the key principle of outbreak risk communication. Without this trust, the public will not believe, or act on, the health information that you give them. Trust is built through the following steps:

1. **Announce early:** Let people know what is going on as soon as possible. Tell the public of a real or potential health risk. It does not matter if you do not have all the answers. Late announcement will break the trust in the health authorities' ability to manage the outbreak.
2. **Don't hide anything:** Keep the public up to date. If there is nothing new to say, keep reinforcing key messages so people stay safe. Aim for total honesty. Promise and deliver regular briefings. Keep detailed records of decision-making meetings, and communicate not only decisions, but how you made those decisions.
3. **Listen**: Tell the truth and then listen. Trust cannot be maintained if you do not know what people are hearing, thinking and feeling. Listen to understand the public's objections, to identify points of confusion, and to respond to concerns whether you believe they are rational or not.
4. **Plan:** Do not wait until there is an outbreak to start thinking about how to communicate with the public and other stakeholders. It is useful to develop a generic outbreak communication plan so that when an outbreak occurs, the plan can be quickly used.

8.3 Community engagement

Communities, particularly in low resource environments, are the key to arboviral disease prevention and control. MoHs should look for opportunities where communities can be directly engaged in MBD surveillance and control. A phrase to remember when working with communities is "**With us, not for us**".

Programs should identity options for community engagement that are appropriate for their situation, setting, communities and subgroups. These may vary across the country. To determine best options:

- **Co-design**: Work with community members and stakeholders to identify the most appropriate engagement and communication approaches for each group.
- **Tailor**: Adapt these approaches so they are accessible, culturally appropriate and relevant for each specific target group.
- **Monitor**: Regularly check how well each approach is reaching and engaging the different groups, using feedback and simple data.
- **Adjust**: Use what you learn to refine and improve your approaches over time, so they stay effective and responsive to community needs.

Table 25 shows examples of engagement activities and behaviour change communication channels that can be considered. Remember it is useful to map the appropriate modes of communication for the different groups within a population and regularly evaluation if this is effectively reaching all target groups.

Further guidance is available in Chapter 7 of the *Manual for surveillance and control of* Aedes *vectors in the Pacific* and Module 7 and the PacMOSSI online course Module 7.

Table 25. Options for community engagement in mosquito surveillance and control

Community engagement activity	Methods	Target	Enabling factors
Clean-up campaigns (waste management)	Periodic area-wide community or municipal action to remove hard-waste by householders, school children or other volunteers.	Municipal councils, community leaders and groups, householders. School or church involvement	Council coordination. School or CBO involvement. Community leader support. Legislation that householders must keep premises free of waste.
Container surveillance and management	Weekly inspection and management of larval habitats in people's households and surrounding areas by school children or other volunteers	Community leaders and groups, householders	School or CBO involvement. Community leader support. Legislation that householders must keep premises free of mosquito habitats.
Larval habitat treatment e.g. larvicide application	Periodic treatment of larval habitats by community-based volunteers	Community leaders and groups, householders	CBO involvement. Community leader support.
Spray operations	Periodic spraying indoors and/or outdoors by community-based volunteers	Community leaders and groups, householders	CBO involvement. Community leader support.

Roles and responsibilities need to be clearly identified, as in **Table 26**.

Table 26. Example community roles and responsibilities for mosquito surveillance and control in PICs

Group	Role or responsibility
Community leaders	Mobilize and unite community; set examples
Community members	Participate in clean-up campaigns; weekly inspection and management of larval habitats; acceptance of spraying
Viraemic patients	Use of personal protection measures (nets, topical repellents)
School and university staff	Integration of activities into curriculum or extra-curricula initiatives
School and university students	Participate in clean-up campaigns; weekly inspection and management of larval habitats; participate in citizen science projects for mosquito surveillance and control
Other volunteers	Implement spraying, larviciding or other measures
Healthcare workers	Provide training, support, and SBCC materials

When starting a community program, these key factors should be considered:

1) **Community willingness –** Does the community and/or subgroups within the community genuinely want to take part in the program?
2) **History of mosquito-borne diseases –** Has the community and/or subgroups within the community previously suffered from mosquito-related illnesses, or are they currently affected? Or are there problems with nuisance mosquito biting particularly in the afternoons?
3) **Strong leadership** – Does the community have influential leaders, such as a respected village chief or church leader, who can mobilize the community effectively? Who are the different respected leaders for target subgroups within the community e.g. for women, people with disabilities, ethnic minority groups.
4) **Existing partnerships –** Does the community already have projects with organisations such as NGOs, DPOs or FBOs? If so, could a mosquito control program build on these existing initiatives?
5) **Past or ongoing community engagement –** What has been the previous experience with community engagement for the community or subgroups? Has there been successful participation in similar health or other initiatives, such as Healthy Islands, Healthy Village, Healthy Schools, and Healthy Markets programs[1]? Are there any ongoing programs that offer the opportunity to integrate mosquito surveillance or control components, such as water and sanitation programs? Are there programs that address the needs of people with disabilities, women, older persons, youth, ethnic minorities, other genders that could offer this opportunity of integration?
6) **Opportunities for integration** – Can mosquito surveillance and control initiatives be integrated into school, higher education or other program curricula, or be included as extra-curricula activities such as citizen science?
7) **Experienced staff** – Does the program have staff skilled in working with communities? Are there established links or opportunities to partner with NGOs, CBOs, DPOs or FBOs to work with different communities?

Success factors for community engagement for mosquito surveillance and control include:

- ✓ Motivated and committed communities with strong leaders and prior success.
- ✓ High community desire for reduced mosquito biting (including nuisance species) or reduced disease.
- ✓ Ensure inclusivity in all community participation activities, including gender, people with disability and other marginalised groups.
- ✓ Weekly activities that build trust, participation, habits and become part of regular life.
- ✓ Integrate with broader health or other community-engagement initiatives to increase sustainability and impact.
- ✓ School or university involvement for long-term change and community reach, including through coordination of citizen science projects.
- ✓ Effective SBCC that supports understanding, motivation, and inclusivity.
- ✓ Program and community personnel who understand community participation.

Box 7 provides examples from the Pacific and Asia where community engagement has been successfully undertaken for *Aedes* and dengue control.

[1] https://www.who.int/publications/i/item/PHMM_declaration_2015

Box 7. Examples of community engagement for *Aedes* control (adapted from Annex 5 of the *Manual for surveillance and control of* Aedes *vectors in the Pacific*)

- **COMBI project targeting selected areas in Fiji by the Ministry of Health:** Community engagement project to reduce mosquito habitats through targeted behavioural messaging, community training, and community-led house-to-house visits.
- **World Mosquito Program:** Community engagement was central to gaining acceptance for *Wolbachia* mosquito releases, using structured outreach and stakeholder mapping.
- **Dengue Day campaigns across Asia:** ASEAN advocacy day held each year on 15 June to promote multisectoral collaboration, community involvement and awareness on dengue prevention.
- **Guam Environmental Public Health Education Campaign:** Public education on mosquito biology and control through school contests, public fairs, and partnerships, aiming to increase knowledge and community participation in mosquito prevention.
- **Vanuatu:** Ministry of Health has established partnerships with educational institutions to incorporate mosquito control education and community activities into school curricula.
- **Community engagement programme in New Caledonia:** Trained dengue prevention agents conduct house-to-house visits to inform and build capacity of communities for habitat elimination, with behavioural and entomological outcomes measured before and after interventions.
- **Dengue fight week in New Caledonia:** Annual campaign that involves clean-up drives, educational activities, and distribution of prevention materials to engage public and private sectors to raise awareness and build capacity to eliminate mosquito larval habitats.

SECTION NINE – Monitoring, Evaluation & Learning

This section:

- Highlights the importance of monitoring and evaluation for mosquito surveillance and control
- Provides examples and options for engaging community leaders and members in mosquito surveillance and control

Monitoring, evaluation and learning are essential for *Aedes* mosquito surveillance and control to provide actionable data, demonstrate intervention impact, and foster a culture of continuous improvement—ultimately reducing the risk and burden of mosquito-borne diseases.

- **Monitoring** enables real-time detection of vector population changes, allowing for rapid response and resource allocation.
- **Evaluation** demonstrates the effectiveness of interventions, such as school-based education or *Wolbachia* releases, by measuring outcomes like adult or larval indices and disease incidence.
- **Learning** informs future program design, ensuring interventions are contextually appropriate and continuously improved.

9.1 Monitoring and evaluation (M&E)

A list of program indicators is presented in Annex 4 of the *Manual for surveillance and control of Aedes vectors in the Pacific* (WHO/SPC, 2020). Select from this list based of relevance, usefulness for decision-making, responsiveness to change, and data availability. Each indicator defined should be specific, measurable, achievable, relevant, and time-bound ("SMART") and should provide a balance across the logical framework, of considering inputs, processes, outputs, outcomes and impacts.

Some practical tips for M&E for mosquito surveillance and control:

- **Monitor both routine and outbreak data**: Collect and analyse data both during intra-epidemic periods and outbreaks for timely response.
- **Choose simple, actionable indicators and expand as needed**: Use indicators that are easy, reliable, and cost-effective to collect, and add more as needed.
- **Map partner organizations to identify options for community-based M&E**: Create and maintain a map showing the reach and activities of all NGOs, CBOs, UN agencies and other partners working in communities and leverage existing relationships and networks for M&E.
- **Engage communities in data collection**: Involve local actors in surveillance and reporting to improve coverage, acceptability, accessibility, sustainability, and community ownership.
- **Set up data collection systems**: If none exist, implement free, GPS-linked tools like Kobo Toolbox to collect local health and entomological data, ensuring offline capability and easy integration.
- **Link to centralised database and validate data:** Link all collected community and partner data to a central system, regularly check for quality, and ensure data can be visualized and analysed spatially.
- **Use evidence to advocate and adapt**: Present clear, mapped data to stakeholders and funding agencies and donors to demonstrate impact, and regularly review and adapt M&E strategies based on findings.

9.2 Learning

Lessons learned

Lessons learned during routine implementation are important to document, such as in annual reports. Recommendations or proposed actions based on these learnings should also be identified, and discussed with relevant decision-makers for implementation.

Intra- or After-Action Reviews provide a useful process for documenting outbreak responses following a standard WHO process to engage relevant stakeholders. A summary of the key questions that guide the reviews is provided in **Table 27**.

Table 27. Questions to be answered through Intra-Action and After-Action Reviews

Intra-Action Review	After-Action Review
• What is happening right now? • What emerging issues are there? • What has worked well so far? • What hasn't worked well so far? • What can be learnt from this? • What should we change immediately?	• What was intended? • What happened? • Was there a difference between what was intended and what happened? If so, why? • What have we learned? • What will we do differently next time?

Operations research

Operations research is an important part of a mosquito control program to understand implementation constraints in order to improve effectiveness and cost-efficiency.

Priorities for operations research should be pre-defined, such as during the VSCP development process. This will assist in engaging partners for collaboration and funding opportunities, and will ensure research is aligned with program objectives. Training and skilled staff will be required to carry out the research. Opportunities to leverage capacity in local research or educational institutes should be explored, including identify student and other community group projects that will address critical information gaps for the program and for which data collection is feasible and realistic.

Detailed implementation information is provided in Chapter 6 of the *Manual for surveillance and control of Aedes vectors in the Pacific* (WHO/SPC, 2020).

SECTION TEN – Inclusivity and equality in mosquito control programs

This section:
- Provides definitions, intersections and spectrum for GEDSI
- Highlights the importance of inclusivity and equality in arboviral disease control
- Identifies main barriers and responses for mosquito control programs in the Pacific
- Gives advice for planning and monitoring GEDSI

The term "GEDSI" refers to gender equality, disability and social inclusiveness. Each of these will be explored in more detail here with regards to the importance and relevance to mosquito control programs in the Pacific.

10.1 Definitions

Gender

- **Gender:** socially constructed norms roles, behaviours, activities, attributes and relations among and between women and men, girls and boys and gender diverse people
- **Gender equality**: equal chances or opportunities to access and control social, economic and political resources, including protection under the law
- **Gender equity**: fairness, considering different needs to achieve gender equality

Disability

Persons with disabilities include those who have long-term physical, mental, intellectual or sensory impairments which in interaction with various barriers may hinder their full and effective participation in society on an equal basis with others.

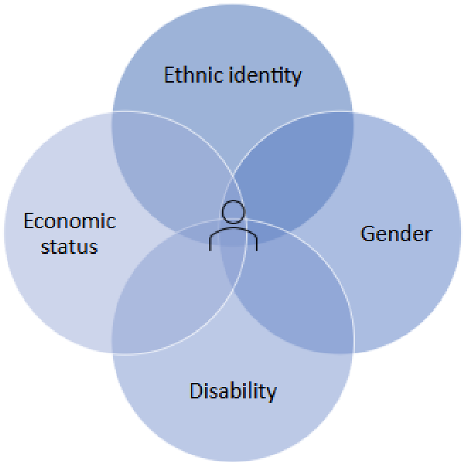
- **Physical**: performance of body functions e.g.. walking, moving arms and legs, using hands, etc. e.g.. spinal cord injury, cerebral palsy, amputation
- **Sensory**: seeing, hearing or communicating. e.g.. people who are Deaf, hard of hearing, blind or have low vision
- **Psychosocial:** chronic severe mental disorders or psychosocial distress. e.g.. schizophrenia, depression, bipolar
- **Intellectual:** language, reasoning, memory, personal care, etc. e.g.. Down syndrome, cognitive impairments/brain injuries

It is important to note that People with disabilities are not all the same. Disability is diverse. It can change over time and is different for each individual.

Marginalisation

Marginalized communities, peoples or populations are groups and communities that experience discrimination and exclusion (social, political and economic) because of unequal power relationships across economic, political, social and cultural dimensions. These can include poverty, ethnicity, literacy, remoteness, stigmatising condition, legal status.

Intersections



A person may belong to more than one of these groups – their identity is at the intersections. Disability can intersect with other identities and can compound or worsen the marginalisation of the person.

For example, a woman with disability living in poverty may face triple discrimination: being female, being a person with disability, and being poor. It is important to consult widely to understand the diversity of experiences and barriers faced.

10.2 Importance of inclusivity and equality in arboviral disease control

There are numerous barriers to effective arboviral control in the Pacific. These include:

- **Vulnerability and exposure to mosquito-borne diseases**: Pregnant women, some people with disabilities and those in high-exposure work or poor housing face greater VBD risk and severity due to intersecting biological and socio-economic factors.
- **Awareness and knowledge of mosquito-borne diseases and their prevention and treatment**: Women, people with disabilities and socially excluded groups often have less education and poorer access to information; SBCC frequently assumes literacy and no sensory or cognitive impairment.
- **Ability to practice preventative behaviours**: Immobile individuals and those in non-standard sleeping spaces may miss spraying or net coverage; intra-household power dynamics and norms influence who benefits from prevention tools.
- **Ability to seek and access timely and quality treatment**: Women may need permission to seek care; men may delay due to norms; people with disabilities and socially excluded groups face mobility, financial and discrimination barriers, especially in remote areas.
- **Ability to complete treatment**: Low literacy, language barriers and non-accessible formats hinder adherence, particularly for people with disabilities and socially excluded groups.
- **Outbreak response**: Emergencies intensify gender, disability and social inequalities, increasing economic hardship and violence risk for women and other marginalised groups and limiting recovery.

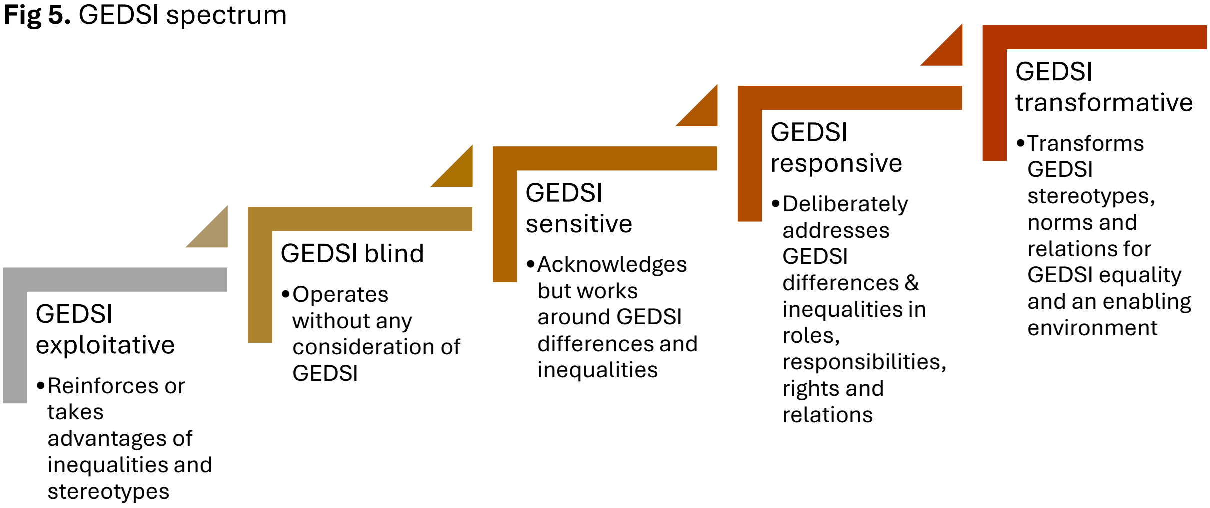
For mosquito control program management, there are often leadership, staffing, data systems, partnerships barriers. For instance, there may be male-dominated leadership and teams that lack diverse representation. Moreover, data rarely captures GEDSI dimensions.

10.3 GEDSI spectrum

A common way of defining where your program or activities are now and where you want them to be is by referring to the steps along the path of the GEDSI spectrum, as shown **Fig 5**.

The mosquito control program needs to move as far to the right as they can, towards being GEDSI transformative. If this cannot be achieved through their own resources or responsibilities, they can advocate for the changes required at higher levels.

Fig 5. GEDSI spectrum



10.4 Main barriers and responses to ensure inclusivity and equality in mosquito control programs in the Pacific

GEDSI barriers in Pacific vector control programs can be addressed through targeted responses integrated into planning, budgeting and monitoring, considering remote islands, cultural norms, gender roles and climate vulnerabilities, as summarised in **Table 28**.

Table 28. Main barrier types, examples and integrated priority responses in the Pacific

Barrier type	Key examples in Pacific contexts	Integrated priority responses
Attitudinal	Discrimination in care-seeking; male-dominated chiefly/leadership structures; exclusion of women/people with disabilities/outer island/youth groups from decisions and prevention.	Train on GEDSI with cultural sensitivity; diversify workforce including women leaders and youth; intentionally include women, people with disabilities, outer islanders and marginalised groups in program design and mosquito control.
Physical	Inaccessible facilities on remote atolls; boat/transport barriers for outer islands/ people with disabilities; overlooked immobile households or informal settlements in spraying.	Conduct accessibility/safety audits for island clinics; provide boat-accessible transport; select inclusive venues; tailor vector control to high-risk settings like informal housing, plantations and separate fale sleeping.
Communi-cation	Low literacy in Pidgin/vernaculars; inaccessible SBCC for non-literate or deaf communities; poor treatment instructions amid cyclones/outbreaks.	Use multiple formats (spoken/Pidgin/pictorial/video/sign language); co-design inclusive SBCC in local languages; respect chiefly protocols and church networks; simplify adherence support for household clusters.
Institutional	Limited disaggregated data from fragmented islands; insufficient nets for extended families; unrepresentative staffing; weak outbreak integration amid climate events.	Review HR/policies for Pacific inclusion; collect and use sex/age/disability/island data for planning/M&E; allocate GEDSI budgets; partner with women's committees, DPOs, churches and community groups across all stages.

Table 29 shows examples of a few practical and strategic ways PICs can address GEDSI in the activities of the VSCP.

Table 29. Example of gender matrix for *Aedes* vector control in a PIC

Activity	Practical (responsive)	Strategic (transformative)
Trainings	Ensure equitable access to training including timing, duration and location with additional support provided if needed	Include GEDSI concepts in training initiatives
RCCE	Ensure activities have positive representation of all genders, people with disabilities and other marginalised groups and are available to people with low literacy and with disabilities	Involve women and people living with disabilities and advocates in co-design of campaigns and other initiatives
Field-based work	Ensure both women and men are included in surveillance and control activities	Implement safeguarding policy to protect women in the workplace, including during field work
Hiring and HR management	Ensure advertisements for recruitment and promotion make clear opportunities are open to all genders and people with disabilities	Ensure fair and equitable recruitment processes. Implement leadership activities that support women in leadership roles within the mosquito control program.

10.5 GEDSI planning and monitoring

There are 4 important planning principles to ensure GEDSI principles and considerations are included in your work. These are:

- **Embed** the collection, analysis, and dissemination of GEDSI disaggregated data e.g. by gender, disability, income, education, location, ethnicity. Use the evidence to inform decision making.
- **Ensure** that the VBD investments are informed by GEDSI data and analysis of the barriers and opportunities of people with diverse backgrounds.
- **Consider** GEDSI in interventions to strengthen organisations e.g. capacity building, human resource management. Includes the VBD staff, GEDSI linked community organizations, and communities.
- **Consult** and actively engage with GEDSI led organisations throughout the program cycle, e.g. design, implement, monitor and evaluate.

Always remember to include assessments of whether the approaches taken improve the GEDSI responsiveness and even transformative outcomes of your work to see are working - for everybody, everywhere, whenever needed. Engage women, people with disabilities and socially marginalised groups in the monitoring, evaluation and joint learning.

Key approaches to ensuring and measuring performance of GEDSI in your mosquito surveillance and control activities, strategies and programs are provided in **Box 8**.

Box 8. Approaches to ensuring and measuring GEDSI performance in a mosquito control program

- Using GEDSI analysis to ensure that your investment in vector control programs and activities is relevant and supports decision making for inclusiveness and equity
- Identifying, mitigating and managing any risks that are linked to GEDSI to ensure that your investment and program do NOT do harm and actually do address GEDSI gaps
- Providing evidence of how the program has supported an active role of all genders, people with disabilities and/or organizations of persons with disabilities and other socially marginalised groups in the annual and strategic plan activities.
- Effectively implementing the GEDSI strategies you have included to drive progress towards both the overall outcomes of the VBD program and GEDSI approach
- Using monitoring, evaluating and learning to provide accountability for and support to an evidence-based approach to VBD and GEDSI and supports the collection and use of GEDSI disaggregated data including on participation
- Ensuring that the resourcing levels and efficiency of using the resources (including budgetary and expertise) achieves the GEDSI objectives

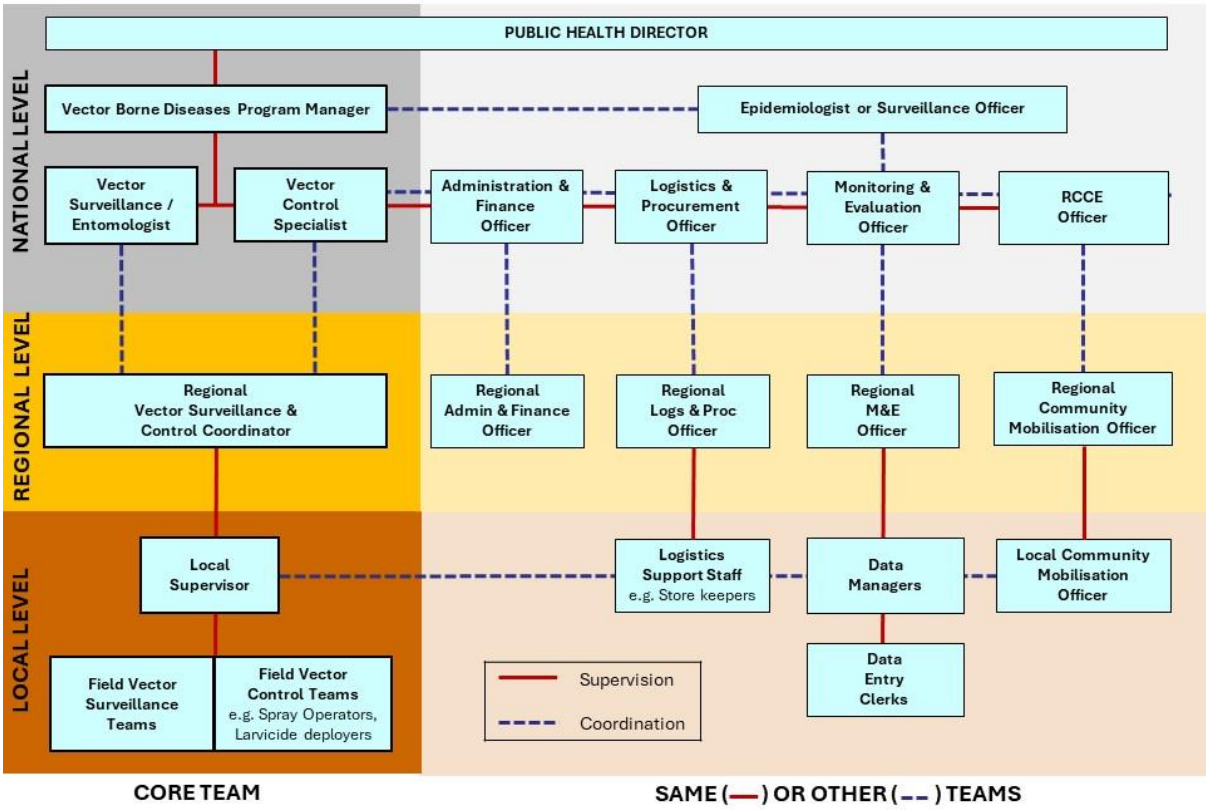
ANNEXES

Annex 1 – Organisational charts

Organisational charts are useful to clearly define roles, responsibilities, and reporting structures, ensuring efficient coordination and communication among team members for effective program implementation. Organisations will be structured based on local aims, settings, resources and circumstances. In low-resource settings, the core team may be small and responsibilities may be assigned to staff in other teams through a matrix structure.

Fig. 1 outlines a hypothetical organisational chart for a spray operation, showing one regional office and one spray team. The actual number of teams will depend on the interventions selected, the area and its layout, and the intended duration of the activity.

Fig. 1 – Example organisational chart for mosquito control program



Annex 2 – Sample job descriptions and terms of reference

Two examples of job descriptions of Program Manager and Entomologist are presented below. Similar TORs can be drawn up for other key staff as those outlined in **Table 7** in **Section 2**, although broader responsibilities are likely in small countries and low-resource settings.

Mosquito Control Program Manager

Position Title: Mosquito Control Program Manager
Location: Name of PIC
Reports To: Director of Public Health

Background:

Viral diseases transmitted by mosquitoes such dengue, chikungunya and Zika are increasingly becoming a problem in the world including the Pacific Region with a number of outbreaks reported in the last few years. Dengue is potentially lethal, chikungunya can have symptoms that last a very long time, and Zika is particularly a problem in pregnant women resulting in birth defects of the unborn child.

The Mosquito Control Program is looking for a manager to spearhead an ambitious program of activities to reduce and eventually eliminate these diseases from the country.

Job Summary:

The Mosquito Control Program Manager is responsible for the coordination, planning, implementation, and evaluation of a mosquito control program to mitigate the spread of vector-borne diseases, and respond to outbreaks when they occur. The role involves coordinating with government agencies, health organizations, and community stakeholders to ensure effective intervention strategies.

Key Responsibilities:

- Develop a National Strategic Plan (NSP) with key partner involvement.
- Develop and oversee mosquito control programs, ensuring alignment with health sector priorities and other relevant national strategies and principles.
- Lead a team of professionals in implementing control measures and conducting surveillance activities.
- Collaborate with government agencies, research institutions, and community partners for program success.
- Ensure compliance with health regulations, safety protocols, and environmental guidelines.
- Manage project budgets, resources, and reports related to mosquito control initiatives.
- Monitor disease transmission trends and adapt strategies accordingly.
- Provide technical guidance and training to staff and stakeholders on mosquito control best practices.
- Advocate for policy improvements and funding allocations to support mosquito control efforts.
- Maintain accurate records and submit reports on program effectiveness and challenges.

Qualifications and Experience:

- Minimum of five years of experience in management, preferably in the health sector.

- Strong coordination skills and ability to work with multiple stakeholders, including community leaders.
- Experience in vector control and disease prevention programs is advantageous.
- Demonstrated ability to develop and implement strategic plans.
- Proficiency in data collection, analysis, and reporting.
- Knowledge of environmental health and epidemiological principles.

Personal Characteristics:
- Visionary leadership with the ability to innovate in mosquito control approaches.
- Highly organized, ensuring tasks are completed within deadlines.
- Works well in partnerships, fostering collaboration among stakeholders.
- Detail-oriented with strong problem-solving capabilities.
- Excellent communication and negotiation skills.
- Committed to Gender equality, disability and social inclusiveness principles

Terms of Employment:
- Contract duration: [Specify Length]
- Working hours: Expected to work normal working hours but should be prepared to be flexible depending on times line and demands such as outbreaks.
- Compensation: [Specify Salary/Benefits]
- Performance evaluation criteria: [Specify Evaluation Process]

Mosquito Control Specialist / Entomologist

Position Title:	Mosquito Control Specialist / Entomologist
Location:	Name of PIC
Reports To:	Mosquito Control Manager

Background

Viral diseases transmitted by mosquitoes such dengue, chikungunya and Zika are increasingly becoming a problem in the world including the Pacific Region with a number of outbreaks reported in the last few years. Dengue is potentially lethal, chikungunya can have symptoms that last a very long time, and Zika is particularly a problem in pregnant women resulting in birth defects of the unborn child.

The Mosquito Control Program is looking for an experienced Medical Entomologist to lead an ambitious program of activities with the aim to reduce and eventually eliminate these diseases from the country.

Job Summary

The Mosquito Control Entomologist is responsible for conducting entomological research, analysing vector populations, and developing strategies to control mosquito-borne diseases. This position requires expertise in medical entomology to design, implement, and evaluate vector control interventions.

Key Responsibilities:
- Conduct research and surveillance on mosquito species, distribution, and resistance patterns. This includes a community-based surveillance and control program.

- Develop and refine mosquito control strategies based on entomological data and epidemiological trends.
- Collaborate with public health teams to integrate entomological findings into disease control programs.
- Train and guide field teams on mosquito identification, control techniques, and monitoring practices.
- Implement insecticide resistance testing and evaluate the efficacy of control measures where feasible.
- Prepare scientific reports, technical guidelines, and recommendations for mosquito control policies.
- Oversee the maintenance of laboratory equipment, mosquito colonies, and field surveillance tools.
- Ensure strict adherence to environmental regulations and health safety protocols.

Qualifications and Experience:

- Minimum of five years of experience in medical entomology.
- Strong leadership skills and ability to manage multidisciplinary teams and work with diverse communities.
- Experience in vector control and disease prevention programs is an advantage.
- Proficiency in data collection, analysis, and reporting using entomological tools.
- Familiarity with insecticide resistance mechanisms and surveillance methods.
- Knowledge of epidemiology and public health strategies related to vector-borne diseases.

Personal Characteristics:

- Highly organized with excellent time management skills.
- Works effectively within a team environment, fostering collaboration and knowledge-sharing.
- Committed to meeting deadlines and delivering quality results.
- Detail-oriented with strong analytical and problem-solving skills.
- Strong communication abilities for stakeholder engagement and scientific reporting.
- Committed to Gender equality, disability and social inclusiveness principles.

Terms of Employment:

- Contract duration: [Specify Length]
- Working hours: [Specify Working Schedule]
- Compensation: [Specify Salary/Benefits]
- Performance evaluation criteria: [Specify Evaluation Process]

Annex 3 – Example of an annual plan

Task	Activity	Responsible Body	J	F	M	A	M	J	J	A	S	O	N	D
Reports	Annual reporting	Mosquito control program	X											
	Quarterly reporting	Mosquito control program				X			X			X		
Plans	Annual planning	MoH, Mosquito control program												X
	Quarterly planning	MoH, Mosquito control program			X			X			X			
Partner Coordination	Identify and consult with key stakeholders	Mosquito control program and other partners	X	X	X	X								
	Fortnightly partner meetings	TWG meetings for all partners	X	X	X	X	X	X	X	X	X	X	X	X
Community Engagement	Identify and consult with communities and sub-groups	Mosquito control program, MoH communication unit												
	Design a SBCC Program	Mosquito control program, MoH communication unit			X	X	X	X						
	Write SBCC Policy	Mosquito control program, MoH communication unit					X	X						
	Produce SBCC Materials	Mosquito control program, MoH communication unit						X	X	X				
	Conduct (and monitor) SBCC campaign	Mosquito control program, MoH communication unit								X	X	X	X	X
	Mobilise communities for LSM activities	Entomologist and SBCC Staff		X	X	X	X	X	X	X	X	X	X	X
Surveillance and Control Program	Procure insecticides and materials	Entomologist and Logistics Staff	X											
	Plan urban control program	Entomologist	X											
	Recruit Staff	Program Manager and Finance and Admin	X	X										
	Implement urban control program	Entomologist and Urban Control Team			X	X	X	X	X	X	X	X	X	X
	Rural larviciding program	Entomologist and RCCE Staff												
	Respond to outbreaks	Entomologist, spray staff and RCCE Staff	X	X	X	X	X	X	X	X	X	X	X	X
M&E	M&E of all activities	Program Manager and M&E Officer	X	X	X	X	X	X	X	X	X	X	X	X

Source: https://pacmossi.org/carbon/assets/2022/10/DAY-1-SP-Workshop-Murphy_Strategic-planning-for-VCS.pdf?form=MG0AV3

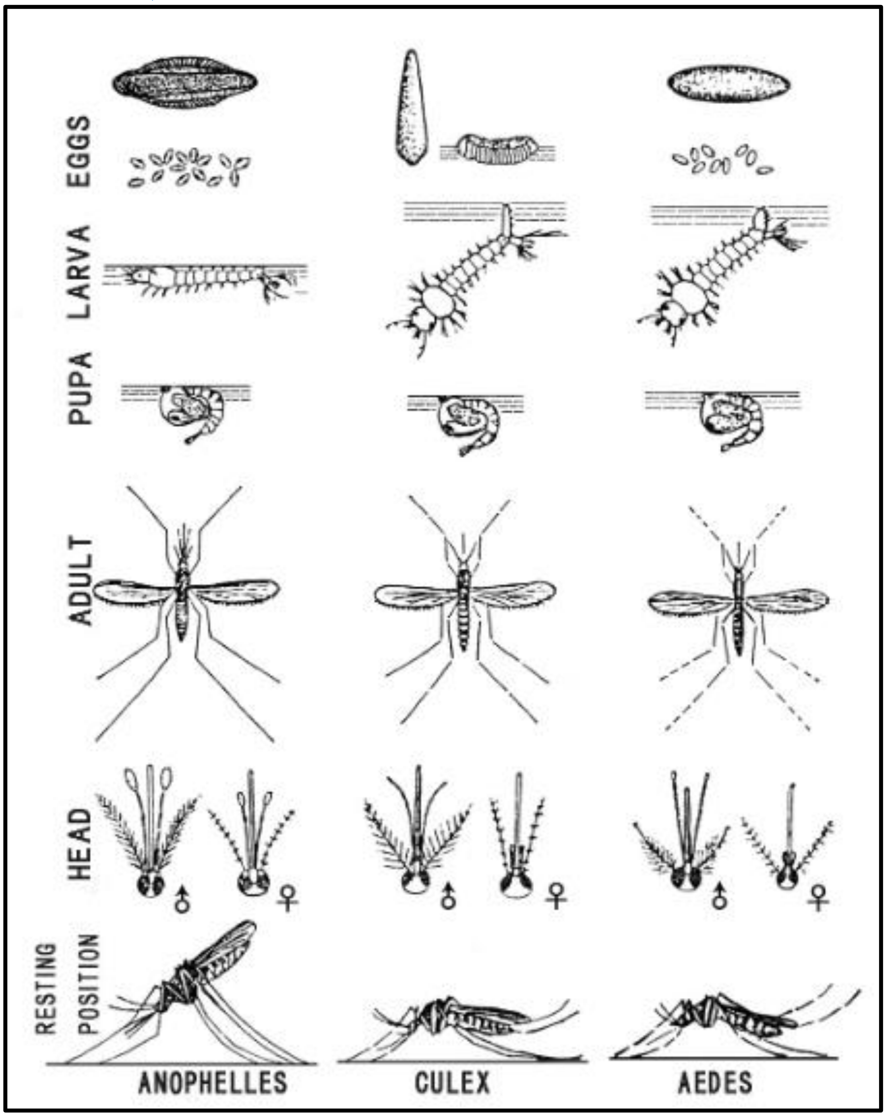
Annex 4 – Example components of a TWG terms of reference

Note: informed by the Roll Back Malaria Partnership (RBM) Vector Control Working Group (VCWG) Terms of Reference

Section / Subsection	Summary
I. Purpose / Rationale	Outlines the purpose of aligning partners on mosquito control and the rationale for the group's existence.
II. Functions of the Working Group	Describes the main functions, such as convening stakeholders including civil society, coordinating activities, and facilitating communication.
III. Roles and Responsibilities	Details the roles and responsibilities of all participants in the Working Group.
a) Members	Explains membership types, criteria, and responsibilities for core members and observers.
b) Chair / Co-Chair	Outlines the election process and responsibilities of the Chair and Co-Chair.
c) Secretariat	Describes the support role and duties of the Secretariat for the Working Group.
d) Sub-Working Groups/Taskforces	States the process for establishing sub-groups to address specific tasks.
IV. Working Procedures	Explains the operational procedures for planning, meetings, and documentation.
a) Annual Work Plan and Funding	Details the process for developing, approving, and funding the annual work plan.
b) Meetings	Describes the organization and types of meetings held by the Working Group, including emergency convenings during outbreaks or other *ad hoc* meetings.
c) Conduct of Business	Outlines the rules and procedures for conducting group business.
d) Minutes	Specifies the requirements for preparing and disseminating meeting minutes1.
V. Reporting and Performance Review	Covers the processes for reporting activities and reviewing performance.
VI. Dissolution of the Working Group	Explains the procedure for dissolving the Working Group.

Annex 5 – Basic differentiation between *Anopheles*, *Culex* and *Aedes* mosquitoes

Source: CDC and Souza, 2017



Summary of key features of *Anopheles*, *Culex* and *Aedes* mosquitoes

Feature		*Anopheles*	*Culex*	*Aedes*
Eggs	**Laid**	Single, on water surface (floats on side)	Rafts (clusters), on water surface	Single, above waterline
Larvae	**Rest**	Parallel to water surface	Downwards from water surface	Downwards from water surface
	Siphon	None	Long and slender (3-5 times width)	Short and stout (1-2 times width)
Adults	**Rest**	Angled - abdomen in the air	Flat - parallel to the surface	Flat - parallel to the surface
	Palps (females)	Long – similar to proboscis	Shorter than proboscis	Shorter than proboscis
	Abdomen shape	Pointed	Blunt and rounded	Pointed

Annex 6 – *Aedes* vector species in the Pacific and natural or container habitat overlap with other mosquito species.

Pacific Island Country or area	*Ae. aegypti*	*Ae. albopictus*	*Ae. polynesiensis*	*Ae. hensilli*	Other known vectors of dengue#	*Cx. quinquefasciatus*	*Cx. annulirostris*	*Cx. sitiens*	*Ae. vexans*
American Samoa	✓		✓		*Ae. cooki*	✓	✓	✓	✓
Cook Islands	✓		✓			✓	✓		✓
Federated States of Micronesia	✓	✓		✓	*Ae. scutellaris, Ae. marshallensis*	✓	✓	✓	✓
Fiji	✓	✓	✓		*Ae. pseudoscutellaris, Ae. rotumae*	✓	✓	✓	✓
French Polynesia	✓		✓			✓	✓	✓	
Guam		✓				✓	✓	✓	✓
Kiribati	✓	✓			*Ae. marshallensis*	✓	✓		✓
Marshall Islands	✓	✓			*Ae. marshallensis*	✓			✓
Nauru	✓	✓				✓	✓	✓	
New Caledonia	✓				*Ae. scutellaris**	✓	✓	✓	✓
Niue	✓				*Ae. cooki*			✓	
Northern Marianas	✓*	✓				✓	✓		✓
Palau	✓	✓		✓	*Ae. scutellaris*	✓	✓	✓	✓
Papua New Guinea	✓	✓			*Ae. scutellaris, Ae. hebrideus*	✓	✓	✓	✓
Pitcairn Islands	✓		✓			✓			
Samoa	✓	✓	✓			✓	✓	✓	✓
Solomon Islands	✓	✓			*Ae. hebrideus*	✓	✓	✓	✓
Tokelau	✓		✓						✓
Tonga	✓	✓			*Ae. cooki, Ae. kesseli, Ae. tonga s.s., Ae. tabu*	✓	✓	✓	✓
Tuvalu	✓		✓			✓	✓	✓	✓
Vanuatu	✓	✓	✓		*Ae. scutellaris, Ae. hebrideus*	✓	✓	✓	✓
Wallis and Futuna	✓		✓			✓	✓	✓	✓

* = likely eliminated; # = not known to transmit chikungunya and Zika.

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