MINISTRI BLONG HELT

National Strategic Plan
for Vector Surveillance & Intervention Monitoring and Evaluation 2023

Version: 3

OVERVIEW

Vector control is expected to remain a core component of both malaria and arbovirus prevention efforts in Vanuatu for years to come. It is therefore crucial that adequate vector surveillance along with monitoring and evaluation of vector control interventions is undertaken. This will inform vector control planning and implementation to ensure that appropriate interventions are being used to maximum impact, and in line with existing National Strategic Plans (NSP).

In general, vector surveillance as well as monitoring and evaluation of control interventions requires urgent strengthening in Vanuatu. Opportunities exist to streamline efforts for malaria and *Aedes*-borne diseases considering similarities in the life cycle of the mosquito genera responsible for transmission, and hence overlap in interventions targeting these vectors. This document therefore seeks to define a strategy and implementation plan to enable the informed and efficient collection and use of such information.

This *National Strategy for Vector Surveillance and Intervention Monitoring and Evaluation* should form a component of the broader activities of the Ministry of Health Malaria and Other Vector Borne Diseases Control Program (VBDCP) as well as Provincial Health Services. Implementation by partner organizations may also be undertaken, as appropriate. Outcomes must be effectively used to select and target interventions, optimise their implementation, and to advocate for additional resources if needed. It should also inform appropriate responses in outbreak, epidemic or natural disaster situations.

This document outlines the priorities for vector surveillance and intervention monitoring and evaluation in Vanuatu. Further detail is also provided to guide the priority activities and to ensure informed planning and implementation. This is especially important considering the ramp-up of activities that is planned to push forward to malaria elimination in Vanuatu and considering a predicted regional increase in the risk of arbovirus outbreaks.

This Strategy should be appraised periodically and revised if necessary to ensure cost-effective use of resources for vector control, particularly when significant epidemiological or entomological changes are observed.

CONTENTS

ACKNOWLEDGEMENTS

This *National Strategic Plan for Vector Surveillance & Intervention Monitoring and Evaluation* would not be completed with the extensive help and contributions of various individuals.

Foremost, I would like to express my sincere gratitude to the Malaria Program Technical Advisor from the World Health Organization, Dr. Tessa Knox for her insightful comments, hard questions and immense knowledge in putting together the information and facts needed to shape this document. Her guidance and support have helped a lot and I could not have imagined having a better advisor.

My sincere thanks also go to the former Malaria National Coordinator, Mr Esau Naket, for his constant advice that allowed me to attend overseas vector control training opportunities which had helped me a lot to excel in my career and thus be able to generate this document. His explanations on the different malaria programs being planned, achievements and way forward is greatly appreciated.

I also thank the current National Malaria Coordinator and my fellow vector control program staffs for providing detailed comments and/or explanations whenever needed to polish and revise this document to its final stage. Technical specialists from the PacMOSSI project provided critical review and appraisal of this document, and their suggestions helped to strengthen it significantly.

My hope is that this *National Strategic Plan for Vector Surveillance & Intervention Monitoring and Evaluation* will assist in achieving overall program goals, and alleviating the burden of mosquito-borne diseases in Vanuatu.

Lekon Tagavi
Vector Surveillance and Control Officer
National Malaria and Other Vector Borne Diseases Control Program
Ministry of Health

1. COUNTRY PROFILE

1.1 Socio-Political System

Vanuatu is a lower-middle income country located in the south-west Pacific. It is a constitutional democracy with a republican political system headed by a President (elected by sitting members of Parliament and presidents of Regional Councils) and a Prime Minister (who is the head of the ruling party or coalition within Parliament). Members are elected every four years to represent multi-seat constituencies. However, governments may change more frequently than four-yearly due to shifting alliances within the Parliament. This can affect the Ministry of Health leadership continuity as well as health priorities, agenda, funding and continuity of support for specific areas, including vector borne diseases control.

1.2 Geography and demographics

1.2.1 Geography

Vanuatu is a Y-shaped archipelago in the south-western Pacific Ocean that consists of approximately 83 islands of volcanic origin (of which 65 are inhabited). The islands lie between latitude 13° and 21°S (spanning 1,176 kilometres from north to south) and longitude 166° and 171°E. Total land area is about 12,274 square kilometres, within a maritime boundary of approximately 700,000 square kilometres. The highest point of elevation is 1,877 metres.

Since 1994, the country has been divided into six provinces. Their names derive from constituent islands or island groups. From north to south, they are: Torba (Torres and Banks Islands); Sanma (Santo, Malo); Penama (Pentecost, Ambae, Maewo); Malampa (Malekula, Ambrym, Paama); Shefa (Shepherds group, Efate); and Tafea (Tanna, Aniwa, Futuna, Erromango, Aneityum).

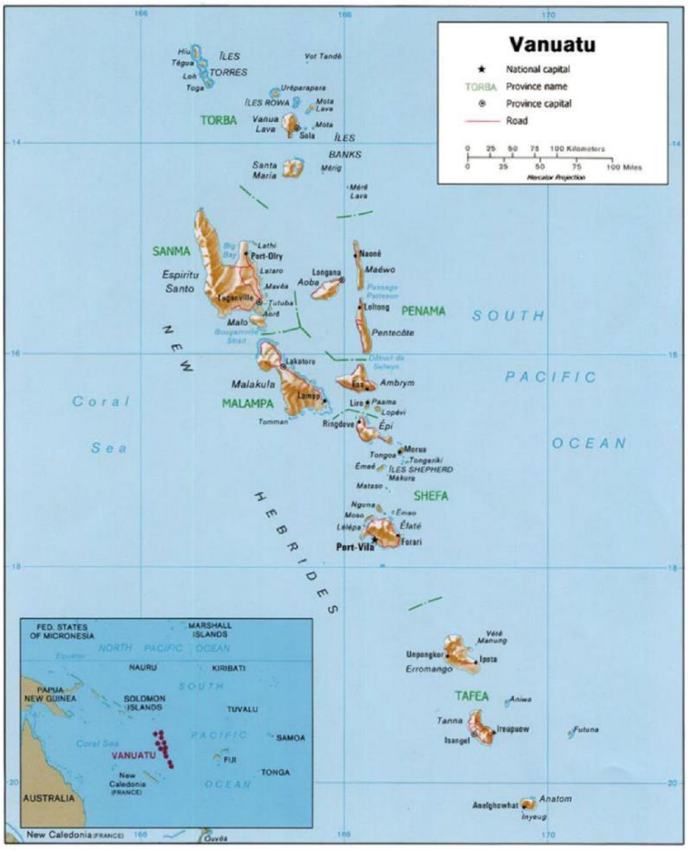


Figure 1. Map of Vanuatu showing provincial composition (Source: Nations Online, 2022)

1.2.2 Population and demographics

The indigenous population, called ni-Vanuatu, is overwhelmingly Melanesian, though some of the outlying islands have Polynesian populations. There are also small minorities of Europeans, Micronesians, Chinese, and Vietnamese. Based on the 2020 census, the population of Vanuatu is 300,019. The median age is 20 years, with 38.6% of the population aged 0-14 years and 55% aged 18 and above with a growth rate of 2.37%. The population has a slight male predominance.

Approximately 77% of the overall population lives in rural areas – either in confluent coastal settlements that may span several kilometres, or in reasonably well-defined villages ranging in size from a few families to several hundred people. However, since independence the two urban centres of Luganville and Port-Vila have drawn significant number of people who are attracted by better opportunities of life, work and schools.

1.2.3 Climate and Environment

There is a rainfall gradient from the north to the south of the country. Rainfall averages about 2,360 mm per year nationwide but ranges from around 2,000 mm in the southern islands (Tafea province) to 4,000 mm in the north (Torba province). The wet season is from November to April and coincides with peak malaria transmission.

The wet season is also associated with tropical cyclone risk; the greatest frequency is usually in January and February. Vanuatu receives between 20–30 cyclones per decade, of which three to five may cause severe damage and extensive disruption of services. Severe TC Pam in March 2015 was the second most intense tropical cyclone ever to strike the South Pacific and is regarded as one of the worst natural disasters in the history of Vanuatu.

The Manaro Voui volcano on the island of Ambae undergoes periodic eruption, resulting in large population displacements in 2005, 2017 and 2018. In April 2020, TC Harold caused widespread destruction, population displacement and disruption of services in the provinces of Sanma, Penama and Malampa, where more than half the population lives; it is the strongest cyclone to strike Vanuatu since TC Pam. In March 2023, TC's Judy and Kevin hit Vanuatu within 48 hours of each other.

There is a slight north-south temperature gradient, but this is less pronounced than the rainfall gradient: Shefa and Tafea provinces have cooler and slightly longer winters than the more northerly island groups. In coastal areas, daily temperatures average 26°C in the hot season with an average maximum of 30°C and an average minimum of 24°C. Night-time minimum temperatures in southern coastal areas may fall to 13°C in the dry season.

1.3 Health care delivery system

The current health system structure must overcome some significant challenges to achieve the first NSDP policy objective of ensuring equitable access to quality, affordable health services. First, there are obvious physical challenges. Vanuatu has a small population that is dispersed across 83 Islands. Villages in remote areas are often small and isolated, and people who live there pay high transport costs (via boat or truck) to reach health facilities. In the wet season, travel by sea is often dangerous and roads may be cut by flooding.

While some programs and services can be delivered effectively nationwide, and in some places services are working well together, overall the health system faces significant challenges in its effort to achieve Universal Health Coverage (UHC). Reasons for this, which are well described in the current Health Sector Strategy, are further outlined in the *National Strategic Plan for Malaria Elimination (2021-2026)*. Challenges include health workforce, service mix/balance, service model and system functionality, management and financing, infrastructure and equipment, and information systems.

2. EPIDEMIOLOGICAL CONTEXT

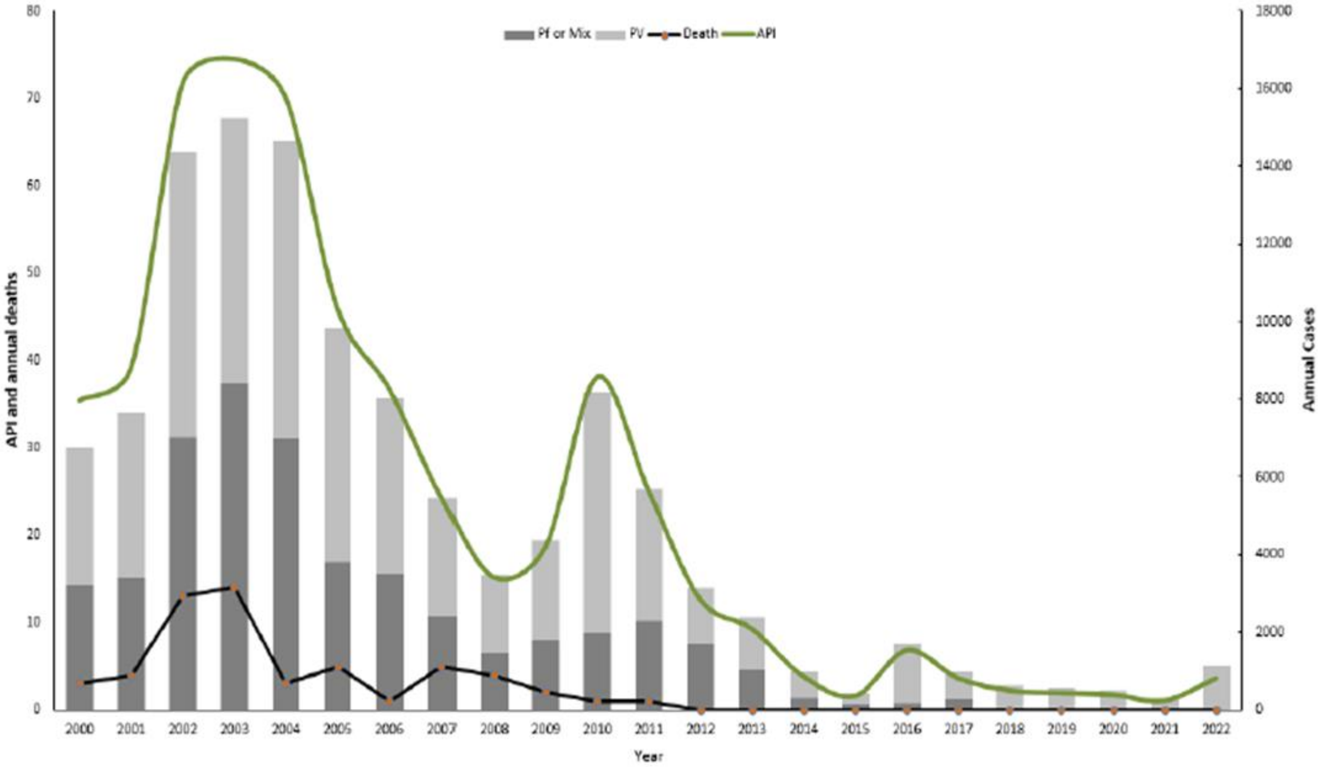
2.1 Malaria Situation

Malaria has historically been one of the leading causes of ill health in Vanuatu. In 1990, it infected an estimated 198 per 1,000 people and caused many deaths (MOH 2013); as recently as 2010, it was among the top 5 notifiable diseases nationally (WHO 2011). Impressive gains have been made against malaria in Vanuatu since, with only 502 cases reported in 2020 and 322 cases in 2021. There have been no deaths attributed to malaria since 2011. However, in 2023, there has been an upsurge in cases with some-1500 cases by the end of the third quarter. Morbidity is now caused predominantly by *Plasmodium vivax*; although not yet reported in 2023 it is possible that *Plasmodium falciparum* might still be present in Vanuatu.

Malaria is endemic in five provinces but was declared eliminated from Tafea province in late 2017 following three years with no local cases. Transmission remains higher on certain islands of Sanma (Santo), Malampa (Malekula) and Shefa (Epi) provinces, with transmission re-established in Torba (Vanua Lava) in 2022 after multiple years of no or low transmission.

Solid progress against malaria was recognised in the *National Strategic Plan for Malaria Elimination (2021-2026)*, however the surge in cases will delay achievement of malaria elimination. This plan considers that while the full population of Vanuatu remain at risk of malaria, progress differs between provinces and prevention and response actions should be increasingly targeted to foci. However, it also recognises that scale-back of vector control in areas with previous transmission is not recommended by WHO. The goals, timelines and targets of the National Strategic Plan are being considered for revision in 2023 given the change in the epidemiological situation.

Figure 2. Number of malaria cases by species (*P. falciparum* & *P. vivax*), deaths, and API for 2000-2021.

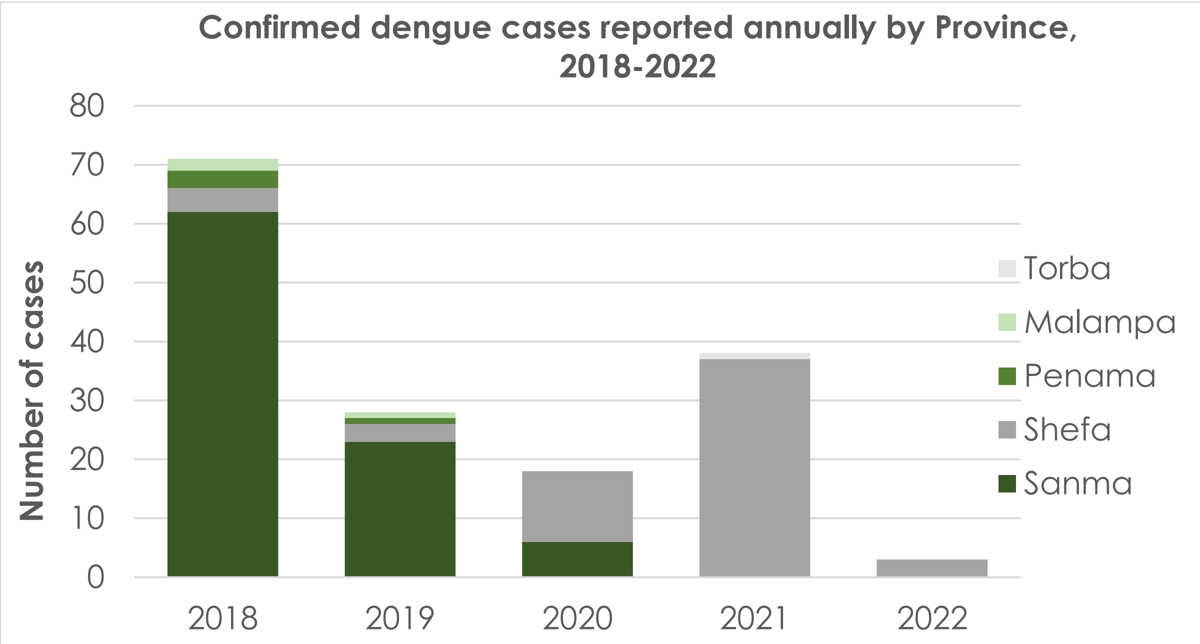


The whole population of Vanuatu is considered at risk of malaria infection. The Buxton Line is known to be the natural limit to the range of *Anopheles* mosquito vectors and lies just east of Vanuatu islands (Kaneko, 2010). The current stratification as outlined in the *National Malaria Stratification 2021* draws on use of receptivity and vulnerability. Relative to the stratification for the previous strategic period (of 2015-2020), the current risk categories based on API have lower thresholds for both high risk (API ≥5) and medium risk (API ≥0.5).

Three urban centres are identified as being particularly vulnerable for importation of malaria, with Port Vila and Luganville considered high vulnerability and Lenakel considered medium vulnerability. As there is a shift to identifying foci based on villages (rather than health zones), any populations in foci outside of high risk areas will also be added to the high risk strata; further work is required to revise the definition and guidance for foci and to reflect this in the stratification plan for consistency.

2.2 Arbovirus Situation

Dengue outbreaks have occurred with increased frequency in Vanuatu in recent years. In 2016-2017, a large outbreak occurred with a total of 578 confirmed cases, most of which were in Port Vila. In 2018-2020, transmission continued in Santo with the highest number of 71 confirmed cases in 2018 and a smaller outbreak in Luganville in 2019. Transmission then increased in Shefa province between 2020-2022, with a peak of 37 confirmed cases in 2021. Total case counts are not yet available for 2022. For all of these recent outbreaks, dengue serotype testing for selected samples detected DENV-2 only.



Based on available data for arboviruses, two areas of Vanuatu are considered endemic for dengue: Port Vila and Luganville (see table below). Given this endemicity, a threshold for outbreaks in these two areas is defined as 12-linked cases for Sanma and 4-linked cases for Port Vila. The threshold for dengue in Vanuatu is different for different island settings.

Table 1. Arboviral situation in Vanuatu, as of October 2022

Arboviral disease	Port Vila	Luganville	Other areas
Dengue	Endemic*	Endemic*	None reported
Zika	None reported	None reported	None reported
Chikungunya	None reported	None reported	None reported
Ross River	None reported	None reported	None reported
Japanese encephalitis	None reported	None reported	None reported
Other	None reported	None reported	None reported

* Cases detected most years since 2016

2.2.1 Arbovirus risk stratification

The risk of mosquito-borne disease transmission depends on factors related to the vector, the human host as well as the pathogen, and how they interact within a receptive environment. Outbreak and transmission risk varies across different locations and also over time. Areas can be stratified as high, moderate or low risk with the following classifications.

- **High risk:** *Aedes* vectors present, arboviruses are circulating or sporadic, and there are regular numbers of incoming travellers.
- **Moderate risk:** *Aedes* vectors are present, but there is no circulating arbovirus and few incoming travellers.
- **Low risk:** no *Aedes* vectors known to be present, no circulating arbovirus, and few incoming travellers.

However, currently there is limited information available on the presence or absence of *Aedes* vectors beyond Port Vila and Luganville. A nationwide mapping at selected sites is urgently required to enable arbovirus risk stratification.

3. ENTOMOLOGICAL CONTEXT

Vector surveillance can be defined as the regular, systematic collection, analysis and interpretation of any entomological data with regards to vector control activities being implemented for risk assessment, planning, implementation, monitoring and evaluation (WHO, Malaria surveillance, monitoring & evaluation: a reference manual, 2018). All surveillance activities must be guided and clearly linked to programme goals and should be directed by the NMP to ensure optimal vector control and appropriate interventions are used where and when needed.

3.1 Types of entomological surveillance

Surveillance can be categorized as: preliminary or baseline surveys, routine sentinel surveys for observation of trends, spot checks for supplementary data collection and focus investigations during elimination or in response to outbreaks.

- **Preliminary surveys**: These initial, time-limited surveys are used to gather baseline data for planning vector control measures. They provide information such as: presence of vector species, resting and feeding habits, changes in species composition by season and over time, types of water bodies used as larval habitats, and vector susceptibility to insecticides.

- **Routine sentinel surveys for observations of trends**: These are long-term observations which are made regularly such as monthly, quarterly and annually in fixed locations. Their primary purpose is to identify any changes in vector species density and composition, behaviour, susceptibility to insecticides and even infection rates, which may explain any observed epidemiological trends in vector-borne disease transmission, and ultimately indicate the appropriate response.

- **Spot checks for supplementary data collection:** These *ad-hoc* assessments are carried out in selected locations as a supplement to routine observations and when more information is required to inform program adjustment or response. Information collected includes investigations in area where there are suspected problems in the quality of implementation of an intervention, expected increases in receptivity and/or importation, and presence of vulnerable populations.

- **Focus investigation during elimination or in response to outbreaks:** These investigations are undertaken in areas of new, persistent or resurgent malaria transmission to determine why the interventions being used are no longer reducing transmission.

3.2 Entomological indicators

The vector surveillance and monitoring/evaluation priorities of VBDCP should build a strong evidence base on the ecology, biology and bionomics of vectors to inform vector-borne disease control activities in Vanuatu. This will assist in planning and implementation of targeted interventions, including guiding efforts to counter residual malaria transmission. Knowledge of these parameters is essential to characterize malaria transmission dynamics within the country to guide stratification and action required. For dengue, vector surveillance will focus firstly on identification of primary and secondary vector species and mapping their distributions, as well as post-implementation monitoring of *Wolbachia* frequency.

This document will list out various surveillance and monitoring/evaluation methods and techniques that are available for measurements, taking into consideration that most can be adapted based on changes in disease, intervention and vector situation. Surveillance will be categorized into two types of activities: 1) longitudinal assessment at fixed sentinel sites; and 2) spot checks in selected areas at selected times. The frequency of each is also indicated.

3.2.1 Longitudinal assessments at fixed sentinel sites

The purpose of these longitudinal surveys at fixed sites is to enable observation of trends. Surveillance will be conducted annually at each sentinel site. The aim will be for the following parameters to be measured.

Table 2. Entomological parameters for longitudinal assessments. Priority parameters in shaded grey.

Type	Parameter	Definition	*Anopheles*	*Aedes*
Adult vector composition	Occurrence	Adult female primary vectors present or absent	High	High
	Density	Number adult female primary vectors collected, usually per sampling method and unit time.	Moderate	High
Adult vector behaviour	Human biting rate	Number of adult female vectors that attempt to feed or are freshly blood-fed, per person per unit time.	Moderate	Moderate
	Human blood index (host preference)	Proportion of blood-fed adult female vectors that feed on humans.	Moderate	Moderate
	Biting time	Number of adult female primary vectors that attempt to feed or are freshly blood-fed, per person per unit time, usually expressed per 2-h increment.	Moderate	Moderate
	Biting location	Proportion of attempted bites or successful blood-feeds by adult female vectors indoors and outdoors, per unit.	High	Moderate
	Resting location (indoor resting density)	Proportion of adult female vectors collected resting indoors (and outdoors in structures sampled). Usually per human-hour.	High	Moderate
Adult vector insecticide resistance	Resistance frequency	Proportion of adult primary vectors alive after exposure to insecticides in WHO tube assays.	High	High
	Resistance status	Classification of adult female primary vector population as confirmed resistant, possibly resistant or susceptible.	High	High
	Resistance intensity	Classification of adult primary vector populations as having high, moderate or low resistance.	Moderate – and only if resistance confirmed	Moderate – and only if resistance confirmed
Adult vector *Wolbachia* infectivity rate	*Wolbachia* prevalence	Proportion of adult vectors that are infected with *Wolbachia*	NA	High

3.2.2 Spot checks in selected areas at specific times

The purpose of these *ad hoc* surveys at purposely selected sites is supplementary data collection to investigate where there may be a problem or suspected problem, as evidenced by residual malaria transmission or a dengue outbreak. Surveillance will be conducted as and when needed. The following parameters may be measured depending on the purpose identified.

Table 3. Entomological parameters for **s**pot check assessments. Priority parameters in shaded grey.

Type	Parameter	Definition	*Anopheles*	*Aedes*
Adult vector composition	Occurrence	Adult female primary vectors present or absent	High	High
	Density	Number adult female primary vectors collected, usually per sampling method and unit time.	High	Low
Adult vector behaviour	Human biting rate	Number of adult female vectors that attempt to feed or are freshly blood-fed, per person per unit time.	Moderate	Moderate
	Human blood index (host preference)	Proportion of blood-fed adult female vectors that feed on humans.	Moderate	Moderate
	Biting time	Number of adult female primary vectors that attempt to feed or are freshly blood-fed, per person per unit time, usually expressed per 2-h increment.	High	Low
	Biting location	Proportion of attempted bites or successful blood-feeds by adult female vectors indoors and outdoors, per unit.	High	Low
	Resting location (indoor resting density)	Proportion of adult female vectors collected resting indoors (and outdoors in structures sampled). Usually per human-hour.	High	Low
Adult vector insecticide resistance	Resistance frequency	Proportion of adult primary vectors alive after exposure to insecticides in WHO tube assays.	High	Moderate – and only where insecticidal interventions
	Resistance status	Classification of adult female primary vector population as confirmed resistant, possibly resistant or susceptible.	High	Moderate – and only where insecticidal interventions
	Resistance intensity	Classification of adult primary vector populations as having high, moderate or low resistance.	Moderate – and only if resistance confirmed	Moderate – and only if resistance confirmed
Immature vector aquatic habitats	Habitat availability	Number of potential aquatic habitats present, by area and habitat type.	Moderate (if LSM to be applied)	High
	Habitat occupancy	Larvae and pupae present and absent, by area and habitat type.	Moderate (if LSM to be applied)	High

	Larval density	Number of immature vectors collected, by individual habitat.	No	High
Human knowledge and behaviour	Perceptions of disease and vectors	Knowledge and perceptions of malaria, dengue and mosquitoes	Moderate	Moderate
	Prevention actions	Knowledge, attitude and practices towards interventions including: LLINs, larval source reduction, personal protection (topical repellents, mosquito coils, protective clothing) and others	High	High
	Risk behaviour	Other behaviours that may increase or decrease risk of malaria or dengue	High	High

3.3 Entomological information for Vanuatu

Significant investments were previously made in evaluating *Anopheles* vector occurrence, distribution, habitats and behaviours to support malaria elimination in Tafea Province. A more recent focus was on *Aedes* monitoring for World Mosquito Program implementation of the *Wolbachia* transmission blocking method. However, there is no routine vector monitoring ongoing in Vanuatu with sporadic and targeted evaluations only. A summary of recent vector evaluations is provided below.

Table 4. Overview of vector surveillance and intervention monitoring and evaluation conducted from 2017-2022

Evaluation	Location	Years
Vector surveillance		
Anopheles insecticide resistance	Sanma, Malampa, Shefa	2017 2019 2020
Anopheles biting time and location	Sanma, Malampa, Shefa, Torba	2017 2019 2020 2022
Aedes monitoring for species composition and *Wolbachia* frequency	Port Vila, Efate, Shefa	2018 2019 2021
Aedes aquatic habitats and species composition	Luganville, Santo, Sanma	2018
Aedes insecticide resistance	Port Vila, Efate, Shefa	2017

In general, vector surveillance as well as monitoring and evaluation of control interventions requires urgent strengthening in Vanuatu. Opportunities exist to streamline efforts for malaria and *Aedes*-borne diseases considering similarities in the life cycle of the mosquito genera responsible for transmission, and hence overlap in interventions targeting these vectors. This document therefore seeks to define a strategy and implementation plan to enable the informed and efficient collection and use of such information.

3.3.1 Anopheles spp.

The principal malaria vector in Vanuatu is *Anopheles farauti,* which has been discovered in the 1900s within few islands in Vanuatu. The few recent assessments have included sampling conducted by VBDCP on an *ad hoc* basis, but data are collected over a short period and in limited locations, and are rarely assessed in relation to disease information.

Insecticide resistance testing was done three times recently, on the island of Epi (Shefa), Malekula (Malampa) and Santo (Sanma). Data shows vectors have developed some degree of resistance to permethrin within the pyrethroid insecticide class (Annex 1). However, this needs to be conducted at other sites also and with other insecticide classes. Insecticide resistance monitoring still needs to be done in other sites to determine the extent of possible resistance, as noted above.

Biting time and location studies have been conducted in selected areas also, in 2017, 2019, 2020 and 2022 (Annex 2). Data shows that location of biting is different within different study sites with a more preferences of outdoor biting.

Information on local vector species i.e. *Anopheles farauti* and their ecology, biology and behaviour needs to be thoroughly assessed to inform control and elimination strategies. Thus, derived information cannot be used optimally to guide decision making. Other information relating to the different entomological indicators still needs to be properly assessed to guide better decision making (including appropriate locations for sentinel sites) in the future.

3.3.2 Aedes spp.

The principal vector of dengue viruses in Vanuatu is likely to be *Aedes aegypti* although the distribution of *Aedes* vector species across Vanuatu is largely unknown. However, relative vector composition is known to vary over time and space, including in response to interventions. The vector competence is also not known for local vector populations. Therefore, the relative importance of each vector in transmission or risk is unknown. Vector surveys beyond the two urban areas of Port Vila and Luganville are urgently needed. Due to the sporadic and often silent nature of arbovirus transmission, it is difficult to associate entomological data with dengue disease information therefore longitudinal monitoring is required.

Knowledge of adult species occurrence and distribution has significantly expanded and entomological capacity was enhanced for Port Vila as a result of the *Wolbachia* activities, including refurbishment of insectary facilities at the George Pompidou complex and technical training of staff particularly in mosquito rearing and identifications. This capacity needs to be leveraged appropriately to ensure it is maintained and provides the necessary information to inform planning and implementation of vector control.

Table 5. Known presence and distribution in Vanuatu of *Aedes* vectors common to the Pacific

Species	Detected in Vanuatu[1]	Known distribution[1]
Ae. aegypti	Yes	Urban areas in Port Vila and Luganville
Ae. albopictus	Yes	Urban and peri-urban areas in Port Vila and Luganville
Ae. hebrideus	No	
Ae. hensilli	No	
Ae. marshallensis	No	
Ae. polynesiensis	Yes	Peri urban areas in Port Vila
Ae. pseudoscutellaris	No	
Ae. rotumae	No	
Ae. scutellaris	No	
Ae. cooki	No	
Ae. kesseli	No	
Ae. tongae s.s.	No	

[1]date of most recent country survey- 2018 -2019

A basic habitat and species survey was conducted in Luganville in 2018 during the dengue outbreak (Annex 3) which identified *Ae. aegypti* and *Ae. albopictus*, with the latter the most predominant. However, further data are required to guide use of interventions targeting larval habitats, such as susceptibility to insecticides for potential use in larviciding.

The *Aedes* species that were identified during the *Wolbachia* project in 2018-2019 were *Aedes aegypti, Aedes albopictus* and *Aedes polynesiensis*. Periodic monitoring conducted after the end of releases in March 2019 indicated that *Wolbachia* was well established in the population of *Aedes aegypti* but other *Aedes* vector species not amenable to *Wolbachia* releases were identified in high numbers (Annex 4). This confirms the potential for ongoing transmission of dengue in Port Vila, as well as risk of transmission of other *Aedes*-borne diseases.

Aedes insecticide resistance monitoring data from 2018 (Annex 5) indicates that the local mosquito population were not susceptible or shows no degree of resistance to chemical used from both pyrethroids and Organophosphate classes of insecticides tested

Other entomological information on local dengue vector species still needs to be correctly collected and used to inform VBDCP activities as well as those activities of other stakeholders concerned.

3.3.3 Points of Entry

At present, monitoring (and control) of vector species at designated Points of Entry in accordance with the International Health Regulations (2005) is limited.

4. VECTOR CONTROL CONTEXT

4.1 Types of vector control interventions

Vector control interventions and their implementation and monitoring status in Vanuatu are summarised above. The below section provides a brief explanation of the interventions in use or planned for use in Vanuatu and therefore those for which monitoring and evaluation should be considered.

4.1.1 Long-lasting insecticidal nets

Insecticide-treated nets that are pre-treated in the factory for sustained release of insecticide circumvent the need for re-treatment and are called long-lasting insecticidal nets (LLINs). LLINs provide an effective barrier between the person who is underneath it and the mosquito vector who is seeking a blood meal, thereby reducing the opportunity for bites and transmission of a pathogen. LLINs are distributed in 3-yearly cycles, with distribution to selected health zones each year.

4.1.2 Residual spraying

Indoor residual spraying (IRS) consists of the application of residual insecticides to the inner surface of dwellings, where many vectors tend to rest. The main effect of IRS is to kill mosquitoes that enter houses and rest on sprayed surfaces before or after taking a blood meal. It has reduced utility for the control of vectors which tend to rest outdoors, although it may still be effective against outdoor biting mosquitoes which enter houses to rest after feeding. IRS is considered a core malaria vector control intervention since it provides protection to communities through a rapid mass-killing effect on vector populations, thereby reducing density and longevity of vectors and therefore their "vectorial capacity" (or propensity to transmit disease pathogens). IRS is now conducted in targeted areas of malaria foci since 2022 but has also been used for response to dengue cases in Port Vila and Luganville.

4.1.3 Space spraying

Space spray is technically fogging with an aerosol, or a liquid insecticide that is dispersed into the air in the form of hundreds of millions of tiny droplets that are less than 50µm in diameter. These are dispensed using a thermal or cold fogger. Space spraying is normally used as a supplementary method of vector control for *Aedes* vectors in specific situations, such as widespread outbreaks or epidemics in urban centres with high population density. To date, space spraying is not recommended for the control of malaria vectors but only *Aedes* vectors due to no evidence confirmed of its impact against malaria. In Vanuatu, space spraying has been used several times to control dengue vectors during dengue outbreaks. It was first used in 2014 to 2015 in Port Vila during an outbreak of dengue and in 2019 after one (1) confirmed imported dengue case from Solomon Islands was reported. However, there are no plans to continue space spraying as indoor residual spraying is preferred for control of both *Anopheles spp.* and *Aedes spp.*

4.1.4 Larval source modification, manipulation or reduction

For *Anopheles* malaria vectors, habitat modification and manipulation can be undertaken. This aims to change the environment to deprive the vector population of its requirements for survival, including for egg-laying, resting and feeding. These changes can be permanent changes to land, water or vegetation e.g., filling, drainage, planting water-loving trees in swampy areas, closing or covering of breeding sites. They can also be temporary changes that need to be repeated i.e. water-level fluctuation, intermittent irrigation, flushing, changing water salinity, clearing vegetation in streams and irrigation of canals.

For *Aedes* arboviral vectors, the destruction of habitats is more feasible, such as through clean up campaigns targeting smaller artificial containers such as discards, tyres and other solid rubbish. This is called source reduction. In Vanuatu, no major source modification and manipulation activities have been introduced but source reduction such as clean up campaigns were encouraged through health education and community advocacy during outbreak seasons in case of dengue whilst for malaria clean up campaigns were also conducted in areas where high number of cases have been observed. I.e. hot spot or foci areas.

For malaria, larval control is conducted only in areas identified as being highly productive of vectors. For dengue, the focus is on source reduction through community clean-up campaigns as implemented in tandem with community sensitisation and engagement.

4.1.5 Larviciding

The application of chemical or biological agents has been recommended for control of both *Anopheles* and *Aedes* vectors. This is only appropriate where high proportion of potential vector aquatic habitats are within flight range of the community to be protected. For *Anopheles*, effective Larviciding relies on aquatic habitats being few, fixed and findable. For *Aedes*, the most productive habitats can be identified through quantitative surveys to define key containers. Available larvicides include oils, organophosphate insecticides, insect growth regulators and microbial larvicides. It is essential that Larviciding is accompanied by robust monitoring to determine the coverage, quality and impact of the intervention, ideally on both entomological and epidemiological indices. Without this, there will not be clear justification to continue or expand Larviciding activities.

Larviciding was first introduced in Vanuatu on the island of Tanna in 2009 where the organophosphate temephos (Abate) or an insect growth regulator (Methoprene) were dispersed into potential breeding sites after a dipping activity was done to confirmed presence and high proportion of *Anopheles* in specific water bodies. It was done as part of the Malaria elimination activities in Tanna (Tafea province). The water bodies were revisited every 3 months to check for the presence of vectors and larvicides, and were and re-treated as needed.

4.1.6 Larvivorous fish (e.g. Gambusia affinis)

Fish that kill and/or consume mosquito larvae have been proposed for introduction into larval habitats to reduce vector population sizes. This can include natural and constructed larval habitat such as water tanks, lakes, fountains, pools, ponds, cattle troughs, swimming pools, water storage tanks, seepages, water storages sites, irrigation cisterns, canals, small dams, rice field, slow moving small streams, swamps and temporary water collection sites. Different types of Larvivorous fish live in different areas, and populate different types of water bodies with different ranges of temperatures and conditions. In Vanuatu, the VBDCP has introduced *Gambusia* fish in numerous islands to be used in potential *Anopheles* aquatic habitats but most when revisited did not have any fish left and the fish had become scarcer in most of the islands into which they were introduce. However, the role of Larvivorous fish in malaria control has been difficult to evaluate and there is no currently no WHO recommendation for their use in malaria control and elimination.

4.1.7 Wolbachia biocontrol (transmission blocking)

Wolbachia is a naturally-occurring bacterium that is present in up to 60% of insect species, including some mosquitoes. It is not usually found in wild populations of *Aedes aegypti* but *Wolbachia*-infected strains have been produced in the laboratory. Presence of these bacteria has been shown to restrict transmission of dengue viruses from human to mosquito to human, and therefore it is posited that is also reduces local transmission of dengue virus and disease. Adult *Aedes aegypti* mosquitoes are mass-reared for release in the wild, where natural transfer from adults to offspring occurs and the frequency of *Wolbachia*-infected *Ae. aegypti* has been shown to increase and be maintained at high levels. This approach was used in Port Vila in 2018-2019. Post-implementation longitudinal monitoring has been conducted sporadically to determine the frequency of *Wolbachia*-infected mosquitoes and to identify any impact on arbovirus transmission.

4.1.8 Mosquito coils

Mosquito coils are among the most popular and widely used insecticide vaporizers. Once lit, coils smoulder and release insecticides into the air at a steady rate, continuing for up to 6-8 hours depending on the product. Mosquito coils are used within households in Vanuatu by those who can afford to purchase them and according to household preferences. They are selected based on perceived protection against mosquito bites and most households when sleeping or drinking kava and chatting late at night. However, there is limited evidence to prove or disprove efficacy for protection against *Aedes* or *Anopheles* bites, and vector-borne diseases. Therefore, these have not been recommended as a public health intervention. Due to selective use by households, monitoring and evaluation of this intervention will not be a focus of VBDCP.

4.1.9 Topical repellents, insecticide-treated clothing, and light-coloured and long-sleeved clothing

Use of repellents and protective clothing may be considered for personal protection of individuals, such as those at high risk of vector-borne diseases. Topical repellents are available in creams, lotions and aerosol sprays which can be applied directly on skin or on clothes. These should be applied appropriately to ensure efficacy during peak vector biting periods, which for malaria vectors is during early to late evening and for dengue vectors is throughout the day but particularly at dawn and dusk. Repellents are used by households in Vanuatu who can afford to purchase them. Due to potential use for personal protection (but not public health), monitoring and evaluation of these interventions will not be a focus of VBDCP.

4.2 Overview of Vector Control in Vanuatu

Vector control is expected to remain a core component of both malaria and dengue prevention efforts in Vanuatu for years to come. VBDCP has the responsibility for vertical vector control operations throughout the country. This mainly comprises prevention of malaria through the delivery of long-lasting insecticidal nets and targeted indoor residual spraying, with larviciding in some areas.

For dengue, vector control has traditionally focussed on response to outbreaks through focal space spraying or fogging with insecticides. However, in 2018-2019 the *Wolbachia* transmission-blocking approach for *Aedes aegypti* was deployed in Port Vila with the most recent data from 2020 indicating high prevalence of the bacteria. Indoor residual spraying was also used in Luganville in areas with dengue cases in the aftermath of Tropical Cyclone Harold. Community clean-up campaigns for larval source reduction are also used in the event of malaria or dengue outbreaks.

The following outlines control interventions currently in use or planned for use in Vanuatu, and recent monitoring and evaluation undertaken.

Table 6. Summary of vector control interventions and their status in Vanuatu including monitoring and evaluation

Purpose	Vector control interventions	Malaria		Dengue and other *Aedes*-borne arboviruses		Monitoring and evaluation undertaken
		WHO recommended?	Implemented in Vanuatu?	WHO recommended?	Implemented in Vanuatu?	
Reduce human-vector control	Long-lasting insecticidal nets*	Yes (core intervention)	**Yes,** 3-yearly campaigns (5 provinces)	Yes (viraemic patients only)	**Yes**, during outbreaks (viraemic patients)	Post-distribution assessment. No coverage survey since 2013. *Ad hoc* field durability monitoring.
	Housing improvements	Not evaluated	na	Yes (window screens)	No	na
	Mosquito coils	Not evaluated	**Yes**, household use	Not evaluated	**Yes**, household use	None
Reduce adult vector populations	Residual spraying	Yes, indoors (core intervention)	**Yes**, during outbreaks	Yes (targeted)	**Yes**, during outbreaks	None
	Space spraying	No	No	Yes (indoors, outbreaks only)	Yes, during outbreaks	None
Modify, manipulate or destroy potential larval habitats to reduce mosquito populations	Larval source reduction	Yes, habitat modification or manipulation (supplementary intervention)	No	Yes	**Yes**, during outbreaks (clean up campaigns)	None
	Larviciding	Yes (supplementary intervention)	na	Yes	No	na
	Larvivorous fish^	Not evaluated	**Yes** (1 province)	Yes	No	na
Block transmission of arbovirus(es)	*Wolbachia* biocontrol	na	na	Under evaluation	**Yes**, Port Vila (2018-2019)	Quarterly adult trapping and testing for *Wolbachia* frequency
	Topical repellents	Yes (personal use)	No	Yes (viraemic patients,	No	na

Provide personal protection				pregnant women)		
	Insecticide-treated clothing	Yes (personal use)	No	Not evaluated	No	na
	Light-colour and long-sleeved clothing	na	na	Yes (personal use)	na	na

* Also reduce adult vector populations through insecticidal effect; na = not applicable; ^ such as *Gambusia affinis*

4.3 Intervention Monitoring and Evaluation

It is critical that adequate vector surveillance monitoring and evaluation of vector control interventions is undertaken to guide planning and implementation for maximum impact. Vector control and associated activities need to be reflected in national and provincial annual business plans to ensure sufficient resourcing to enable implementation. In particular, *Aedes* vector control are often overlooked but need to be absorbed as a subset of the VBDCP activities to ensure adequate planning, resourcing and sustainability.

Table 7. Overview of vector control intervention monitoring and evaluation conducted from 2017-2022

Evaluation	Location	Years
Vector control M&E		
LLIN Rapid Coverage Assessments	NIL	NIL
LLIN nationwide coverage and usage survey	All provinces except Tafea	Nov 2020
Used LLIN chemical content	Malekula, Malampa Santo, Sanma	2018 2019
Used LLIN bioefficacy	Malekula, Malampa Santo, Sanma	2018 2019
Aedes monitoring for species composition and *Wolbachia* frequency	Port Vila, Efate, Shefa	2018 2019 2021

*Samples collected; testing pending

In terms of vector control intervention monitoring and evaluation of malaria vector, there are few ongoing activities. To name a few, LLIN field durability, bioefficacy and chemical content assessments were conducted for selected sites in 2018-2019 (Annex 6) but further information is required from additional sites to be able to guide decision-making.

In late 2020, LLIN coverage (access and usage) was assessed in the five provinces that received bed nets in the past 3 years (ie. all except Tafea province). This indicated that too few nets were available for the overall target coverage rates, with poor availability of LLINs in all other provinces except for Shefa province (Annex 7), indicating that usage of bed nets may not be a major driver of poor coverage across all provinces. Data from earlier bednet coverage assessments is also presented (Annex 8) and indicates the importance of using standardised indicators.

5. STRATEGIC FRAMEWORK

5.1 Rationale

It is of vital importance that the VBDCP has in place a strategy to guide vector surveillance and vector control monitoring and evaluation in Vanuatu. This will define the collection and use of information to guide planning and decision-making for effective vector control. In line with the *WHO Global Vector Control Response (2017-2030),* this will support the potential use of different vector surveillance and control tools, technologies and approaches against *Aedes* and *Anopheles* vectors, with an aim of reducing the burden of vector-borne diseases in Vanuatu. It is envisioned that annual work plans will be developed based on this Strategy.

5.2 Framework

5.2.1 Aim

The aim of the *National Vector Surveillance and Intervention Monitoring and Evaluation Strategy* is to support the planning and implementation of effective vector control to fulfil the vision outlined in disease plans, such as a malaria-free Vanuatu by 2026-2030, contributing to the good health and well-being of the population.

5.2.2 Values

The guiding values are aligned with those outlined in the *National Strategic Plan for Malaria Elimination (2021-2026)*.

5.2.3 Goals

Through effective vector control guided by sufficient information:

- To achieve malaria free provincial targets by 2023; and
- To prevent local transmission of arboviruses in all non-endemic provinces by 2023; and
- To prevent the incidence of arbovirus disease from reaching outbreak thresholds in all endemic provinces by 2023.

5.2.4 Objectives

Overarching objectives are:

1. To have a clear overview of *Anopheles* vector species occurrence to determine relative receptivity for malaria stratification
2. To have a clear overview of *Aedes* vector species occurrence to guide arbovirus risk stratification
3. To provide *Anopheles* and *Aedes* vector insecticide resistance information to inform insecticide selection for LLINs, IRS and larvicides
4. To provide information on the biting times and places of key Anopheles vectors to guidance community education and action
5. To understand key *Aedes* aquatic habitats to guide larval control, including source reduction and larviciding
6. To track *Wolbachia* frequency to understand impact of project

5.3 Strategic Priorities

1. To establish and maintain adequate and appropriate vector surveillance for *Anopheles* and *Aedes* vectors, including evaluation of insecticide resistance and *Wolbachia* status
2. To evaluate vector control interventions for quality prior to deployment
3. To monitor the implementation of vector control, including LLIN coverage (access, usage)
4. To assess the field durability and performance of vector control products
5. To conduct vector and intervention evaluations in areas where there is ongoing transmission, such as malaria hot spots
6. To leverage vector and intervention information along with disease data to optimize vector control planning and implementation

5.4 Priority Activities

5.4.1 Vector Surveillance

1. Monitoring of the insecticide resistance status of *Anopheles farauti* – through targeted surveys
2. Monitoring the frequency of *Wolbachia* infections in *Aedes aegypti* in Port Vila – through longitudinal trapping post-implementation

5.4.2 Vector Intervention Monitoring and Evaluation

1. Targeted evaluation of LLIN distribution outcomes – through targeted surveys within 6 months of distribution
2. Nationwide assessment of LLIN coverage rates – through a cross-sectional nationwide survey
3. Targeted assessment of LLIN field durability – through targeted assessment post-distribution of physical/fabric integrity and insecticidal activity/bio-efficacy
4. Assessing the Impact of IRS application (IRS residual efficacy)

5.5 Enabling factors

The following have been identified as key enabling factors:

1. Program management
2. Governance
3. Risk Communication and Community Engagement
4. Human resources
5. Procurement, Supply Chain Management and Logistics
6. Infrastructure and Assets
7. Coordination and Partnerships

Two other key areas for consideration are:

- Risk Identification and Mitigation
- Knowledge and Research Gaps

6. PRIORITY ACTIVITIES

Based on the vector control interventions planned for implementation and the key indicators identified, a list of high priority activities for vector surveillance and intervention monitoring and evaluation was formulated for 2023-2024. This covers activities targeting both *Aedes* and *Anopheles* in order to reduce the burden and risk of malaria and arboviral diseases in Vanuatu. This priority list will be subject to change as interventions change and as the epidemiological and entomological context may change.

Priority	Activity	Information use
High	Annual monitoring of the landing behaviour and insecticide resistance status of *Anopheles farauti* at selected sentinel sites with high malaria transmission	• Community messages on bednet use • Location and insecticide class for IRS
High	Baseline monitoring of *Aedes* vector distribution, aquatic habitats and insecticide resistance status at selected urban sites throughout the country	• Risk stratification for Aedes-borne diseases • Larval control targets and approaches • Insecticide class for IRS • Community messages
High	Targeted evaluation of LLIN coverage (access and usage) in selected areas 6 months after distribution	• Bednet distribution strategies • Community messages
High	Nationwide assessment of LLIN coverage rates by cross-sectional survey and LLIN field durability (physical/fabric integrity and bioefficacy) of LLINs after use for 1, 2 and 3 years	• Bednet distribution strategies • Community messages • Quality control for LLINs
High	IRS residual efficacy in field post-spraying	• Spray operations • Insecticide product for IRS

Annex 8 provides different mosquito collection techniques used in these priority activities. Annex 9 provides further details for each of these priority activities, which may also be subject to change depending on timing and availability of human, infrastructural and financial resources. Brief protocol considerations are then presented in Annex 10.

This section lists and then gives details of the vector surveillance activities that will be coordinated by VBDCP, including the purpose, approach, sampling and indicators to be used for each.

Further details are provided below on the proposed key activities for vector surveillance monitoring in Vanuatu to address the **high priority data needs** as outlined above.

VECTOR SURVEILLANCE

6.1 Monitoring the insecticide resistance status of Anopheles farauti

Resistance testing using selected insecticides against local *Anopheles* malaria vector (*An. farauti*) in specific health zones will be used to identify areas where insecticide resistance is confirmed or possible, or to confirm where there is susceptibility. This information will be used to identify the most appropriate insecticidal vector control tools and products, and will inform the development of a national insecticide resistance monitoring and management plan. IR testing has been done in the past but further IR testing is required at other sites in Vanuatu, both with pyrethroids and with other insecticide classes for a clearer understanding of the resistance profile of *An. farauti* across Vanuatu.

6.2 Monitoring the frequency of Wolbachia infections in Aedes aegypti in Port Vila

This first ever biological means of vector control in Vanuatu was introduced in 2018. This involved the mass-release of *Wolbachia*-infected adult *Aedes aegypti* from 2 July 2018 to 28 March 2019, and releases in twelve (12) reporting areas of Port Vila. More than 19,000 *Wolbachia*-infected adult mosquitoes were released over an eight (8) month period. It is important that monitoring is conducted following these releases to evaluate the frequency of *Wolbachia* infections in wild mosquitoes and to identify any relationships with dengue or other arbovirus transmission to determine the impact of the intervention. This will be used to inform whether to expand implementation to other localities that have experienced transmission, such as Luganville on Santo Island (Sanma province) or even Tanna Island (Tafea province).

VECTOR CONTROL MONITORING AND EVALUATION ACTIVITIES

Correct deployment of vector control interventions is necessary to ensure adequate coverage of the targeted populations. For malaria, this requires appropriate strategies for distributing LLINs, timely and quality-controlled IRS, and correct application of larvicides, supported by the necessary information, education and communication activities.

For arboviral diseases, monitoring outcomes from interventions such as community clean-up campaigns and *Wolbachia*-infected *Aedes aegypti* releases are important. Much of this information may be outside of routine entomological data collection and are instead part of programme monitoring.

Key components of intervention monitoring and evaluation are included here. This includes post-deployment monitoring. However, this section does not include quality assurance and quality control monitoring of specific vector control products.

This section lists and then gives details of the vector control monitoring and evaluation activities that will be coordinated by VBDCP, including the purpose, approach, sampling and indicators to be used for each.

The monitoring and evaluation activities that will be focussed on during the elimination for routine and *ad hoc* operations are:

1. Targeted evaluation of LLIN distribution outcomes – through targeted surveys within 6 months of distribution
2. Nationwide assessment of LLIN coverage rates – through a cross-sectional nationwide survey
3. Targeted assessment of LLIN field durability – through targeted assessment post-distribution of physical/fabric integrity and insecticidal activity/bio-efficacy
4. Assessing the Impact of IRS application (IRS residual efficacy)

Further details of each of these assessment types are provided below. As much as possible, entomological and intervention data will be analysed in relation to epidemiological data to identify any spatial and temporal associations, as described in a later section.

6.3 Targeted evaluation of LLIN distribution outcomes

In some countries, campaigns distribute a fixed number of nets, typically two or three nets, to each household. In other countries, the number of nets allocated to a household varies by the size of the household or by sleeping places on the households which is the case for Vanuatu. And it is distributed within a three-year cycle. Continuous distribution of long lasting insecticidal nets is thought to be an effective mechanism to maintain ownership and access between or in the absence of mass campaigns but evidence is limited. A community-based evaluation will be done to further assess and evaluate the effectiveness of this important distribution strategy.

6.4 Nationwide assessment of LLIN coverage rates

A nationwide assessment of LLINs coverage will be conducted for the whole of Vanuatu, to ideally include all provinces and all health zones covered. These would have received replacement between 2017 and 2019. This study will assess LLIN coverage, including access and usage. It will also include sub-sampling of LLINs to test for field durability components (fabric/physical integrity, Bioefficacy), as outlined in (3) below.

6.5 Targeted assessment of LLIN field durability

According to WHO (WHO, Achieving and maintaining universal coverage with long-lasting insecticidal nets for malaria control , 2017), all malaria programmes that have undertaken medium- to large-scale LLIN distributions should conduct LLIN durability monitoring in line with available guidance. Field durability monitoring includes assessment of survivorship/attrition, fabric/physical integrity and insecticidal content/bio-efficacy.

Where there is evidence that LLINs are not being adequately cared for or used, programmes should design and implement behaviour change communication activities aimed at improving these behaviours.

6.5.1 Survivorship/attrition

Long-lasting insecticidal nets (LLINs) are a key tool for malaria prevention and control. Currently, the recommended serviceable life of an LLIN is 3 years under field conditions. However, past field studies show considerable variation in LLIN lifespan, from less than 2 years to more than 4 years. This study aimed to determine the attrition, physical integrity and functional survival of LLINs under different field conditions.

6.5.2 Insecticidal activity/bio-efficacy and chemical content

Long-lasting insecticide-treated nets (LLINs) are one of the main methods used for controlling malaria transmission in Vanuatu. The proliferation of several types of LLINs and the re-emergence of insecticide resistance in the local vector populations poses challenges to the local malaria control programme on selecting suitable insecticide-based vector control products. Therefore, this study will evaluate the insecticide susceptibility and bio-efficacy of selected LLINs product that are used in Vanuatu against wild populations of *Anopheles farauti*. It will also investigate whether the insecticide contents on the LINNs fabrics were within the WHOPES recommended target range.

6.6 Other data collection approaches

An assessment of Knowledge, attitude and practices (KAP) will be conducted within villages in health zones that continuously report high numbers of cases of malaria through an observational, cross-sectional study to answer all three respective parameters. Information will be collected by interviewers through a structured, standardized questionnaire that may include both quantitative and qualitative data which will be directed to randomly select individual households to assess the level of knowledge transfer on malaria, its preventative measures and treatment techniques.

7. Use of Information to Guide Decision Making

Specific forms will be filled to capture the necessary information, such as: date, collector(s), location, hour, number collected, and noting any anomalies. Data will be used to determine occurrence, density, biting time, biting location and resting location.

Entomological and interventions data derived from routine surveillance at fixed sentinel sites and spot checks in selected areas over time must have a clear purpose to inform decision making, planning and implementation of targeted or optimised vector control activities. Information from all parameters should be integrated with other relevant data such as epidemiological and environmental factors to ensure a complete overview of transmission dynamics and drivers. All data will be managed in Excel spreadsheets following good data management practices and will be backed up.

The vector surveillance and control personnel of the VBDCP tasked with implementing the above-mentioned activities will create summary scientific reports and make recommendations based on the different findings based on the different parameters captured. The finalised reports and recommendations will be disseminated to relevant MOH and other stakeholders involved in supporting progress towards eliminating Malaria in Vanuatu such as the MOH Directorate of Public Health, other MOH managers and staff, development partners such as UNDP, Global Fund, DFAT and others, and other NGOs involved. Reports will be disseminated through mechanisms such as the MOH internal Malaria Elimination Steering Committee and the external Malaria Elimination Advisory Group.

Recommendations which were made will be specifically monitored to ensure that these are used to inform future control interventions, and hence are contributing to malaria elimination in Vanuatu.

8. Enabling factors

8.1 Program management

Once the priority VS and VC activities identified, then what is needed from a planning, budget and time point of view to manage the programme Planning and implementation

8.2 Governance

The Public Health Act 1995 part 5 talks about the “Prevention and Destruction of Mosquitoes and Vermin” which focus on the prevention and control of malaria and other vector borne diseases. It outlines and discuss introduction and harbouring of breeding places and premises which includes natural breeding places such as tall / long grass, bushes or shrubs as well as artificial manmade breeding sites such as septic tanks, soak ways and other water storage containers. All these involve the aquatic life cycle stage of a mosquito but not much on the adult stage which is an important stage which aid in the transmission vector borne disease. People could either be panelised or entitled to imprisoning if were caught doing such activities that allows mosquito to breed.

However, little or no Act was focused on the prevention and control of adult mosquito in terms of using LLINs and other prevention towards adult biting. This Act could be revised to captured coverage (access & Usage) of LLINs, proper usage of old and new nets and/ or waste disposal of old LLINs. In addition, the right for all vulnerable groups including woman, children and people with disability to access LLINs and other vector borne prevention. Proper waste management of artificial containers such as re-use, reduce and recycle should also be included and be effective as it is important control and prevent dengue vector.

All these important factors need to be captured and be followed with the assistance of the various stakeholders of concerned such as; Department od policy and planning, MoH, Public works, Municipal, Police department, community leaders, Department of Environment, Department of Water, and supporting donor partners. Every individuals are entitled to abide by the Act or be held responsible.

On the other hand, the Act must state that to provide emergency response whenever there a disease outbreak including Vector borne. MoH must take the lead in response whilst the specific public health program responsible will provide technical insights and forward logistics and/ or public health response plan not the National Disaster management office.

8.3 Risk Communication and Community Engagement

According to WHO, the five risk communication principles were; trust, transparency, announcing early, listening and planning which should be in cooperate to control and prevent a disease in an outbreak or ad hoc situation. The vector borne program needs a fulltime risk communication and community engagement officer who will be located at the Health promotion unit at the MoH. That person is going to be responsible for only vector borne disease messaging and communication. The officer will be someone who has more than 1 year experience with the malaria program or someone who have proven to be knowledgeable about malaria prevention and control.

This will ensure timely, accurate and trusted information is being communicated. The information being communicated is able to encourage positive and healthy behaviours in relation to vector control and protective measures based on a sound understanding of the socio-cultural environment and information eco system. The information being put out also able to foster community engagement and accountability as well as the officer will be able to collect, analyse and respond to rumours and inaccurate information and erroneous ideas as quickly as possible.

8.3.1 Healthy Island/Village approach

Healthy island and healthy village approaches have not been a major focus of vector control and prevention of malaria. It is best if this approach is introduced into the vector control strategies. For instance, it can be promoted during the 'World Malaria Day" on 25th of April annually. This date can be used to promote clean-ups, competitions and award-winning events that will motivate communities to take the ownership of any vector control activities that are introduced. For instance, rubbish collection, proper and hygienic use of LLINs, clean communities, and clean environments such as water edges and others.

Another approached towards this is having the vector control activities inserted into the primary school syllables as it helps to create and educate young minds, younger generation on the different vector control and prevention techniques that will help reduce malaria and other vector borne diseases in their respective communities. In addition, the world malaria day will also be celebrated in schools as a way to promote malaria and other vector borne diseases.

8.4 Human resources

Vanuatu noted that there are national and provincial staff, and staff drawn when required for specific activities from WASH, Environmental health, Neglected tropical diseases and in province – the provincial health managers

8.4.1 Recruitment

There is a need to maintain core entomological and vector control capacity within the Malaria and Other Vector Borne Diseases Control Program, as a priority. The program needs someone who is a professional entomologist to guide the surveillance and monitoring operations and to appropriately use the data obtained from the studies and /or surveys to guide effective and efficient decision making.

Recruitment of additional technical assistance through either staffing or a consultant for support to vector-specific activities is needed to guide vector control planning and activities especially in terms of doing surveys, entomological surveillance and monitoring studies.

8.4.2 Training

Training of current staff in entomology and vector control is currently ad hoc, and needs to be more strategic and focussed. This should aim to ensure skills are built across the compliment of staff, in order to avoid major impact when key staff leave the program. Some examples of how to build capacity sustainably include:

- New staffs to go through "on-the-job training" by senior vector control staffs or to be sent overseas to be up-skilled.
- For existing staff, refresher training to be done by the program technical assistant from WHO, and/or to be sent annually to attend training and workshops organize by APMEN, PacMOSSI, APLMA and other vector control partners.
- Casual staff (such as spray teams) to be trained annually or periodically whenever needed, such as in advance of IRS operations to be conducted routinely, during an outbreak or for targeted prevention.
- Individuals seconded for outbreak response to be trained on malaria, vector behaviour and control by program staff before deployed to assist.

It is important to remember that surge deployment teams for malaria or dengue outbreak response must include individuals with vector surveillance or control expertise.

8.5 Procurement, Supply Chain Management and Logistics

Further details on procurement and supply chain management as included in the broader National Strategic Plan also apply to the vector surveillance and control monitoring and evaluation activities. Therefore, details will not be repeated herein. One exception is insecticidal papers for resistance monitoring, which are usually procured with the support of the WHO country office to ensure simpler and shorter procurement processes.

8.6 Infrastructure and Assets

There are currently no plans in place for the Ministry of Health to improve entomological infrastructure in Vanuatu. Laboratory capacity was significantly enhanced in 2016-2018 through the *Wolbachia* project. This included extensive refurbishment and additional equipment at the facility at George Pompidou to support the production of large numbers of *Wolbachia*-infected mosquitoes. However, this capacity was not maintained at the conclusion of external support to the project, and as of late 2022 the insectary and entomology laboratory are not functioning. Given this experience, this plan focusses on ensuring activities can be conducted in the absence of sustained laboratory capacity.

While there are no specific vehicles allocated to entomological activities, malaria teams in provinces can draw on quad bikes, motorbikes, boats and trucks allocate either to malaria or wider public health teams. This requires adequate planning and support from provincial managers, and will depend on competing health priorities at the time of planned entomological activities. Maintenance of assets can be an issue, and should be built into any grant applications for substantive vector surveillance or control operations.

8.7 Coordination and Partnerships

In 2020, WHO identified Vanuatu as one of the 39 countries worldwide that was well placed to eliminate malaria by 2025. Technical and financial support towards elimination in line with the National Strategic Plan for Malaria Elimination (2021-2026) is from recurrent budget as well as from the Global Fund to Fight AIDS, Tuberculosis and Malaria, WHO, Rotarians Against Malaria, DFAT, Vanuatu Health Program. The Program also accesses technical, coordination and financial support through the Roll Back Malaria Partnership and the Asia Pacific Malaria Elimination Network (APMEN).

In 2020, the PacMOSSI project co-led by James Cook University and the World Health Organization with a large consortium of other partners, commenced training of Pacific Island vector teams. Vanuatu was included in these activities, and will continue to be an active member.

With a focus on vector surveillance, this is an important initiative that can assist in enhancing capacity and opportunities that will enable implementation of this current strategy. The Program will continue to strengthen interactions and collaboration with key partners as listed above, whilst identifying further opportunities. The new Pacific Network for Vector Control Response was supported by Vanuatu in the Pacific Public Health Surveillance Network annual meeting, and also presents an opportunity to liaise with Ministries from other countries to share experiences, best practices and data in order to protect against the threat of outbreaks and incursive vector species.

8.8 Other

Additional important cross-cutting issues such as gender, One Health, climate change and environmental impact are covered in brief in other documents, such as the Health Sector Strategy. However, additional work is required to put in place key documents related to vector control such as an insecticide lifecycle management protocol to minimise environmental impact.

8.9 Risk Identification and Mitigation

The following provides a brief overview of risks and proposed mitigating measures. However, further discussions will be required to determine how these apply for each aim and implementation period.

Key risk identified	Mitigating measures
Insufficient human capacity to fully implement	Ongoing entomological training should be conducted for members of national and provincial teams, to ensure that key staff attrition does not impact on continuity of implementation. All

	opportunities for training should be explored, including training, mentorship and online modules.
Insufficient infrastructure or assets to fully implement	Provincial teams must be involved in any operational planning for vector surveillance and M&E to ensure that plans are realistic, supported by managers, and that necessary resources will be available when needed.
Insufficient finances to fully implement	Multiple opportunities for funding (such as from WHO, PacMOSSI, APMEN, RAM) should be investigated with clear allocation of funds in the annual operational plans for the Program.
Community leaders or members are not engaged or reject/prevent activities	Health promotion teams at national and provincial levels should be involved to ensure correct and advance community engagement ahead of the planned activities. Incentives may be identified if needed.
Climatic conditions, natural hazards or other health priorities constrain implementation	Vanuatu is at high risk of natural disasters and outbreaks. It will be important to ensure that cyclone season or other key events be incorporated into planning to ensure goals and timelines are realistic, and that there is flexibility in the event of any crisis events.

9. Knowledge and Research Gaps

There is lack of evidence and knowledge across many areas of vector surveillance and control that needs to be addressed. Given the lack of entomological research capacity in any national institutes, the Ministry of Health should actively pursue opportunities to partner with research and academic institutes in order to address these gaps. Ideally, this should be as part of a broader health sector research priority strategy to ensure that this addresses the needs outlined in the Health Sector Strategy. Key areas are identified below as a starting point.

What type of study	Explanation	Where (sites)	Who responsible	Priority	Study type
Confirm malaria vector species in Vanuatu	Evidence base since early 1900s focussed on *An. farauti* but need confirmation this is the only species complex present.	Torba, Sanma, Malampa, Shefa, Penama	Vector Control Team	High	Survey

Conduct mosquito behaviour, i.e. biting preferences, timing and connect with climate change-weather pattern	Need evidence on any relationship with weather patterns esp. rainfall to guide outbreak and upsurge prediction	Santo, Malekula , Pentecost, Epi	Vector Control Team	High	Operational Research
Implementation of *Wolbachia*	Determine if to establish *Wolbachia* mosquito population in Santo	Santo	Vector Control Team	Medium	Operational Research
Anopheles larval habitat assessments for all vector species	Observe if there are any potential changes and connect with climate data.	Santo, Malekula, Pentecost, Epi	Vector Control Team	High	Operational Research

10. Annual activity plan

Strategies	Activities	Frequency	2023	2024	2025	2026	2027
1. To have a clear overview of *Anopheles* vector species occurrence, information on the biting preferences of Key Anopheles vectors to guide community education and action to determine relative receptivity for malaria stratification							
Overview of Anopheles vector species occurrence	Compile data on highly productive permanent and temporary aquatic habitats of *Anopheles farauti* in different locations throughout Vanuatu	Periodically		X		X	
	Conduct night catch to determine *Anopheles* biting preferences and biting time (HLC) in selected malaria hot spot areas	Annually, at difference locations where info gaps detected	X	X	X	X	X
	Conduct night catch to determine *Anopheles* occurrences and density (light traps) in selected malaria hot spot areas	Annually at locations where info gaps detected	X	X	X	X	X
Community engagement activities during routine times	Work with communities to reduce larval habitats, encouraging the removal of aquatic habitats	Ongoing during outbreak					
	Disseminate locally appropriate information in hot spots: malaria transmission, importance and role of vector preventive control activities	Ongoing during outbreak					

Strategies	Activities	Frequency	2023	2024	2025	2026	2027
2. To have a clear overview of *Aedes* vector species occurrence to guide arbovirus risk stratification							
Overview of *Aedes* vector species occurrence	Map all historic location data for *Aedes* species	Periodically		X		X	
	Egg, adult and larval surveys to determine best collection methods and provide information on occurrence and productivity of aquatic habitats for *Aedes*	Once, at key locations with likely highest risk	X				
	Additional surveys to provide information on occurrence and key behaviours for *Aedes*	Annually, at selected locations		X	X	X	X
Community engagement activities during routine times	Disseminate locally appropriate information in areas where dengue transmission occurs, importance and role of preventive control activities	Ongoing during outbreak					
	Undertake a clean-up campaign, in collaboration with waste management partners, Municipal, PTAG, Provincial EOC, and other stakeholders concerned	Ongoing, during outbreak					

Strategies	Activities	Frequency	2023	2024	2025	2026	2027
3. To provide *Anopheles* and *Aedes* vector insecticide resistance information to inform insecticide selection for LLINs, IRS and larvicides							
Insecticide resistance testing of common insecticide class with *Anopheles* local population	Compile and review previous surveillance data for insecticide resistance status and biting/resting behaviour	Periodically		X		X	
	Collect *Anopheles* mosquito through HLC and perform Insecticide resistance testing in selected specific sites	Every 2 years	X		X		X
Insecticide resistance testing of common insecticide class with *Aedes* local population	Collect *Aedes* mosquitoes through ovitraps, perform insecticide resistance testing on F1 generation	Every 2 years	X		X		X
Risk communication and community engagement if resistance seems to be the case in any of the insecticides class tested	Conduct community mobilization and engagement to disseminate key messages on the information found	If any resistance is detected					
	Vector control management and TA partners be made aware of any resistance for any high level decision making in terms of chemical to be used for IRS, larvicides and LLINs						

Strategies	Activities	Frequency	2023	2024	2025	2026	2027
4. To understand key *Aedes* aquatic habitats to guide larval control, including source reduction and larviciding							
Breeding site survey to determine most common and productive breeding sites of *Aedes* vector	Baseline monitoring of *Aedes* vector distribution, aquatic habitats at selected urban sites throughout the country	Annually at selected high risk locations	X	X	X	X	X
Risk communication and community engagement in high-risk areas, including promotion of personal protection measures	Printing and performing community awareness (leaflets, posters, pamphlets, flyers)	Ongoing during outbreak of Dengue					
	Immediate action be taken by the vector control officer to prevent and control breeding sites	Ongoing during outbreak of Dengue					
	During outbreak: Implement RCEE plan, working with communities to reduce larval habitats, encouraging the removal of breeding sites	Ongoing during outbreak of Dengue					

Strategies	Activities	Frequency	2023	2024	2025	2026	2027
5. To track *Wolbachia* frequency to understand the impact of "*Wolbachia*" project							
Monitoring the frequency of *Wolbachia* infections in *Aedes aegypti* in Port Vila – through longitudinal trapping post-implementation	Set and collect BG traps at specific locations within the 9 *Wolbachia* reporting areas	Periodically		X			
	Lab identification of *Aedes* species at local entomology lab in Vanuatu	Periodically		X			
	Shipment of *Aedes* species sample to Australia	Periodically		X			
	Lab identification to check and confirm *Aedes* species and *Wolbachia* frequency	Periodically		X			

11. 2023 Annual budget

Strategic Plan #	Strategies	Activity	Estimated budget (VUV)	Potential funder
1	Overview of Anopheles vector species occurrence	Compile data on highly productive permanent and temporary aquatic habitats of *Anopheles farauti* in different locations throughout Vanuatu	0	
		Conduct night catch to determine *Anopheles* biting preferences and biting time (HLC) in selected malaria hot spot areas	970,000	WHO
		Conduct night catch to determine *Anopheles* occurrences and density (light traps) in selected malaria hot spot areas		
	Community engagement activities during routine times	Work with communities to reduce larval habitats, encouraging the removal of aquatic habitats	0	
		Disseminate locally appropriate information in hot spots: malaria transmission, importance and role of vector preventive control activities	0	
2	Overview of *Aedes* vector species occurrence	Map all historic location data for *Aedes* species	0	
		Egg, adult and larval surveys to determine best collection methods and provide information on occurrence and productivity of aquatic habitats for *Aedes* (*SEE ALSO 3 AND 4 BELOW*)	1,900,000	PacMOSSI
		Additional surveys to provide information on occurrence and key behaviours for *Aedes*	0	

	Community engagement activities during routine times	Disseminate locally appropriate information in areas where dengue transmission occurs, importance and role of preventive control activities	0	
		Undertake a clean-up campaign, in collaboration with waste management partners, Municipal, PTAG, Provincial EOC, and other stakeholders concerned		
3	Insecticide resistance testing of common insecticide class with *Anopheles* local population	Compile and review previous surveillance data for insecticide resistance status and biting/resting behaviour	0	
	Risk communication and community engagement if resistance seems to be the case in any of the insecticide classes tested Insecticide resistance testing of common insecticide class with *Aedes* local population Risk communication and community engagement if resistance seems to be the case in any of	Collect *Anopheles* mosquito through HLC and perform Insecticide resistance testing in selected specific sites	0 (covered in budget above)	WHO
		Collect *Aedes* mosquitoes through ovitraps, perform insecticide resistance testing on F1 generation	0 (covered in budget above)	PacMOSSI
		Conduct community mobilization and engagement to disseminate key messages on the information found	0	
		Vector control management and TA partners be made aware of any resistance for any high level decision making in terms of chemical to be used for IRS, larvicides and LLINs		

	the insecticides class tested			
4	Breeding site survey to determine most common and productive breeding sites of *Aedes* vector	Baseline monitoring of *Aedes* vector distribution, aquatic habitats at selected urban sites throughout the country	0 (covered in budget above)	PacMOSSI
	Risk communication and community engagement in high-risk areas, including promotion of personal protection measures	Printing and performing community awareness (leaflets, posters, pamphlets, flyers)	0	
		Immediate action be taken by the vector control officer to prevent and control breeding sites		
		During outbreak: Implement RCEE plan, working with communities to reduce larval habitats, encouraging the removal of breeding sites		
5	Monitoring the frequency of *Wolbachia* infections in *Aedes aegypti* in Port Vila – through longitudinal trapping post-implementation	Set and collect BG traps at specific locations within the 9 *Wolbachia* reporting areas	0	
		Lab identification of *Aedes* species at local entomology lab in Vanuatu		
		Shipment of *Aedes* species sample to Australia		
		Lab identification to check and confirm *Aedes* species and Wolbachia frequency		

REFERENCES

Dengue Outbreak in Vanuatu-Situational Report 03. (2019, April 24). Retrieved from reliefweb.int: https://reliefweb.int/report/vanuatu/dengue-outbreak-vanuatu-situational-report-03-24-apr-2019

Jacob Williams and Joao Pinto. (2012, September). Tranining Manual on Malaria Entomology-Fro Entomology and Vector Control Technician (Basic Level). United States, America. Retrieved from RTI International .

Khumbulani W hlongwana, Musawenkosi LH Mabaso, Simon Kunene, Dayanandan Govender and Rajendra Maharaj. (2009). Community Knowledge, attitudes and practices (KAP) on malaria in Swaziland: A country earmarked for malaria elomination. *Malaria Journal*.

Mosquito Life-Cycle | Dengue | CDC. (2019). Retrieved from Life cycle of mosquitos in a diagram: https://www.google.com/search?q=the+life+cycle+of+aedes+aegypti+mosquito&safe=active&tbm=isch&source=iu&ictx=1&fir=uCwgeahjPxUOIM%253A%252CmrjbN8-qkPkf3M%252C_&vet=1&usg=AI4_-kRDLqCOX2VX_iLfg7_VnUoY-lwreg&sa=X&ved=2ahUKEwjQ5_38ud3iAhUCVysKHap1CPUQ9QEwAHoE

NMSP Working Groups. (2015). *National Malaria Strategic Plan, Vanuatu,2015-2020.* Port Vila: Ministry of Health.

Olivia Pigeon et al. (2018). *TEST REPORT.* Belgium: Wallon Agriculture Research Centre (CRA-W).

Rajiv Kumar Gupta, Sunil Kumar Raina, Tajali N. Shora, Rayaz Jan, Renu Sharma, Shahid Hussain. (2016). A household survey to assess community knowledge, attitude and practices on malaria in rural population of Northern India. *Journal of Family Medicine and Primary Care*.

Seng, D. C. (2013). Malaria Entomology Training Manual. *Malaria Entomology Training manual*.

Vanuatu MoH. (2017). *Summary of recent Anopehles Insecticides resistance monitoring data.* Port Vila.

WHO. (2011). *Guidelines for Durability of Long-Lasting Mosquitoe Nets Under Operational Conditions.* Retrieved from Control of Neglected Tropical Diseases WHO Pesticide Evaluation Scheme and Global Malaria Progamme Vector Control Unit-WHO: https://apps.who.int/iris/bitstream/handle/10665/44610/9789241501705_eng.pdf?sequence=1

WHO. (2011). *Guidelines for monitoring the durability of long-lasting insecticidal mosquito nets under operational conditions.* Retrieved from World Health Organization : https://apps.who.int/iris/bitstream/handle/10665/44610/9789241501705_eng.pdf?sequence=1

WHO. (2013). *Malaria Entomology and Vector Control-Guide for Participants.* 20 Avenue Appia, 1222 Geneva 27 : World Health Organization.

WHO. (2016). *Test Procedures for Insecticides Resistance Monitoring in Malaria Vector Mosquitoes 2nd endition.* Geneva, Switzerland: World Health Organization.

WHO. (2017, 12). *Achieving and maintaining universal coverage with long-lasting insecticidal nets for malaria control* . Retrieved from Global malaria program: https://apps.who.int/iris/bitstream/handle/10665/259478/WHO-HTM-GMP-2017.20-eng.pdf;jsessionid=5C26A177D9EC71DA2069753D8FBC2A30?sequence=1

WHO. (2018, March). *Malaria surveillance, monitoring & evaluation: a reference manual.* Retrieved from World Health Organization: https://www.who.int/malaria/publications/atoz/9789241565578/en/

WHO. (2018). *Malaria Surveillance, Monitoring & Evaluation: A reference Manual.* Geneva: World Health Organization.

WMP. (2017). *Insecticide Resistance Bioassay Results* . Port Vila.

WMP. (2018, 03 18). Proposal for long-term monitoring of Wolbachia in Port Vila, Vanuatu. Melbourne, Oceania Hub, Australia.

Working group on Monitroing & Evaluation. (2014, June). *Knowledge, Attitudes, and Practices (KAP) Surveys during Cholera Vaccination Campaigns: Guidiance for Oral Cholera Vaccine Stockpile Cambaigns)* . Retrieved from World Health Organization : https://www.who.int/cholera/vaccines/kap_protocol.pdf

www.researchgate.net. (2019). Retrieved from Stages of Anopeheles Mosquito Life-cycle: https://www.google.com/search?q=the+life+cycle+of+anopheles+mosquito&safe=active&tbm=isch&source=iu&ictx=1&fir=RFGunRj7rLJfhM%253A%252CZ9ifO1z2x4tinM%252C_&vet=1&usg=AI4_-kRQFVdMo0pVfcSGXVbdyLakVZQ95g&sa=X&ved=2ahUKEwj7ytS5uN3iAhXJfysKHdQ9AJQQ9QEwAHoECAMQ

ANNEX 1. SUMMARY OF RECENT *ANOPHELES* INSECTICIDE RESISTANCE MONITORING DATA

Summary of standard WHO tube testing for *Anopheles farauti s.l.*, 2017-2022

Location	Time of testing	Insecticide tested	Outcome
Barrick & Potindir Village	2017	Alpha-cypermethrin 0.05%	Susceptible
Barrick & Potindir Village	2017	Deltamethrin 0.05%	Susceptible
Barrick & Potindir Village	2017	Lambda-cyhalothrin 0.05%	Susceptible
Barrick & Potindir Village	2017	Permethrin 0.75%	Possible resistance

ANNEX 2. SUMMARY OF RECENT *ANOPHELES* BITING DATA

Location	Time of testing	Outcome
Barrick & Potindir Village	2017	Mosquitoes favours indoor biting
Saramauri- Bigbay Bush	2017	-
Hassaviah, South Santo	2019	Mosquito favours outdoor biting
Aulua, Repaksivir-Malekula	2019	Mosquito favours indoor biting
Lamen island	2020	Mosquito favours outdoor biting
Malau – Tolomako, Bigbay coastal	2020	Mosquito favours outdoor biting

ANNEX 3. SUMMARY OF AEDES COMPOSITION AND AQUATIC HABITATS IN LUGANVILLE

Table 1. Number of mosquito immature, their habitat types and *Aedes* species identified

Place	Habitat Type and Number	No. of positive habitats	Number of larvae/pupae collected	Species
Near Airport	Tyres (3), Discarded containers (>50)	3 2	>100 <10	*Ae. albopictus*
Seaport –Niscol	Tyres (18) Boats (4)	12 1	>100 1-10	*Ae. albopictus*
Seaport – Punjas	Discarded containers (>20)	2	<10	*Ae.albopictus*
Luganville Town	Tyres (3) Household items (2) Buckets (2) Flower vases (1) Discarded containers (8) Flower pots (6)	3 1 1 1 2 1	10-100 >100 <10 <10 10-100 <10	*Ae.albopictus* *Ae.albopictus* *Ae.albopictus* *Ae.aegypti* *Ae.albopictus* *Ae.albopictus*
Pepsi village (20 premises)	Tyres (29) Pond (4) Plastic drums (6) Ice box (2) Flowerpots (13) Discarded containers (>50)	12 Neg 2 1 2 2	>100 - 10-100 <10 10-100 <10	*Ae.albopictus* - *Ae.albopictus* *Ae.albopictus* *Ae.albopictus* *Ae.albopictus*
Banban village (10 premises)	Tyres (23) Pond (1) Plastic drums (4) Ice box (1) Toys (1) Discarded containers (>10)	19 Neg 4 Neg 1 4	>100 - 10-100 - >100 <10	*Ae.albopictus* - *Ae.albopictus* - *Ae.albopictus* *Ae.albopictus*
St.Therese	Tyres (16) Discarded containers (>50)	14 2	>100 <10	*Ae.albopictus* *Ae.albopictus*

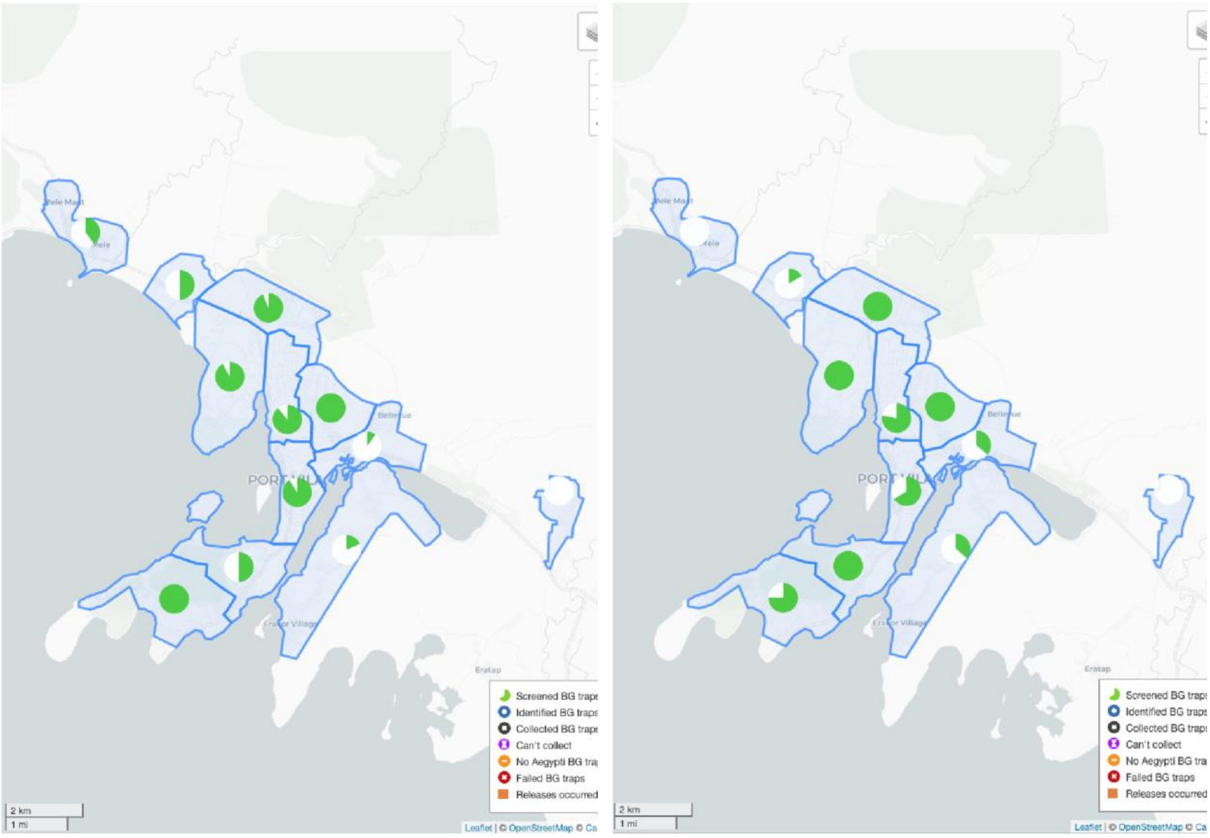
ANNEX 4. SUMMARY OF *AEDES* COMPOSITION AND *WOLBACHIA* FREQUENCY IN PORT VILA

Annex 4.1 Vanuatu quarterly progress report, 11 October 2019

The Vanuatu Ministry of Health is monitoring the Aedes aegypti mosquito population in Port Vila to measure the impact of the World Mosquito Program's Wolbachia method. This progress report provides explanatory notes that complement the Vanuatu Core Data dashboard and the corresponding epidemiology dashboard.

Entomology outcomes

Figure 1 shows the percentage of Wolbachia mosquitoes collected over two 1-week periods in Port Vila. Wolbachia mosquitoes are prevalent (pie chart majority green) in the reporting areas with the highest human population. In some reporting areas the Wolbachia prevalence is intermediate. Wolbachia establishment is expected to accelerate in these areas in the coming months. Natural spread of Wolbachia mosquitoes into these locations is also expected, eventually resulting in a high Wolbachia frequency.



(a) **(b)**

Figure 1. *Wolbachia* % in screened *Ae. aegypti* collected from BG traps in Port Vila in the 12 release sites in two collection weeks: (a) 19 August to 25 August 2019; and (b) 26 August to 1 September 2019.

For each of the 12 release sites in Port Vila, Figure 2 shows the number of *Aedes aegypti* mosquitoes tested and the proportion that contained *Wolbachia* between June 2018 and September 2019. The light-green shading indicates the original release period. Figure 2 also shows the mean catch per BG trap per day and the %wMel for the two collection periods: week to 25 August and week to 1 September.

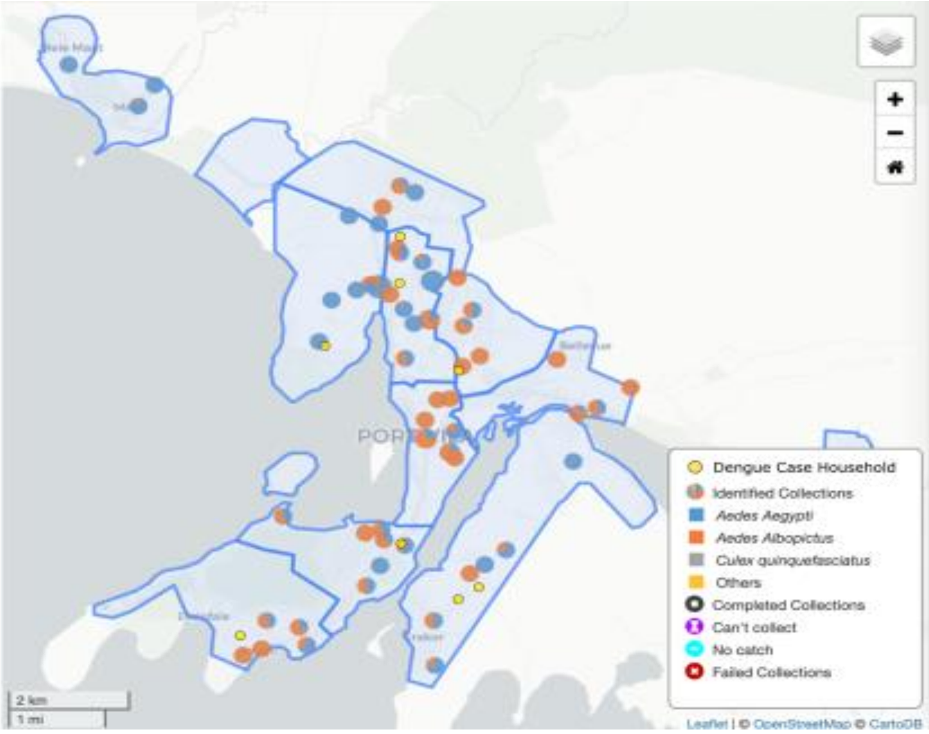
Figure 2. Number of *Aedes aegypti* mosquitoes tested (LH axis) and the proportion that contained *Wolbachia*
(RH axis) between June 2018 and September 2019, Port Vila, Vanuatu
MCPTPD = mean catch per trap per day; wMel = *Wolbachia Aedes aegypti*

Annex 4.2 Vanuatu quarterly progress report, 3rd – 16th of May 2021

3rd – 9th May, 2021

Reporting area	MCPTPD (BG)	Mean catch (Asp.)	Aedes aegypti	Aedes albopictus	Culex quinquefasciatus	Others	Successful collections	Failed collections	Can't collect locations	Zero aegypti collections	Contains unsorted sample
Total	0.35	-	186	173	235	6	78	0	-	35	-
Port Vila											
Bellvue-Tassiriki	0.11	-	4	18	14	0	5	0	-	3	No
Blacksands-Malapoa	0.58	-	37	4	8	0	9	0	-	4	No
Bladinieres-Tagabe	0.39	-	19	13	14	0	9	0	-	4	No
Erakor	0.28	-	18	8	10	3	9	0	-	4	No
Etas	-	-	-	-	-	-	-	-	-	-	-
Freshwota-Beverly Hills	0.14	-	5	17	31	1	6	0	-	3	No
Joint Court-Nambatu	0.22	-	14	34	34	0	9	0	-	6	No
Mele-Mele Maat	0.27	-	11	1	9	0	6	0	-	3	No
Nambatri-Lagoon	0.18	-	13	17	21	0	9	0	-	3	No
Ohlen-Namburu	0.83	-	54	39	49	0	9	0	-	2	No
Pango	0.24	-	11	22	45	2	7	0	-	3	No
Prima	-	-	-	-	-	-	-	-	-	-	-

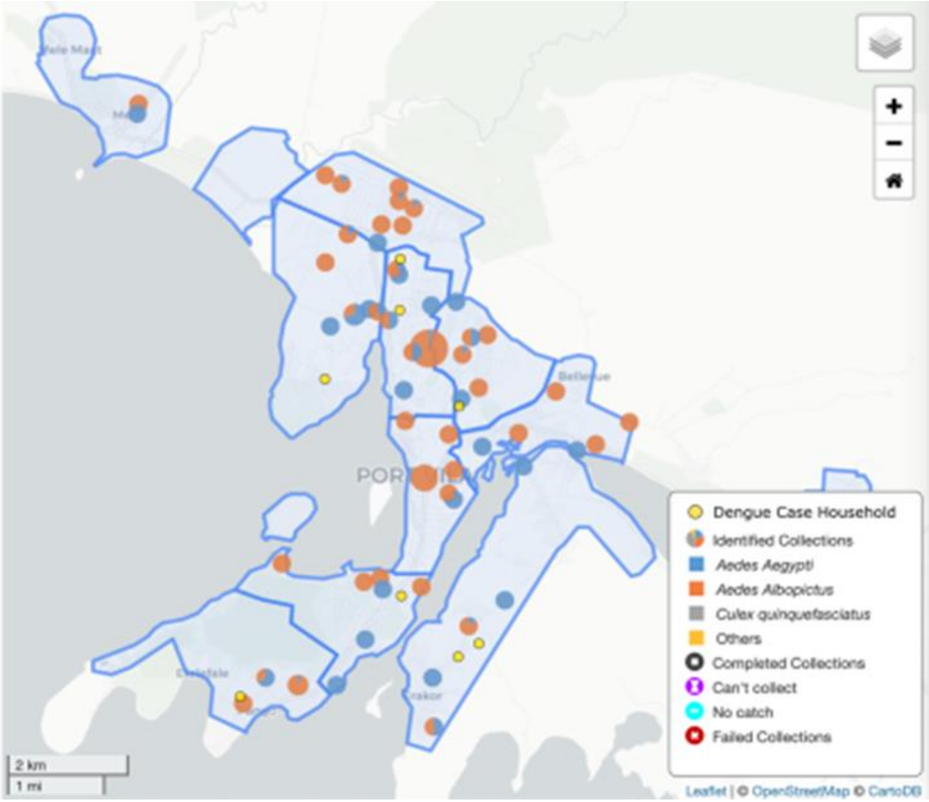
3-9th May



10th – 16th May, 2021

Reporting area	MCPTPD (BG)	Mean catch (Asp.)	Aedes aegypti	Aedes albopictus	Culex quinquefasciatus	Others	Successful collections	Failed collections	Can't collect locations	Zero aegypti collections	Contains unsorted sample
Total	0.20	-	105	202	225	4	82	0	-	44	-
Port Vila											
Bellvue-Tassiriki	0.04	-	2	13	28	1	9	0	-	6	No
Blacksands-Malapoa	0.32	-	20	15	6	1	9	0	-	4	No
Bladinieres-Tagabe	0.14	-	9	36	34	0	9	0	-	5	No
Erakor	0.19	-	12	7	4	1	9	0	-	4	No
Etas	-	-	-	-	-	-	-	-	-	-	-
Freshwota-Beverly Hills	0.19	-	8	15	28	0	6	0	-	2	No
Joint Court-Nambatu	0.05	-	3	36	47	0	9	0	-	7	No
Mele-Mele Maat	0.30	-	13	2	12	0	6	0	-	5	No
Nambatri-Lagoon	0.09	-	5	13	10	1	9	0	-	6	No
Ohlen-Namburu	0.51	-	28	46	14	0	9	0	-	1	No
Pango	0.14	-	5	19	42	0	7	0	-	4	No
Prima	-	-	-	-	-	-	-	-	-	-	-

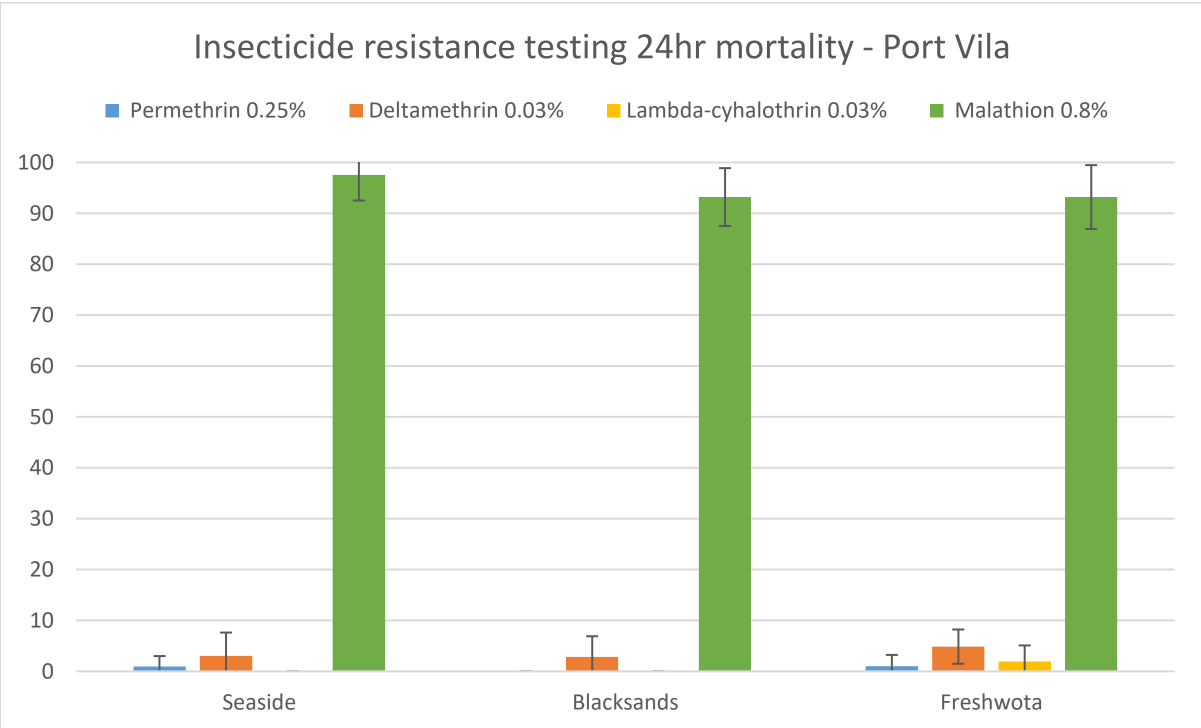
10-16th May


Bellevue
PORT VILA
2 km
1 mi
Dengue Case Household
Identified Collections
Aedes Aegypti
Aedes Albopictus
Culex quinquefasciatus
Others
Completed Collections
Can't collect
No catch
Failed Collections
Leaflet | © OpenStreetMap © CartoDB

ANNEX 5. SUMMARY OF RECENT *AEDES* INSECTICIDE RESISTANCE MONITORING DATA

Insecticide	Area	% 60min knockdown	SD	% Mortality 24hrs	SD
Permethrin 0.25%	Seaside	0.96	2.03	1	2.03
Deltamethrin 0.03%	Seaside	3.00	4.62	3	4.62
Lambda-cyhalothrin 0.03%	Seaside	0.00	0.00	0	0.00
Malathion 0.8%	Seaside	34.57	5.00	98	5.00
Permethrin 0.25%	Blacksands	0.00	0.00	0	0.00
Deltamethrin 0.03%	Blacksands	1.87	4.09	3	4.09
Lambda-cyhalothrin 0.03%	Blacksands	0.97	0.00	0	0.00
Malathion 0.8%	Blacksands	32.04	5.68	93	5.68
Permethrin 0.25%	Freshwota	0.99	2.24	1	2.24
Deltamethrin 0.03%	Freshwota	1.94	3.37	5	3.37
Lambda-cyhalothrin 0.03%	Freshwota	0.00	3.11	2	3.11
Malathion 0.8%	Freshwota	32.04	6.28	93	6.28
Permethrin 0.75%					
ambda-cyhalotrhin (0.05%)					
Deltamethrin (0.05%)	Port Vila (WHO)			42	
Malathion (5%)					
*WHO IR bioassay results					

(WMP, Insecticide Resistance Bioassay Results , 2017)



(WMP, Insecticide Resistance Bioassay Results , 2017)

ANNEX 6. SUMMARY OF LLIN FIELD DURABILITY (INSECTICIDE CONTENT AND BIOEFFICACY)

Results for insecticidal Testing was prepared by the Walloon Agriculture Research Centre (CRA-) in Belgium.

The results from an assessment of insecticidal content of PermaNet 2.0 long-lasting insecticidal bed nets (LLINs) collected 1- and 2-years after distribution to two health zones in Malampa province indicate that:

1. *LLINs collected 1 year after distribution* (n = 28): Mean deltamethrin content was 1.11 g/kg (range: 0.72 – 1.48 g/kg). 23 nets (82.1%) had content that was within the expected lower and upper limit for new, unused nets. Mean retention rates of insecticide relative to target dose were high (≥86%) for all net sizes. **This indicated that insecticidal content was overall very good for the nets tested.**

2. *LLINs collected 2 years after distribution* (n = 26): Mean deltamethrin content was 0.66 g/kg (range: <0.01 – 1.52 g/kg). 12 nets (46.2%) had content that was within the expected lower and upper limit for new, unused nets. Mean insecticide retention rate relative to target dose was high (87%) for medium nets but low for large nets (30%) as well as the one small net tested (11%). There appeared to be a binomial distribution wherein half of all nets tested had good retention rates and half had very poor retention rates. **This indicates that insecticidal content was highly variable for the nets tested, with significant loss between 1 and 2 years particularly for large nets.**

The very good insecticidal content of 1 year nets and the mix of very good and very poor content in the 2 year nets is unexpected. It may be due to wide variance in net handing, washing or use, such as pre-storage and only recent use of some nets. It may also be attributable to quality issues with nets prior to distribution. However, collections of nets were not accompanied by any survey to capture information on net handling, washing or use. Batch information was also not able to be associated with specific net outcomes as different batches appear to have been used for the roof and body of the nets. This means that there is limited information to be able to explain the results of the assessment.

Summary Figures

Figure 1: Insecticide content (mean ± standard deviation) for LLINs distributed 1- and 2-years prior.

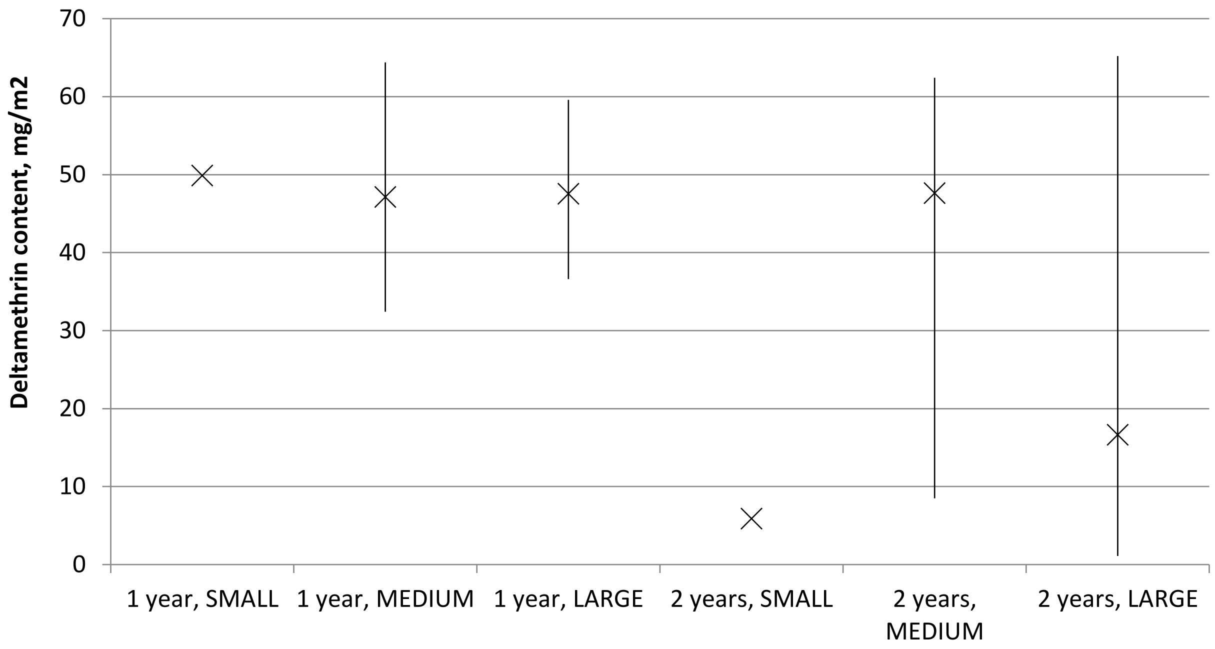
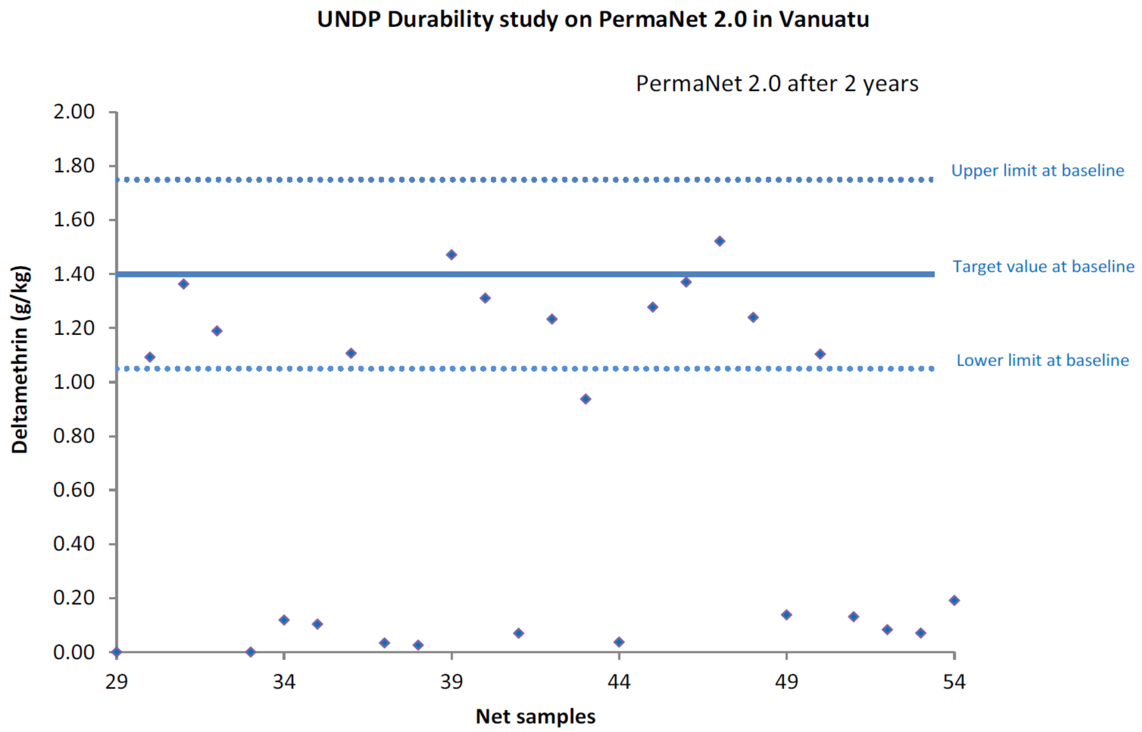


Figure 2: Insecticide content (mean ± standard deviation) for LLINs distributed 1- and 2-years prior, and retention relative to target dose or previous year.

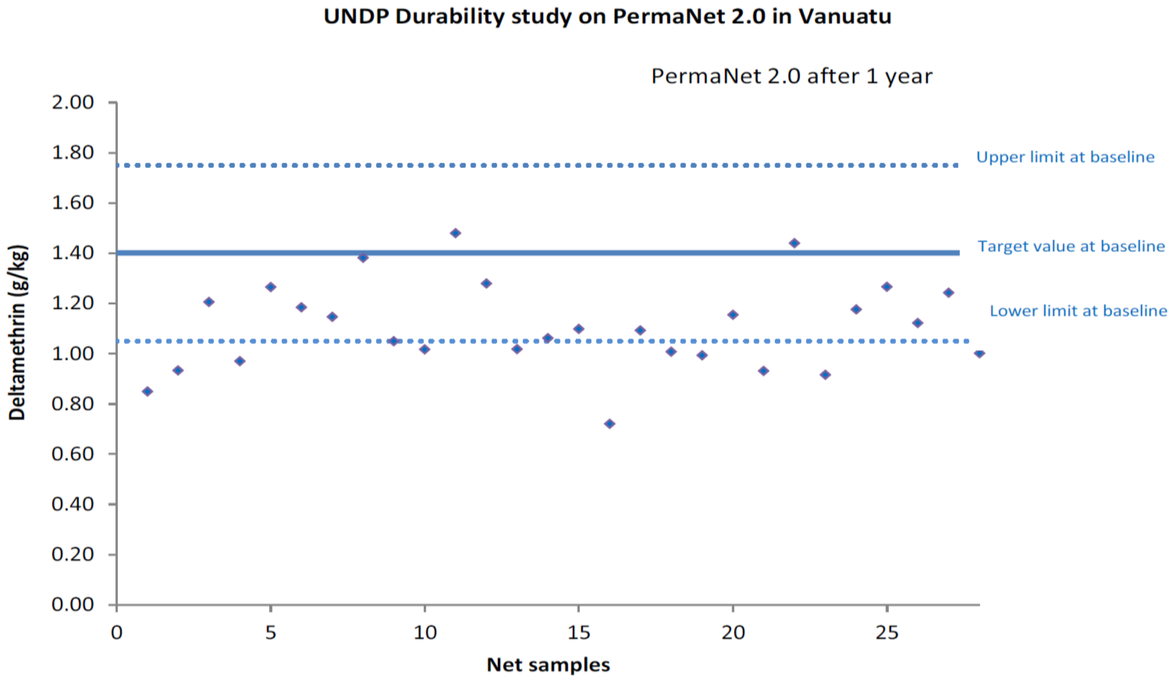
Time since distribution and size	New	1 year				2 years				
	Target (mg/m2)	Measured content (mg/m2)			Retention (target)	Measured content (mg/m2)			Retention (target)	Retention (1 year)
	mg/m2	n	Mean	SD	%	n	Mean	SD	%	%
Small	55	1	49.9	na	91%	1	5.9	na	11%	12%
Medium	55	15	47.2	7.8	86%	11	47.6	14.4	87%	101%
Large	55	12	47.6	7.5	87%	12	16.6	24.5	30%	35%

Figure 3: Showing experimental results illustrated in graph hereunder



(Olivia Pigeon et al, 2018)

Figure 4: Showing experimental results illustrated in graph hereunder



(Olivia Pigeon et al, 2018)

ANNEX 7. SUMMARY OF 2020 LLIN NATIONWIDE ACCESS AND USAGE (COVERAGE) SURVEY

The study's findings highlight a number of successes of the Vanuatu National Malaria and Other Vector Borne Diseases Control Program whilst also bringing to light areas where more targeted action may enhance the program's future achievements. Key findings and recommendations from the study have been summarised below:

1. Nationally, 92.07% of households have at least one LLIN. This figure varies across provinces with the highest reported presence in Torba (99.13%) and the lowest in Sanma (85.65%). Just 7.88% of households did not have LLINs.
2. Common reasons for not having LLINs for sleeping under were being away during the distribution or not having received them, and bed nets being damaged, broken or throw away. Of particular concern, those residing in foci villages were almost twice as likely to report distributions not occurring in their community in the previous three years than those in non-foci communities. Rectifying inequitable access and aligning future distribution cycles with population need and vulnerability to malaria is integral to enhancing the success of the program.
3. 76.21% of households had a sufficient number of LLINs (defined as one LLIN per two household members) Households had an average of 2.83 LLINs. Rates of sufficient LLINs per household and household averages highlight positive results for Malampa, Penama and Torba provinces. Findings demonstrate the need for a great focus on LLIN distribution in Shefa and Sanma, particularly in health zones SAN01, SAN09, SHE02 and SHE04.
4. On the night preceding the survey, 68.41% of household members slept under an LLIN. Those in Shefa had lowest rates of utilisation, with just 54.11% of household members sleeping under bed nets the previous night. Utilisation was 66.93% in Sanma, 71.25% in Penama and 74.88% in Malampa. The highest rate of utilisation was identified in Torba province, where 88.74% of household members slept under bed nets the night before the study.
5. Demographically, children under five had the lowest reported rate of sleeping under an LLIN the previous night. This was statistically significant, with just 64.76% of children under five utilising LLINs during the preceding evening compared with 67.46% of those aged 5-14 years and 69.56% of those 15+. Greater community dialogue is needed to understand the factors leading to lower LLIN utilisation by children and build effective strategies for reducing this disparity.
6. There was also a significant gendered difference in LLIN utilisation. Women were less likely to have slept under a bed net the preceding evening than men in every province. Of particular concern, girls under the age of five were the demographic least likely to have slept under an LLIN the previous evening. There was a statistically significant different in LLINs usage by

gender in the under-five age bracket, with just 56.81% of girls under five having slept under an LLIN in comparison to 73.43% boys. Further, just 60% of pregnant women slept under an LLIN during the previous evening. This mean pregnant women were significantly less likely to have slept under an LLIN than men, children and other women of reproductive age. A greater understanding of these gendered trends is needed to inform more targeted programmatic responses to increasing LLIN utilisation amongst women and girls.

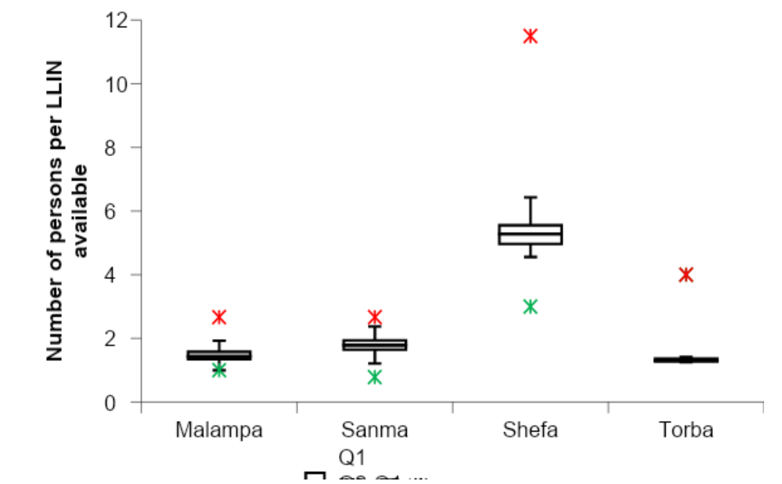
7. Diverse practices in the cleaning and care of LLINs were recorded. Such variability is indicative of the need for greater standardisation in LLIN care instructions to accompany the distribution of nets and be conveyed to communities through broader public health messaging.
8. Old or damaged LLINs are commonly repurposed in Vanuatu with between 31.78% and 40.68% of households never formally disposing of bed nets. Common alternate uses of LLINs include their use in supporting walls, roofing and windows of houses; restricting and restrain animals; and in fencing and covering of gardens.
9. However, more than half of households (58.07%) incorrectly dispose of LLINs (defined as techniques other than burying away from waterways). Of environmental concern, common disposal techniques included burning LLINs and throwing them into the bush, oceans or waterways. Based on frequency data provided, annually it is projected that each household buries 0.02 LLIN, burns 0.27, throws 0.13 LLIN into the bush and 0.01 into the ocean or waterways. This equates to 13138.2 LLINs burned, 6325.8 LLINs thrown into the bush, 973.2 LLINs buried and 486.6 LLINs thrown into the ocean or waterways annually across the malaria endemic provinces of Vanuatu. Improved communication, repurposing and collection practices are recommended to address this waste stream and its subsequent environmental ramifications.
10. Of promise, community awareness of malaria as a serious health concern remains high. Almost one fifth of all respondents (19.01%) identified that household members had had malaria in the previous year. 62.95% of respondents considering malaria to be a serious to extremely serious concern. Further, whilst pluralistic health seeking behaviour was common, 89.84% of respondents identified that they would seek help from a health facility if household members had a fever.
11. Finally, and a testament to the program, 93.1% of respondents considered LLINs to be effective or extremely effective in preventing malaria. Other commonly identified techniques for malaria prevention included cleaning up around the house, yard and garden; and burning coils or fires. Reinforcing health messaging of this nature is important to sustaining health promoting behaviour. Building a greater understanding of the processes which have fed into such widespread uptake of malaria messaging may also hold important lessons for future malaria-specific and broader health promotion messaging and activities in Vanuatu.

ANNEX 8. SUMMARY OF LLIN SURVEY FOR 2018

Available data for 2018

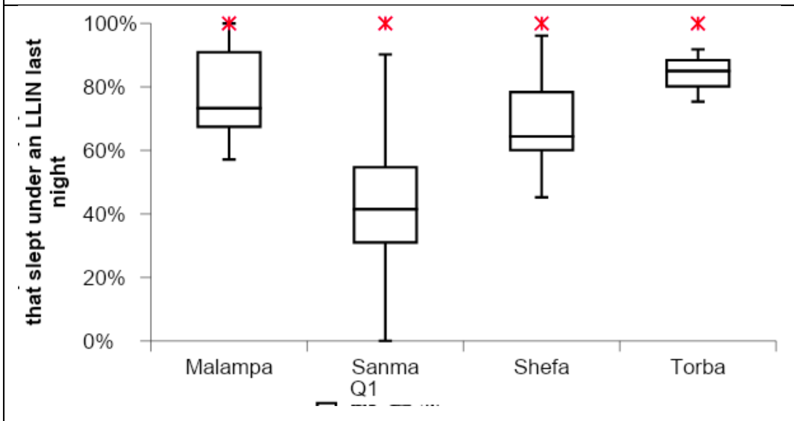
An LLIN survey was carried out in 2018 in Torba, Sanma, Malampa and Shefa provinces (that latter of which was partially completed). This focused on assessing availability, condition and usage of available LLINs. In total, data were provided for 2,331 nets across 53 villages comprising a population of 5,030 persons in 1,132 households. Data were provided aggregated to village level which somewhat restricted analyses. Nevertheless, a brief summary of the data and a preliminary interpretation is provided below.

Summary of data



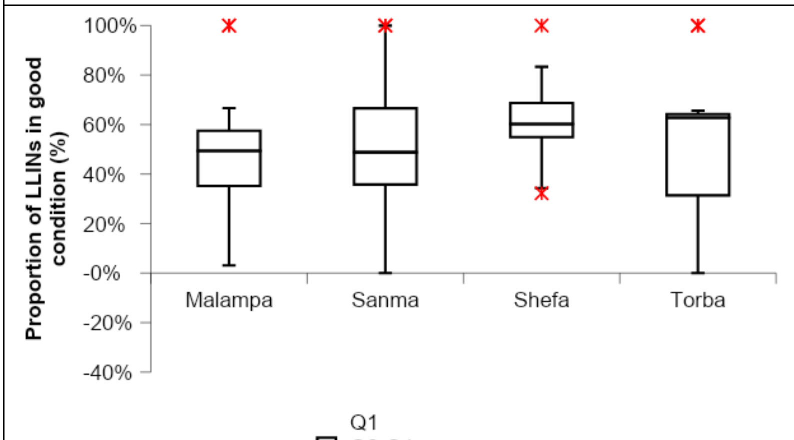
Coverage (proxy):

- The median number of persons per LLIN exceeded 1.25 in all provinces, indicating that too few nets were available for the overall target coverage rate.
- The median number of persons per net was particularly high in Shefa province (5.28), indicating particularly poor availability of LLINs.



Usage (proxy):

- The median proportion of the population that reportedly slept under an LLIN the previous night was low in Sanma (41%) but higher in other provinces (64-85%).
- This indicated that usage may not be a major driver of poor coverage across all provinces.



Condition:

- The proportion of nets in good condition varied widely between villages, with a median of 49% to 64% across the four provinces.
- Data were not provided on the age of nets, noting that this varied between villages of a province.
- There is likely to be a skew towards better condition

	nets as this was a retrospective study that looked at all nets still available in households rather than all those initially distributed.

Boxes show the 75% percentile (upper line), median (mid-line), and 25% percentile (lower line). Whiskers show the maximum (upper) and minimum (lower). Stars show upper and lower outliers.

Note that the survey sought to collect data on the number of times nets were washed in the last year. A high level of inaccuracy is expected due to recall bias, and data were not well reported for this field. Data on the number of family members with malaria the previous year was also collected, but there is not expected to be any correlation with LLIN indicators at village level.

Recommendations

1. Data should be provided at the individual and household level (rather than by village), to ascertain whether standard indicators can be calculated.
2. A comprehensive assessment of LLIN coverage (considering access and usage) should be conducted in Vanuatu. The approach taken must enable calculation of standard indicators.
3. In the interim, LLIN survey forms should be revised to ensure that data collected during the upcoming LLIN distribution round in Q2 2019 are of maximum use.

References

1. World Health Organization. 2019. Guidelines for malaria vector control. Geneva, Switzerland. https://apps.who.int/iris/bitstream/handle/10665/310862/9789241550499-eng.pdf
2. World Health Organization. 2017. Achieving and maintaining universal coverage with long-lasting insecticidal nets for malaria control. Geneva, Switzerland. https://apps.who.int/iris/bitstream/handle/10665/259478/WHO-HTM-GMP-2017.20-eng

ANNEX 9. MOSQUITO COLLECTION METHODS

Standard collection methods will be used where possible to collect *Anopheles* and *Aedes* mosquitoes, or alternative methods may be selected based on best practice established in Vanuatu or in other areas with similar vectors (e.g. Solomon Islands *for Anopheles farauti*).

Anopheles spp.

For *Anopheles* vectors, mosquitoes will be collected using either larval sampling or human landing catches conducted at sentinel sites or purposely selected sites (as above). At each site, ideally four (4) villages or communities will be identified for sampling.

For immature *Anopheles*, larvae will be collected from a variety of habitats at those locations using standard dippers. Collections will initially be planned for a four-day period to ensure sufficient numbers are collected. If high numbers of larvae are collected on the first or second day and sufficient resources are available, additional samples will be taken at more locations and specimens will be held separately (not pooled) to maintain geographically-distinct collections for separate tests.

Collected larvae will be examined visually with the naked eye to confirm that they are *Anopheles*. They will then be transferred to larval holding containers and will be provided sufficient larval food until they pupate. Pupae will be transferred to cages to await emergence as adults. Emergent adults will be examined phenotypically to determine species. Where a large number are collected, a subsample only will be examined (e.g. 10% or a minimum of 30). If genotypic confirmation of species is needed (i.e. to differentiate between species of the An. farauti complex), this will be done through sending samples to an external laboratory.

For adult *Anopheles*, human landing catches will be conducted from 1800 hours (6.00pm) until 0600 hours (6.00am). Collections will be done at a minimum of 3 houses at each sampling location, for 4 nights in a row at each house. The houses will be selected to be a minimum of 50 meters from each other so as to not influence respective collections. Each night human landing catches will be made inside and outside the houses, concurrently. This is essential to ensure that comparative indoor and outdoor biting rates are notes.

Twelve (12) collectors will be used as bait for human landing catches at each of the communities. These 12 collectors will be engaged in two different six hour shifts: 6 collectors per shift from 1800 hours to 2400 hours (3 indoors and 3 outdoors, at each of 3 houses), and 6 collectors per shift from 2400 hours to 0600 hours (3 indoors and 3 outdoors, at each of 3 houses). Every two hours, the collectors will be rotated between locations (indoors/outdoors) at a specific house.

Mosquitoes will be collected using mouth aspirators when they try to land on collectors, and the number will be counted and recorded. Collected mosquitoes will be grouped for the hour of collection and transferred to holding cups (maximum 20-25 adult mosquitoes per cup) with the time and place of collection clearly marked on the cups.

Collected or raised adult *Anopheles* will be held in cups with the opening covered with netted/nylon fabric with access provided to a sugar/water solution. Mosquitoes will be held until use for bioassays or for other purposes such as in the insectary. Adult specimens will be stored appropriately either pooled or individually in labelled tubes, depending on intended use.

Aedes spp.

For *Aedes* vectors, adult mosquitoes to test for Adult Vector Composition i.e. occurrence and density, will be collected using Biogents (BG) adult traps. VBDCP will work with communities around collection areas to identify best sites for collection based on previous *Wolbachia* releases, or reports of high number of *Aedes* vectors. In the event of an arbovirus outbreak (e.g. dengue), collections may be focussed on areas with high number of confirmed reported dengue cases. BG traps are to be set-up based on pre-approval of the householders. Full community engagement and education materials developed by the World Mosquito Program are available and can be adapted as needed.

Specimens for *Aedes* adult vector insecticide resistance will be collected through setting of ovitraps to collect mosquito eggs on ovistrips. The eggs on ovistrips will be hatched in the insectary lab and larvae will be feed and looked after. For this, they will be maintained at sufficiently low immature density in larval rearing trays and provided with larval food. When reaching pupae stage, they will be put into cages to avoid flying around when reaching adult stage 24 to 48 hours later. Then 2-5 day old female adult mosquitoes will be used to perform insecticide resistance tests.

Immature vector aquatic habitats for *Aedes* will be assessed by conducting larval surveys of potential breeding containers within households of selected boundaries. This will involve full sampling of immature from small- and medium-sized containers, and targeted sampling of larger containers with a sweep net or another method as identified.

ANNEX 10. BRIEF OVERVIEW OF PROTOCOLS

Annex 10.1 monitoring the insecticide resistance status of *Anopheles farauti*

Resistance testing using selected insecticides against local *Anopheles* malaria vector (*An. farauti*) in specific health zones will be used to identify areas where insecticide resistance is confirmed or possible, or to confirm where there is susceptibility. This information will be used to identify the most appropriate insecticidal vector control tools and products, and will inform the development of a national insecticide resistance monitoring and management plan. IR testing has been done in the past but further IR testing is required at other sites in Vanuatu, both with pyrethroids and with other insecticide classes for a clearer understanding of the resistance profile of *An. farauti* across Vanuatu.

Purpose	Appropriate monitoring of vector susceptibility to insecticides is an integral component of planning and implementing malaria vector control to allow informed response such as with IRS in focal areas of ongoing transmission or in the event of upsurges.
Survey type	Ongoing annual monitoring will be conducted in selected sites, mainly those targeted for IRS.
Method	Insecticide resistance tests will be conducted in accordance with the WHO *Test procedures for insecticide resistance monitoring in malaria vector mosquitoes 2nd edition* (2016). IR testing with 2- 5-day old non-blood fed females will be done where possible on one (1) insecticide from each of four insecticide classes (Pyrethroid – Deltamethrin 0.05%; Organophosphate – Pirimiphos-methyl 0.25%; Carbamate – Bendiocarb 0.1%; Clothianidine – if test papers are available)
Dates	To be conducted when vector densities are sufficient ie. after the onset of the rainy season and when it is hot, such as from November to April.
Site(s)	One site each in four provinces: • Shefa: Lamen Bay, Epi • Torba: Sola, Banks • Malampa: Lamap Area, Malekula • Sanma: South Santo or Big Bay Bush, Santo
Sample population	Mosquito collections will be primarily aimed to derive sufficient *Anopheles* of larval stage. If collection of sufficient larvae is not possible, or that transport of collected larvae back to the Port Vila insectary is not possible, and alternative approach is also outlined below.
Sample unit	All *Anopheles* adults caught overnight (150 adult per test) from all selected six (6) households in selected four communities/villages within each health zones from each

	of the four (4) provinces will be tested for susceptibility to selected insecticides.
Mosquito collections	• Primary approach – larval *Anopheles* collections as outlined above • Alternative approach – adult *Anopheles* collections as outlined above
Simple random sampling	When enough mosquitoes are collected for IR testing (this requires at least 150 adult females per insecticide tested), these will be transported back to the Port Vila insectary facility at George Pompidou to await testing. Alternatively, where efficient transport back to Port Vila is not possible then testing will be done in accessible health facilities within the community.
Indicators to be captured	1. Resistance Frequency - Proportion of adult female vectors alive after exposure to insecticides 2. Resistance Status - Classification of adult female vector populations as confirmed resistance, possibly resistant or susceptible. If resistance is detected, 3. Resistance Intensity - Classification of adult female vector populations as having high, moderate or low resistance.
Intended use of information	Resistance profiles for the local *Anopheles* malaria vector (*An. farauti*) to four classes of insecticides will identify areas where resistance is confirmed or possible, or where there is susceptibility. This information will be used to identify the most appropriate insecticidal vector control tools, and will inform the development of a national insecticide resistance monitoring and management plan.

Annex 10.2 monitoring the frequency of *Wolbachia* infections in *Aedes aegypti* in Port Vila

This first ever biological means of vector control in Vanuatu was introduced in 2018. This involved the mass-release of *Wolbachia*-infected adult *Aedes aegypti* from 2 July 2018 to 28 March 2019, and releases in twelve (12) reporting areas of Port Vila. More than 19,000 *Wolbachia*-infected adult mosquitoes were released over an eight (8) month period. It is important that monitoring is conducted following these releases to evaluate the frequency of *Wolbachia* infections in wild mosquitoes and to identify any relationships with dengue or other arbovirus transmission to determine the impact of the intervention. This will be used to inform whether to expand implementation to other localities that have experienced transmission, such as Luganville on Santo Island (Sanma province) or even Tanna Island (Tafea province).

Purpose	To monitor the prevalence of *Wolbachia* bacteria within local mosquito population and to report on the impact.
Survey type	Cross sectional monitoring for "*Wolbachia*" bacterial infections in *Aedes aegypti* mosquitoes in Port Vila
Method	Quarterly cross-sectional monitoring
Dates	Three weeks of trapping in July and November
Site(s)	10 Reporting areas [MLM, BLK, BLD, OHL, FRB, TAB, PAG, NLI, ERK & JOI]
Sample population	BG #: 86 traps
Sample unit	All Aedes aegypti mosquitoes collected across 86 BG sentinel traps deployment at selected sites across 10 reporting areas Port Vila region for 1 week every 4 months will be tested for presence of *Wolbachia* bacteria
Mosquito collections	Primary method – Adult *Aedes* mosquito collections using BG traps, as outlined above Supplementary data – dengue case information will be captured through the routine surveillance system and active screening during outbreaks
Simple random sampling	• All *Aedes* caught in any of the 86 traps with a network of 4 traps per sqkm will be screened by *Wolbachia* bacteria.
Indicators to be captured	1. Frequency of wild *Ae. aegypti* with *Wolbachia* caught on BG traps 2. Number of confirmed dengue cases locally transmitted

Intended use of information	The intermittent measurement of *Ae. aegypti* populations, coupled with the measurement of *Wolbachia* frequency and the incidence of dengue and related arboviruses, will enable Ministry and WMP to measure the long-term success of the project. The monitoring of these traps will determine; - Whether released *Wolbachia*-carrying mosquitoes survive, - If *Wolbachia* is establishing itself in the wild population, - When *Wolbachia* is established (>80% frequency), and - Whether *Wolbachia* persists long-term in the release areas. - If it does, does it has impact on decrease or no reported local dengue cases

Annex 10.3 Targeted evaluation of LLIN distribution outcomes

Purpose	To assess LLIN coverage (access and use) rates at least 6 months after distribution.
Survey type	Spot checks
Dates	Ongoing
Site(s)	5 provinces were LLINs distributed in 2019 (Torba, Sanma, Penama, Malampa, Shefa)
Sample population	All Households within all villages by health zones covered in 2019 LLINs distribution
Sample unit	Household selected in the sample
Sample frame	List of all Health Zones covered in 2019 LLINs Distribution; List of all Villages within individual health zones covered; list of all households within all villages covered per health zones including households missed during distribution
Sample method	Post-distribution list of Households per villages per health zones have been registered and recorded, 30% of villages within each health zones will be selected taking into consideration the logistic, accessibility of the area and visibility of conducting the survey. Out of that 30% villages being selected every household's number per villages be recorded and individual households will have an equal chance to be chosen as part of the sample
Simple random sampling	• From the list, there will be 30% of household selected per the total number of household within each village. • Using random numbers table depending on household number from the list per villages, all will be numbered • From the random table commencing from row 4 and column 7, picking the last two (2) digits. This procedure will be applied until all the 30% household participants were selected.
Indicators to be captured	a) number of LLIN distributed versus targeted population, at household level
Intended use of information	The standard LLIN indicators captured will be used by VBDCP to determine how and where to improve LLIN distribution strategies, including community advocacy on the importance of correctly and consistently using LLINs.

Annex 10.4 Nationwide assessment of LLIN coverage rates

A nationwide assessment of LLINs coverage will be conducted for the whole of Vanuatu, to ideally include all provinces and all health zones covered. These would have received replacement between 2017 and 2019. This study will assess LLIN coverage, including access and usage. It will also include sub-sampling of LLINs to test for field durability components (fabric/physical integrity, Bioefficacy), as outlined in (3) below.

Purpose	To assess LLIN coverage (access and use) rates up to 3 years after distribution
Survey type	Retrospective cross-sectional survey
Dates	April to June 2020
Site(s)	All six (6) provinces, targeting those with highest burden (Sanma, Malampa) but also generating estimates for other provinces
Sample population	All Households within all villages by health zones covered in 2019 LLINs distribution.
Sample unit	Household selected in the sample.
Sample method	List of all Health Zones covered in 2017-2019 LLINs distribution campaigns; List of all Villages within individual health zones covered; list of all households within all villages covered per health zones including households missed during distribution. Stratified sample will be conducted to ensure higher precision in areas with higher malaria burden. Method is yet to be determined, based on feedback from expert consultant. It may include the following: After all list of Households per villages per health zones have been registered and recorded, 20% of villages within each health zones will be selected taking into consideration the logistic, accessibility of the area and visibility of conducting the survey. Out of that 20% villages being selected every household's number per villages be recorded and individual households will have an equal chance to be chosen as part of the sample using Simple Random Sampling Method.
Simple random sampling	• From the list of villages, there will be 20% of household selected per the total number of household within each village. • Using random numbers table depending on household number from the list per villages, all will be numbered • From the random table commencing from row 2 and column 6, picking the last two (2) digits. This

	procedure will be applied until all the 30% household participants were selected.
Indicators to be captured	Standard Indicator captured - Coverage rate (Access & Usage) a) proportion of households with at least one LLIN; b) proportion of population with access to a LLIN within their household; c) Proportion of population reporting having slept last night under a LLIN (by age (<5 years; 5–14 years; 15+ years), gender and access to LLIN).
Intended use of information	Coverage Level (%) will show the % of people having access to LLINs, % of people using LLINs and be linked to # of cases shown in that specific village by HZ. It will direct the VBDCP as to whether Insecticides resistance testing needs to be done to test for the susceptibility of the Insecticides; Planning of insecticides to be used, if there's need for community advocacy on the importance of using LLIN. Will conclude that LLINs has been an effective vector control intervention, and/or what are the recommendations needing to be consider for future distribution.

Annex 10.5 Targeted assessment of LLIN field durability

According to WHO (WHO, Achieving and maintaining universal coverage with long-lasting insecticidal nets for malaria control , 2017), all malaria programmes that have undertaken medium- to large-scale LLIN distributions should conduct LLIN durability monitoring in line with available guidance. Field durability monitoring includes assessment of survivorship/attrition, fabric/physical integrity and insecticidal content/bio-efficacy.

Where there is evidence that LLINs are not being adequately cared for or used, programmes should design and implement behaviour change communication activities aimed at improving these behaviours.

Survivorship/attrition

Purpose	Monitor the durability of long-lasting insecticidal nets
Survey type	Retrospective targeted survey in accordance with WHO guidelines
Dates	TBC
Site(s)	All health zones within the 6 provinces being covered with LLINs distribution in 2017 i.e. 3 years ago [including from Torba to Tafea]
Sample population	All Households within all villages by health zones covered in 2019 LLINs distribution for <1 Yr. old usage, 2018 for <2 Yr. old usage and 2017 for <3 Yr. old usage.
Sample unit	Household selected in the sample.
Sample frame	List of all Health Zones covered in 2017-2019 LLINs distributions from the six (6) provinces; List of all Villages within individual health zones covered; list of all households within all villages covered per health zones including households missed during distribution
Sample method	• Two (2) health zones per six (6) provinces will be randomly chosen • Out of the two (2) health zones chosen, 5 Villages will be randomly selected taking into consideration the logistic, accessibility of the area and visibility of conducting the survey. • From the five (5) chosen villages, list of all Households per villages will be registered and recorded, 20% of households per village within each health zones will have an equal chance to be chosen as part of the sample using Simple Random Sampling Method.
Simple random sampling	• Using random numbers table depending on household number from the list per villages, all will be numbered.

	• From the random table commencing from row 2 and column 6, picking the first two (2) digits. This procedure will be applied until all the 20% household participants were selected.
Indicators to be captured	Survivorship: Numerator: Total number of each LN product present in surveyed households (and available for sleeping under) x 100 Denominator: Total number of each LN product distributed to surveyed households Attrition rate-1 for nets that have been destroyed or disposed of: Numerator: Total number of each LN product reported as lost due to wear and tear (poor condition) in surveyed households x 100 Denominator: Total number of each LN product distributed to surveyed households Attrition rate-2 for nets not available for sleeping under: Numerator: Total number of each LN product reported as lost for reasons other than poor fabric integrity (given away, stolen, sold or used in another location) in surveyed households x 100 Denominator: Total number of each LN product distributed to surveyed households Attrition rate-3 for nets used for other purposes: Numerator: Total number of each LN product reported as being used for another purpose in surveyed households x 100 Denominator: Total number of each LN product distributed to surveyed households NB: For each LN product, the survivorship rate plus attrition rate-1, attrition rate-2 and attrition rate-3 should add up to 100%. Physical / Fabric Integrity: Proportion of LN with any holes (with 95% confidence interval) Numerator: Total number of each LN product with at least one hole of size 1–4 Denominator: Total number of each LN product found and assessed in surveyed households
Intended use of information	Shows if 3 years the expected effective life span of LLINs is being distributed, if community advocacy on usage of

	LLINs needs to be improved through revised health education and communication.

Insecticidal activity/bio-efficacy and chemical content

Purpose	The insecticidal content of the LLINs will be confirmed with regards to the mortality rate exhibited by susceptible *Anopheles* mosquitoes during the cone bioassay tests as well as the level of insecticidal content from laboratory analysis.
Survey type	Retrospective Cross-Sectional Study as per WHO guidelines, monitoring the durability of long-lasting insecticidal mosquito nets
Method	Procedures of the Insecticidal Activity using WHO cone test: [Refer to (WHO, Guidelines for monitoring the durability of long-lasting insecticidal mosquito nets under operational conditions, 2011)
Dates	TBC
Site(s)	With priority, assessments will be done on LLINs collected from two provinces which were not included in the 2019 insecticidal study. These are SANMA and SHEFA provinces in malaria health zones with malaria foci.
Sample population	See Flowchart of a Retrospective Cross Sectional Study Design (WHO 2011)
Sample unit	LLINs within all households of the selected health zones with malaria foci.
Sample frame	List of all HZ reporting high number of cases. List of all Villages within individual health zones covered in 2019, 2018 and/or 2017 (1 Yr., 2Yr., 3Yr.) LLIN distribution and generation of a master list for distribution within that specific HZ.
Sample method	3 HZ from the list of HZ with high number of reported cases will be randomly selected using systematic sampling method taking into consideration the coverage age of LLINs. From the 3 selected HZ, 5 Villages will be randomly selected taking into consideration the logistic, accessibility of the area and visibility of conducting the survey. From the 5 villages, Households will be selected using Systematic random sampling (every 4th Households). It will happen for all Yr.1 to Yr.3 LLINs Sample collection

Simple random sampling	• From the list of every 4th household, 30 household will be selected for LLINs samples to be collected using random number table. • From the random table commencing from row 3 and column 7, picking the last two (2) digits. This procedure will be applied until all the 30 household participants were selected. • It will happen for all Yr.1 to Yr.3 LLINs Sample collection
Indicators to be captured	• Rates of knockdown at 60 minutes and mortality at 24 minutes (for pyrethroid-only LLINs) for samples from each LLIN, with an average generated per net • Proportion of LLINs tested for bioassays for which there is confirmed sufficient knockdown and/or mortality rates of susceptible Anopheles mosquitoes.
Intended use of information	Programs and agencies must choose products to procure and determine whether products are likely to perform better over time than others in their setting. Knowledge about the durability of LLINs after distribution is needed to estimate the necessary rate of replacement in continuous distribution systems and when necessary to plan for disposal or recycling of old nets.

Annex 10.6 Knowledge, Attitude and Practices Survey

An assessment of Knowledge, attitude and practices (KAP) will be conducted within villages in health zones that continuously report high numbers of cases of malaria through an observational, cross-sectional study to answer all three respective parameters. Information will be collected by interviewers through a structured, standardized questionnaire that may include both quantitative and qualitative data which will be directed to randomly select individual households to assess the level of knowledge transfer on malaria, its preventative measures and treatment techniques.

Purpose	- To assess the level of knowledge, attitudes, and practices regarding malaria, its preventative measures, and treatment techniques amongst residents of the population targeted for the study. - To evaluate the impact of Malaria campaign being done through IEC materials given and/or during SV, LLINs distributions and other sources of information that may have promote malaria.
Survey type	Spot checks
Dates	TBC
Site(s)	In all 5 provinces (Torba, Sanma, Penama, Malampa, Shefa) targeting specific health zones in provinces that constantly reporting high number of malaria cases
Sample population	All Households within all villages by health zones that continuously reporting high number of malaria cases.
Sample unit	Household selected in the sample
Sample frame	List of all Villages within individual health zones covered; list of all households within all villages covered per health zones
Sample method	Within every EA (enumeration area), selection of participation will start with the first household at the corner of the EA. Interviewers will then skip households moving in an anti-clockwise manner to cover every street using a pre-determining sampling interval base on the total number of HHs in the EA (e.g., # HHs in EA divided by 7). From the household chosen, a representative will be asked to answer the questionnaire.
Simple random sampling	• From the list, there will be 30% of household selected per the total number of household within each village. • Using random numbers table depending on household number from the list per villages, all will be numbered

	• From the random table commencing from row 3 and column 2, picking the last two (2) digits. This procedure will be applied until all the 30% household participants were selected.
Indicators to be captured	Level of KAP will be summarized by; - Knowledge gaps, cultural beliefs and behavioural patterns that may identify needs, problems and barriers to help plan and implement interventions - Deepen the understanding of commonly known information, attitudes and factors that influence behaviour regarding malaria intervention & treatment technique - Generating baselines levels and measure changes that result from interventions. - Assess and identify communication processes and sources important for program implementation and effectiveness. % of total household who lacks information at all on malaria prevention and treatment techniques. % of total household/ population who has some information about malaria prevention and treatment techniques. Medium of information will also be assessed accordingly.
Intended use of information	Aggregated results will be reported to the key stakeholders such as Ministry of Health, the Malaria Steering Committee, other partners, and donors such as WHO, UNDP/Global Fund, DFAT which will presented at relevant meetings to encourage discussion on way forward and inform program planning in the future.