



Queensland  
**Chikungunya**  
management plan  
2014 – 2019

This plan shall be titled and known as the:  
**Queensland chikungunya management plan 2014–2019**

## Authorisation

The *Queensland chikungunya management plan 2014–2019* is issued under the authority of the Chief Health Officer and is a sub-plan to the Queensland joint strategic framework for mosquito management.

To meet the challenge of preventing or minimising chikungunya outbreaks in Queensland, Queensland Health in collaboration with local government and other key stakeholders has developed the *Queensland chikungunya management plan 2014–2019*. This plan serves to guide and coordinate efforts to manage chikungunya in Queensland.

## Approved by:

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**Date:** 3 March 2014

## Authority and planning responsibility

The development, implementation and revision of this plan is the responsibility of the Senior Director, Communicable Diseases Unit.

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This plan will be updated and available electronically at [www.health.qld.gov.au](http://www.health.qld.gov.au)

## Acknowledgements

The *Queensland chikungunya management plan 2014–2019* (CMP) was developed in consultation with the following agencies:

- Queensland Health
- Local government representatives

The CMP is based on the international best practice model as outlined by the WHO (World Health Organisation) regional office for South East Asia. This CMP would not be possible without the contribution from those stakeholders involved in the development and subsequent reviews of the plan.

### Queensland chikungunya management plan 2014–2019

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<b>Abbreviations and glossary</b>	<b>4</b>
<b>Executive summary</b>	<b>5</b>
<b>1. Introduction</b>	<b>6</b>
1.1 Aim .....	6
1.2 Purpose.....	6
1.3 Objective.....	6
1.4 Scope.....	6
1.5 Legislation.....	7
<b>2. Background</b>	<b>8</b>
2.1 What is chikungunya .....	8
2.2 Epidemiology .....	8
2.3 Chikungunya mosquito vectors .....	9
2.4 Outbreak risk.....	10
2.5 Stakeholders and their roles .....	12
<b>3. Mosquito surveillance</b>	<b>14</b>
3.1 Selection of surveillance locations .....	14
3.2 Adult mosquito surveillance.....	16
3.3 Egg surveillance (ovitrap) .....	16
3.4 Larval and pupal survey .....	16
<b>4. Mosquito control</b>	<b>18</b>
4.1 Source reduction .....	20
4.2 Chemical application .....	20
4.3 Possible future directions in biological control.....	22
4.4 Eradication programs for chikungunya vector species .....	23
<b>5. Disease surveillance, investigation and response</b>	<b>24</b>
5.1 Routine disease surveillance .....	24
5.2 Case investigation and response .....	26
<b>6. Managing chikungunya outbreaks</b>	<b>28</b>
6.1 Communications.....	28
6.2 Role of local government.....	28
6.3 Staffing requirements .....	28
<b>7. Public awareness and community engagement</b>	<b>29</b>
<b>Bibliography</b>	<b>30</b>
<b>Appendix 1</b>	<b>31</b>
Summary of the intrinsic and extrinsic factors that may influence the vectorial capacity of Australian mosquitoes for CHIKV.....	31
<b>Appendix 2</b>	
Container inhabiting mosquito surveillance methods.....	32
<b>Appendix 3</b>	
Diagnostic chikungunya virus tests.....	35
<b>Appendix 4</b>	
Chikungunya case report form.....	38

# Abbreviations and glossary

<b><i>Aedes aegypti</i></b>	The primary mosquito vector for dengue viruses in Queensland and potential chikungunya vector
<b><i>Aedes albopictus</i></b>	Mosquito vector of chikungunya and dengue viruses, detected and established throughout the Torres Strait (Qld) since 2005
<b>Authorised person</b>	A person appointed as an authorised person under section 377 of the <i>Public Health Act 2005</i>
<b>BFV</b>	Barmah Forest virus
<b>BG</b>	Biogents BG-Sentinel trap
<b>CDU</b>	Communicable Diseases Unit
<b>CHIKV</b>	Chikungunya virus
<b>CMP</b>	Chikungunya management plan
<b>Contact address</b>	Residential address associated with a case
<b>Crepuscular</b>	Refers to dawn and dusk
<b>DA</b>	Australian Government Department of Agriculture
<b>DEET</b>	N,N-dimethyl-m-toluamide, constituent in personal insect repellent
<b>DENV</b>	Dengue virus(es)
<b>Diurnal</b>	Refers to daylight hours
<b>ECSA</b>	East, Central and Southern Africa CHIKV lineage
<b>Endemic</b>	The constant presence of a disease or infectious agent within a given geographic area or population group
<b>EIP</b>	Extrinsic incubation period, the incubation period of the virus in the mosquito
<b>Epidemic</b>	The occurrence in a community or region of cases of an illness or other health related events clearly in excess of what is normally expected
<b>FSS</b>	Forensic and Scientific Services, Department of Health
<b>GAT</b>	Gravid <i>Aedes</i> Trap
<b>GIS</b>	Geographic information system
<b>HHS</b>	Hospital and Health Service
<b>IgM and IgG</b>	Immunoglobulin M and immunoglobulin G; two different classes of antibodies
<b>Imported case</b>	A confirmed chikungunya case with virus acquisition from a known overseas chikungunya endemic or epidemic region
<b>IIP</b>	Intrinsic incubation period, the incubation period of the virus in humans
<b>IMT</b>	Incident management team
<b>IRS</b>	Indoor residual spraying (of insecticide)
<b>LO</b>	Lethal ovitrap
<b>Outbreak</b>	One or more locally acquired cases of chikungunya
<b>PCI</b>	Premise Condition Index
<b>PHU</b>	Public Health Unit
<b>QIMR</b>	QIMR Berghofer Medical Research Institute
<b>Queensland Health</b>	Refers to both Hospital and Health Services and the Department of Health
<b>RNA</b>	Ribonucleic acid
<b>RRV</b>	Ross River virus
<b>RT-PCR</b>	Reverse transcriptase polymerase chain reaction
<b>Serotype</b>	A strain of a micro-organism distinguished from other strains by a serological (i.e. immunological) test
<b>SINV</b>	Sindbis virus
<b>Sylvan</b>	Bushland
<b>Vector</b>	A living carrier capable of transmitting an infectious agent
<b>Viraemia</b>	The presence of virus(es) in the blood
<b>Viral culture</b>	The isolation and growth of virus by propagation in culture medium
<b>WHO</b>	World Health Organization

# Executive summary



Chikungunya has emerged as a significant vector borne disease in many regions across the world. Since 2004, chikungunya virus (CHIKV) has caused large epidemics in many regions including Africa, the Indian subcontinent, South East Asia, the Western Pacific and, most recently, Papua New Guinea (PNG) and the Caribbean. Some of these outbreaks have resulted in significant morbidity. Further outbreaks have also been reported in Europe. These outbreaks have had a severe impact on individuals, communities and public health resources.

Outbreaks of chikungunya tend to be cyclical with seasonal trends occurring mainly in the post monsoon period when vector density is high. In novel locations, outbreaks spread rapidly and have high attack rates, in part due to the absence of immunity in local populations, difficulty in identifying cases in formerly CHIKV free areas, and rapid transmission times.

Chikungunya virus is transmitted by female mosquitoes, primarily of the genus *Aedes*. The principal vectors identified are *Aedes aegypti* and *Ae. albopictus*. These vectors are also responsible for dengue transmission throughout the world. Currently, *Ae. aegypti* is endemic in parts of north Queensland and has been identified in some areas of central and southern Queensland. *Aedes albopictus* is currently (December 2013) established in the islands of Torres Strait and poses a serious risk of extending its range to mainland Australia.

Despite a relatively low testing and notification rate of imported chikungunya in Queensland to date, cases and hence the possibility of local transmission where vectors are present, has increased in recent years. This is due in part to increasing travel between endemic areas in Asia, the Western Pacific and north Queensland.

To address this risk Queensland Health, in collaboration with local government, has developed the *Queensland chikungunya management plan 2014–2019* (CMP). The plan reflects current international best practice in the prevention and management of chikungunya outbreaks and outlines three core strategies: vector surveillance and control, disease surveillance and control and community awareness and engagement.

### 1.1 Aim

The aim of this plan is the rapid identification and control of outbreaks of chikungunya in Queensland by strengthening and sustaining risk based surveillance, prevention and control measures for both imported human cases and the mosquitoes that vector CHIKV.

The Queensland Chikungunya management plan 2014–2019 (CMP) supports this aim by providing direction for disease surveillance, enhancing and coordinating mosquito surveillance, prevention and control measures and educating the community, industry and relevant professional groups.

### 1.2 Purpose

The purpose of the CMP is to provide strategic guidance for best practice public health management of chikungunya in Queensland.

### 1.3 Objective

The objective of the CMP is the prevention and control of CHIKV transmission in Queensland through measures that support:

- timely detection and reporting of all suspected chikungunya cases
- implementation of sustainable statewide surveillance for the detection of CHIKV vectors in Queensland
- effective and timely control methodologies to prevent local transmission of chikungunya
- adoption of protective behaviours by the public.

### 1.4 Scope

The CMP highlights three central components of chikungunya management:

- mosquito surveillance and control
- disease surveillance
- public awareness and community engagement.

The CMP provides strategic direction for the prevention and control of chikungunya in Queensland. The plan provides guidance to, but does not substitute, local operational response plans.

The CMP calls for continued and improved collaboration in chikungunya management between Queensland Health, other government agencies and non-government stakeholders.

The CMP does not include advice on the clinical management of people with chikungunya.



## 1.5 Legislation

The primary elements of legislation relevant to disease surveillance and mosquito management in Queensland are:

- *Public Health Act 2005*
- Public Health Regulation 2005
- *Pest Management Act 2001*
- Pest Management Regulation 2003.

Chikungunya is a notifiable condition under the *Public Health Act 2005*. Under Schedule 1 of the Public Health Regulation 2005, directors of pathology services must notify if a pathology examination of a specimen indicates that a person has a pathology diagnosed notifiable condition.

Mosquitoes that transmit CHIKV to humans are classified as pests that pose a public health risk.

There are three legislative avenues available for controlling public health risks as defined in Chapter 2 Part 1 of the *Public Health Act 2005*. These are an Approved inspection program, an Authorised prevention and control program, and public health orders.

The Director-General of Queensland Health or the chief executive officer of a local government can approve an Approved inspection program under which authorised persons may enter places to monitor compliance with a regulation referring to public health risks. An Authorised prevention and control program can be approved by the chief executive of the local Hospital and Health Service (HHS) or the Director-General of Queensland Department of Health if there is, or is likely to be, an outbreak of a disease capable of transmission to humans by a designated pest, or a plague or infestation of a designated pest including mosquitoes.

The provisions for Approved inspection programs are contained in Chapter 9. Part 4 of the *Public Health Act 2005* and those pertaining to Authorised prevention and control programs are contained in Chapter 2, Part 4 of the Act.

Under the Public Health Regulation 2005 local governments can also instruct residents to control mosquito breeding on their properties and maintain compliance of water tanks.

The *Pest Management Act 2001* requires all mosquito control activities involving the application of pesticide to be conducted by a licensed pest management technician with the exception of the application of S-methoprene formulations and the deployment of prescribed lethal ovitraps for dengue control.

For further details of these programs and requirements, including information on powers of entry, please refer to *Public Health Act 2005* resource kit:

[www.health.qld.gov.au/publichealthact/resource\\_kit.asp](http://www.health.qld.gov.au/publichealthact/resource_kit.asp)

### 2.1 What is chikungunya

Chikungunya is a viral infection with an abrupt onset typically characterized by high fever and polyarthralgia caused by CHIKV of the genus *Alphavirus* in the family *Togaviridae*. It is part of the Semliki Forest virus complex and is closely related to Ross River and Barmah Forest viruses.

The virus was first isolated in Tanzania in the 1950s and is now found in many parts of Africa, South and South East Asia and has three genetic lineages: an East, Central and Southern Africa (ECSA) lineage, a West African lineage and an Asian lineage.

The word 'chikungunya' is from the Makonde language of eastern Tanzania and means 'that which bends up'. The name describes the stooped position of those suffering severe joint pain which often characterises the disease.

Chikungunya illness presents with an abrupt onset of fever, rash and severe joint pain in approximately 70 per cent of cases. The acute disease typically lasts 3 to 10 days, however convalescence can be prolonged with joint pain and swelling lasting weeks or months. Chikungunya disease can be clinically similar to dengue, including occasional cases with haemorrhagic manifestations. The case fatality rate is low and treatment is symptomatic. Notably, some recent outbreaks have recorded cases involving severe disease, including neurological manifestations. Currently there is no available vaccine although clinical trials of potential vaccine(s) are underway.

### 2.2 Epidemiology

Since identification in East Africa, outbreaks of chikungunya have been documented in various African regions and throughout Asia and the Western Pacific.

Between 2004 and 2007 an unprecedented series of outbreaks occurred originating on the east coast of Kenya and spreading quickly to the Indian Ocean islands including Madagascar, Mauritius, Seychelles and Reunion. From these islands the virus spread to the Indian subcontinent in 2006, where over a million cases were reported. In 2007 the virus was introduced into Italy by a traveller returning from India, resulting in 205 cases of local transmission.

Since that time, several outbreaks have occurred across South East Asia including locations in Malaysia, Singapore, Indonesia and East Timor. Local transmission was recorded in France in 2010 and New Caledonia in the Western Pacific region in 2011. In 2013 outbreaks were again identified in New Caledonia and across West and South East Asia and Central Africa. In 2012–2013 a widespread epidemic was reported for the first time in Papua New Guinea (PNG).

During 2013, imported cases were widely reported in travellers returning from endemic countries to North America, Europe and Australia. The number of imported cases has been increasing annually in Queensland and Australia (Table 1 and 2). However, no local transmission has been recorded (as at January 2014).





**Table 1 Imported cases of Chikungunya: Australia and Queensland 2009 to 2013**

	2009	2010	2011	2012	2013
AUST	30	62	39	19	129
QLD	4	5	3	0	14

**Table 2 Chikungunya notifications in Queensland by Hospital and Health Service 2009–2013**

Hospital and Health Service	Total
Cairns and Hinterland	6
Central Queensland	1
Darling Downs	2
Gold Coast	2
Metro North	6
Metro South	4
Sunshine Coast	2
West Moreton	2
Wide Bay	1
Grand total	26

### 2.3 Chikungunya mosquito vectors

*Aedes aegypti* and *Ae. albopictus* (Asian Tiger Mosquito) are primary vectors of CHIKV between humans. *Aedes aegypti* is also the principal vector of dengue viruses and, in Australia, is abundant in population centres in northern Queensland, but also in some locations in central and southern Queensland.

*Aedes albopictus* is found across Europe, the Americas, Asia and Africa and was first detected in the Torres Strait in 2005 where it is now established. A single incursion of this species was also detected on the northern tip of Cape York in 2009 but this event did not lead to establishment on the mainland. Due to the ongoing risk of colonisation by *Ae. albopictus* on the mainland, the Cairns and Hinterland HHS is funded by the Commonwealth to maintain a surveillance and control program in the Torres Strait and the Northern Peninsula area of Cape York.

*Aedes aegypti* and *Ae. albopictus* lay eggs and the larvae develop in artificial containers. *Aedes aegypti* primarily occurs around human habitation while *Ae. albopictus* will utilise both urban and sylvan container habitats. Generally, *Ae. albopictus* is potentially more invasive than *Ae. aegypti* as it feeds on a range of hosts, has the ability to survive in both urban and sylvan areas, and can withstand more temperate environments.

In addition to *Ae. aegypti* and *Ae. albopictus*, recent laboratory experiments have demonstrated that several other Australian mosquito species can transmit CHIKV in the laboratory. Importantly, some of these competent species, including *Ae. vigilax*, *Ae. notoscriptus*, *Ae. procax* and *Coquillettidia linealis*, are geographically widespread and can be abundant in urban areas. However, when the ecology and behaviour of these secondary species are considered, it is apparent that they would likely play a lesser role in transmission when compared with *Ae. aegypti* or *Ae. albopictus* (Appendix 1). Nevertheless, their potential role in transmission should not be ignored and will need to be considered when investigating notifications of possible local transmission in areas where *Ae. aegypti* is absent (e.g. South East Queensland).

## 2.4 Outbreak risk

Chikungunya outbreaks are often characterised by rapid spread and high attack rates which can lead to a severe impact on communities and public health resources. In part this can be explained by the absence of immunity in local populations and short incubation periods in the mosquito vector. Given these characteristics, Queensland is susceptible to incursion (importation and epidemics) of chikungunya and medical and public health practitioners need to be vigilant to ensure early detection and notification of chikungunya cases.

Limited and/or non-uniform surveillance for *Ae. aegypti* outside of the northern coastal towns can be a source of considerable uncertainty when assessing the risk of local CHIKV transmission, but the available information suggests that Queensland can be divided into three areas, based on local characteristics:

- **High risk**—areas where at least one major vector (*Ae. aegypti* or *Ae. albopictus*) is endemic, there is regular influx of travellers or residents who have visited CHIKV endemic areas, and where there is a recent history of regular transmission of other arboviruses which are vectored by *Ae. aegypti* or *Ae. albopictus* (e.g. Cairns, Townsville, Torres Strait).
- **Moderate risk**—areas where at least one major vector (*Ae. aegypti* or *Ae. albopictus*) is present, few viraemic travellers arrive from CHIKV endemic areas and where there is no recent history of other *Ae. aegypti* or *Ae. albopictus* vectored arboviruses (e.g. Rockhampton, Gladstone, Mackay).
- **Low risk**—areas without populations of major vectors *Ae. aegypti* or *Ae. albopictus* (e.g. Sunshine Coast, Brisbane and Gold Coast), but where there remains a risk of transmission by abundant local endemic species shown to be competent in laboratory studies and the presence of travellers and residents who have visited CHIKV endemic areas.

Importantly, the risk categorisation for a particular location or region is dynamic, and will vary both temporally and spatially across the area being considered. Nevertheless, locations with established populations of primary vectors are more likely to have a higher risk of local transmission than areas where these vectors are scarce. For instance, the risk of local transmission of CHIKV occurring in north coastal Queensland is very high given



increasing travel from endemic countries and the presence of competent vectors with a demonstrated ability to sustain epidemic transmission abroad. However, the risk of transmission classification for large parts of Queensland is uncertain due to the paucity of vector surveillance data and the uncertain role of secondary vectors.

Appropriate surveillance and control actions can mitigate the risk of CHIKV transmission. Accordingly, the following actions are suggested priorities for stakeholders, in line with the level of risk described above:

- **high risk areas**
  - ongoing temporal and spatial surveillance/monitoring of *Ae. aegypti* and/or *Ae. albopictus* populations
  - vector population suppression, as required
  - appropriate routine case response, based on a high risk of transmission from imported cases and/or suspected local transmission
  - establishment and maintenance of efficient communication of notification data to vector control teams to ensure timely response.
- **moderate risk areas**
  - regular surveillance, particularly with an aim to achieving comprehensive spatial distribution data of vectors
  - application of a risk assessment process to all case notifications
  - activation of response to case notifications in line with perceived risk
  - vector population suppression as required
  - efficient communication of notification data to vector control teams to ensure timely risk-based response.
- **low risk areas**
  - surveillance to verify the absence of primary vectors, *Ae. aegypti* and *Ae. albopictus* at least yearly, with a focus on high risk domestic and commercial premises during peak seasons (approximately January to March)
  - application of a risk assessment process to case notifications
  - response planning for incursion of *Ae. aegypti* and *Ae. albopictus*
  - stakeholder engagement to increase preparedness for incursion of *Ae. aegypti* and *Ae. albopictus*
  - during periods of high mosquito abundance, consideration of endemic mosquito control in response to notified chikungunya cases.

Where surveillance or response actions are based on consideration or assessment of risk, a protocol for assessing risk should be implemented.

### 2.5 Stakeholders and their roles

Under the *Public Health Act 2005* control of CHIKV vectors in urban and commercial environments is the responsibility of the public and local government. Supporting this, Queensland Health takes the lead in surveillance and control in areas with particularly high transmission risk or in the presence of virus imports or disease outbreaks.

#### 2.5.1 Local government

The responsibility of administering relevant sections of the *Public Health Act 2005* and Public Health Regulation 2005 which relate to mosquitoes and mosquito breeding sites rests with local government ([www.health.qld.gov.au/publichealthact/resource\\_kit.asp](http://www.health.qld.gov.au/publichealthact/resource_kit.asp)).

Some local governments conduct sophisticated mosquito management based on knowledge of local conditions conducive to mosquito breeding and have access to adequate resources for conducting wetland mosquito control operations, which may include elements of chemical control, habitat modification and public education. Other local governments rely on health education and/or limited treatment of known breeding sites to control mosquitoes.

#### 2.5.2 Queensland Health

Queensland Health (Communicable Disease Unit, Forensic and Scientific Services and HHS Public Health Units) is responsible for disease surveillance, prevention and outbreak management of chikungunya across the state. This includes:

- investigating notifications of chikungunya infection
- confirming laboratory diagnosis, developing novel diagnostic capacities and genotyping virus strains
- monitoring chikungunya incidence in Queensland via surveillance activities
- coordinating, leading, supporting or assisting local government as required with the implementation of mosquito surveillance and control activities for CHIKV vectors through partnership arrangements
- leading chikungunya outbreak vector control activities
- collaborating with local government to implement public awareness activities to promote self-protective behaviours by the public, including reducing mosquito breeding sites around domestic and commercial premises
- undertaking research to identify possible Australian CHIKV vectors
- monitoring the statewide distribution of CHIKV vectors and conducting pesticide resistance testing on CHIKV vectors where relevant in Queensland
- supporting local government through the provision of specialised training in mosquito identification, surveillance and control methods, and expert technical advice through medical entomology support
- developing relevant public health legislation and monitoring and supporting its administration.



### 2.5.3 Australian Government Department of Agriculture

The Australian Department of Agriculture (DA) do not have a role in outbreak response to chikungunya, but is responsible for detection of exotic disease vectors at international first ports of entry into Australia and maintaining an exotic mosquito exclusion zone of 400 metres around these ports. Where private residential property or commercial premises are located within the 400 metres zone, DA liaises with local government to plan appropriate surveillance and control measures. Incursions of *Ae. albopictus* are not uncommon at north Queensland first ports. Responses to these incursions are coordinated by the Public Health Units of the local HHS in collaboration with local government.

Surveillance for *Ae. aegypti* and *Ae. albopictus* can determine vector distribution, estimate vector population density, identify productive larval habitats and define spatial and temporal risk factors related to CHIKV transmission. These can be used to prioritise the locations for and timing of vector control efforts. However, populations of container-inhabiting mosquito species can be difficult to monitor due to the highly localised nature of their distribution in some locations, and complex drivers of population dynamics, including climatic factors and human behaviours. The challenge for surveillance activities is to identify where, when and what vector species are present and at what densities. This information must be informative at appropriate spatial and temporal scales and gathered using limited human resources.

Mosquito surveillance should be conducted as regularly as required to provide meaningful comparative data. For example, where only presence or absence is being determined, an infrequent but large surveillance activity might suffice to confirm the status of low risk. However, in moderate or high transmission risk areas a more detailed temporal and spatial picture is required to inform control operations. Importantly, surveillance data should be of a consistent and high quality, standardised and kept in a format for ease of reference. Where possible, survey data should be mapped to aid visualization of the scale of surveillance activities.

### 3.1 Selection of surveillance locations

In many high risk areas widespread surveillance of *Ae. aegypti* may be necessary. Elsewhere surveillance will focus on residential and commercial premises that present the greatest public health risk. For example, some locations may have a history of inspections by local government or health authorities arising from complaint and/or dengue responses that warrants continued surveillance effort.

Surveillance efforts will depend upon the availability of local resources. To maximise these efforts, the area or properties selected for inspection should be based on some assessment of risk (e.g. Premise Condition Index (PCI), or prior information regarding container breeding mosquitoes or disease transmission likelihood). High risk premises are those that have frequent contact with viraemic travellers, provide large numbers of mosquito breeding sites and/or represent an opportunity for large numbers of people to be infected. Thus, many high risk premises are non-residential and may include high-traffic premises like backpacker accommodation which host a disproportionate number of viraemic international visitors. Conversely, individual residences, often regarded as ‘key premises’, may be high risk if they support the production of large numbers of mosquitoes. Indeed, current data shows that most transmission occurs at residential addresses and that most viruses are imported by returning residents rather than international visitors.



Potential high/medium risk premises may include:

- older or poorly maintained households (potentially lacking air conditioning and insect screens or with gardens providing large amounts of shade and potential containers)
- backpackers/hostels/guest houses
- hospitals
- tyre dealers
- plant nurseries
- schools (pre-schools, primary, high schools, TAFE colleges, day-care centres)
- transit centres.

Geographical hot spots for potential virus transmission include:

- older or poorly maintained areas of town with non-screened housing (especially with a history of high *Ae. aegypti* numbers)
- areas that have supported previous dengue activity
- industrial areas (especially those with tyre yards and wreckers)
- bushland on the urban fringe including parkland (particularly if *Ae. albopictus* is a suspected vector).

In areas where *Ae. aegypti* are uncommon they can be difficult to detect. The Premise Condition Index (PCI) is a simple metric which may assist the identification of properties which harbour *Ae. aegypti* in some locations. High scores reflect untidy houses and yards, along with plentiful shade and it follows that the PCI relies on the assumption that a premise with a poorly maintained house, cluttered yard and lots of shade is more likely to have containers that will harbour mosquitoes than a new or well-kept house with a tidy, shadeless yard. The PCI is assessed from the street, but a similar assessment can be conducted remotely with the aid of satellite imagery or aerial photographs.

If *Ae. aegypti* or *Ae. albopictus* are found in a novel location they should be controlled immediately using the methods broadly outlined in the *Queensland Dengue Management Plan 2010–2015*. This may prevent the mosquito from becoming established. In all but the most minor of incursions, a large scale response facilitated by an Authorised prevention and control program (*Public Health Act 2005*) will be essential. If *Ae. albopictus* is detected or suspected on the Queensland mainland, Queensland Health must be notified urgently to initiate an emergency response.

Each of the mosquito life stages (eggs, larvae, pupae, adults) requires different surveillance techniques for detection and monitoring (Appendix 2). As each methodology has limitations, integration of more than one surveillance method is recommended.

### 3.2 Adult mosquito surveillance

Sampling the adult vector population using a variety of trapping tools can provide essential data regarding vector distribution, seasonal population trends, transmission dynamics, transmission risk and evaluation of vector control interventions. In comparison with larval and pupal surveillance, adult surveillance methodologies are typically more sensitive but less labour-intensive and less dependent on the collector's proficiency and skill. Because adult *Ae. aegypti* and *Ae. albopictus* generally disperse over short distances, adult presence can be a reliable indicator of close proximity to cryptic larval habitats. This is particularly informative in the case of *Ae. albopictus* in sylvan habitats.

In north Queensland, Biogents Sentinel (BG) traps and Gravid Aedes Traps (GAT) are used to monitor adult *Ae. aegypti* numbers in high risk areas. These traps might be deployed in other areas in Queensland to monitor *Ae. aegypti* and *Ae. albopictus* and may be particularly useful when deployed along potential pathways for incursion into new areas. Further, in areas where target species are widespread, multiple traps can be used in a surveillance network to locate 'hot spots' of elevated vector populations and thus target management efforts.

Landing/biting collections on humans are another sensitive means of detecting low-level infestations. However these surveys are labour intensive, require human ethics approval and risk virus transmission to humans, especially during outbreak events.

### 3.3 Egg surveillance (ovitrap)

Ovitrap collect the eggs of container-breeding mosquito species including, but not limited to, the target species *Ae. aegypti* and *Ae. albopictus*. However, the morphological identification of eggs to species level is not practical and it is often necessary to rear the eggs to at least fourth instar larvae for species identification. Alternatively, molecular identification of eggs or early instar larvae may be considered.

Ovitrap are relatively inexpensive, and are not reliant on the detection and sampling of cryptic larval habitats. However, as with adult surveillance, ovitrap do not provide details regarding the type and availability of larval habitats beyond providing an indication of their close proximity.

### 3.4 Larval and pupal survey

Around the globe, the routine use of larval and pupal numbers (derived from container surveys) to assess mosquito densities and transmission risk has largely been superseded in favour of adult survey methods. However, container surveys may comprise an important part of an operational surveillance and/or response program, particularly where characterisation and/or treatment of container habitats is required.

Container surveys can be used to infer the spatial distribution of the vector, and the diversity and availability of container habitats. Note that container surveys will not provide information regarding the contribution of cryptic breeding sites including subterranean sites, roof gutters or rainwater tanks unless such sites are particularly targeted.





Larval surveys may also provide a relative measure of density when they are used to derive *Stegomyia* indices including the Container, Breteau and House Indices. Generally, the more premises that are inspected, the more informative such indices can be, but the actual numeric thresholds for transmission are impossible to define in most situations and will be strongly impacted by numerous additional factors including:

- number of viraemic imports to an area
- adult mosquito biting rates
- temperature and humidity (which affect mosquito survival and virus incubation times).

Further, logistical problems associated with counting individual stages, distinguishing between morphologically similar species and, in some cases, poor correlation with adult mosquito densities has limited the application of these indices on an operational basis.

Traditional *Stegomyia* indices do not account for differences in the productivity of adult *Ae. aegypti* between containers. However, the concepts of ‘key containers’ and ‘key container types’ can be useful, and are defined as individual containers or container types that produce disproportionately more adult mosquitoes. For example, while tyres and drums may comprise only 10 to 20 per cent of the total number of water-holding containers in some locations, they may account for up to 83 to 99 per cent of total *Ae. aegypti* production. Likewise, key premises account for a disproportionate amount of the total adult production when compared with other premises. Importantly, identification of key container types and key premises will lead to site specific and cost-effective control programs if treatment can be focused on key container types or premises that produce most of the adult *Ae. aegypti*.

# Mosquito control

The risk of local transmission should be assessed for each chikungunya notification (Section 2.5), and any mosquito control response should be in line with this risk. Importantly, coastal north Queensland and Torres Strait communities are high risk, so mosquito control operations should commence without delay. However, in the absence of surveillance data or where the likelihood of primary vector presence is unknown, the appropriate level of risk may be difficult to assess for some locations.

Risk assessments should utilise available tools and other relevant mosquito surveillance data. In response to a notified case, adult traps (BG or GAT) are the recommended tool to measure the presence and relative abundance of primary vectors where there may be a risk of exposure to daytime mosquito bites. When appropriate, candidate addresses for response should be derived from case travel history. The results of these trap events should serve as a trigger mechanism to implement emergency control operations in medium and low transmission risk regions of Queensland if *Ae. aegypti* or *Ae. albopictus* are detected. Trap results enable respective addresses to be ranked into a priority list for any control operations. Supplementary traps (carbon dioxide-baited CDC or EVS-type traps) for potential endemic vectors may also be considered in some cases, particularly if secondary vectors are suspected to be involved in potential transmission.

Chikungunya emergency vector control operations will largely emulate emergency protocols for dengue control (*Queensland Dengue Management Plan 2010–2015*) but would include additional measures (e.g. barrier spraying of vegetation) in areas where *Ae. albopictus* is implicated.

The key to effective vector control is speed and timeliness. To prevent local transmission arising from an imported viraemic case, vector control teams must be notified of viraemic cases within a timeframe that allows them to target the mosquitoes that may have fed on a viraemic import, but before the end of the virus incubation period in the mosquito—known as the extrinsic incubation period (EIP). The EIP is temperature dependant and, for example, is 8 to 10 days for dengue viruses in north Queensland. For vector control teams to initiate a response before the completion of the EIP, they must be alerted to viraemic cases quickly. However, an EIP for CHIKV may be as low as two days, making rapid response to transmission all the more critical. Note that the average delay in notification of dengue cases in north Queensland is five to six days.

The timeliness of response to a locally transmitted case is also critical, but offers less certainty of preventing further cases. Locally acquired cases only appear once a period equivalent to the sum of the EIP and the intrinsic incubation period (IIP)—the period of incubation in a human—has expired. This period is variable depending on the circulating virus strain. After the EIP and IIP have lapsed, most of the mosquitoes responsible for the initial local transmission will already be dead and any control measures will therefore have little impact on transmission by that older infected cohort responsible for the human cases already incubating. Again, the major impact of any vector control effort will result from effects on newly infected mosquitoes within which the virus is replicating.



Importantly, the EIP and IIP for CHIKV may be shorter than for DENV. In the case of very short EIPs, as demonstrated by the E1:A226V mutation of the CHIKV ECSA strain responsible for a 2012 Papua New Guinea outbreak, vector control efforts would have little chance of killing infected adult mosquitoes in time to prevent transmission. Thus, the scale of any control program would have to increase dramatically and response actions revised. For example, if transmission was rapid due to a very short EIP, the speed at which interior residual spraying (IRS) could be conducted would be slower than the spread of the transmission and thus timeliness of response is imperative. Further, lethal ovitraps (LO) might lose their function if the EIP was less than the gonotrophic cycle (time taken to develop eggs after a blood meal). House-to-house indoor fumigation may be a viable alternative, but its acceptability to residents is uncertain. An area-wide response, aimed at decimating the mosquito population over entire city blocks would have to be implemented.

Areas identified for mosquito control activities should be mapped and the response should be coordinated between Queensland Health and local government. In medium and high risk regions, the control areas should be determined in consultation with experienced staff (e.g. medical entomologists). The size of each response area should reflect the species involved, the timeliness of case notification, the duration of time spent by a case at a particular address, the abundance of the vector, environmental conditions and information describing previous dengue or chikungunya outbreaks in the area.

The aim of a response activity is to break the transmission cycle by quickly killing infective mosquitoes and removing their breeding sites. This is achieved by house-to-house inspections of residential and/or commercial blocks within the expected flight range of mosquito vectors (normally 100 to 200 metres radius of contact addresses) to perform the following activities:

**Adult mosquito control:**

- interior residual spraying of contact address and adjacent premises
- deployment of lethal ovitraps in large arrays within the specified area
- barrier spraying (for *Ae. albopictus*).

**Larval control:**

- application of residual chemicals to all appropriate containers capable of holding water within the response area
- source reduction—removal or mosquito-proofing of water-bearing containers.

Note that only control measures targeting adult mosquitoes have a large and immediate impact on virus transmission, whereas larval control will have little effect on an immediate transmission threat.

Control activities will be most effective where the community actively undertakes preventative behaviours. Fewer breeding sites equate to fewer vector mosquitoes, and fewer mosquito bites reduce the risk of exposure to virus.

Routine mosquito control around domestic and commercial premises is the responsibility of the householder or business owner (Public Health Regulation 2005). These activities may be supported by local government and/or Queensland Health when there is a risk of a disease outbreak (*Public Health Act 2005*).

### 4.1 Source reduction

Source reduction, through the removal, destruction or treatment of breeding sites, can reduce the overall abundance of mosquitoes and therefore the likelihood of a viraemic person being bitten. However, source reduction does little to combat active transmission and is only effective in reducing populations if sufficient coverage of potential habitats is achieved.

All containers in both residential and commercial premises that can collect water should be emptied or rendered ‘mosquito-proof’ (i.e. turned upside down, disposed of or filled with sand and mortar mix, or made free-draining). Property occupiers should fill tree holes with sand and mortar mix and remove excessive amounts of vegetation that can hold water (e.g. fallen palm fronds or bromeliads). Sylvan areas adjacent to communities should also be targeted in areas where *Ae. albopictus* is established. Rainwater tanks must be screened (gauze with less than 1 millimetre aperture) to comply with the Public Health Regulation 2005.

### 4.2 Chemical application

Any chemical treatment or application conducted by a resident, contractor or health authority must be consistent with label recommendations.

#### 4.2.1 Larval chemical control

The treatment of permanent containers with residual pyrethroids and insect growth regulators (e.g. S-methoprene) may turn some containers into effective egg sinks.

#### Insect growth regulators (IGR)

S-methoprene is available in a range of slow-release formulations (sand granules, pellets or briquets) and has low non-target toxicity. The chemical does not kill larvae, but prevents the emergence of adult mosquitoes. The product is activated when in contact with water, so it is also possible to ‘pre-treat’ dry containers. Sand granules and pellets can be applied to containers that are difficult to inspect (e.g. wells, drain sumps, bromeliads, roof gutters). Pellets provide residual activity for up to one month whereas briquets last approximately three months. However, in areas receiving frequent heavy rain (which may flush containers) more frequent use may be necessary. Briquets are registered for use in rainwater tanks and have been used during dengue outbreaks and *Ae. albopictus* eradication programs in the Torres Strait. However, this should be regarded as a temporary measure until tank screens can be repaired to comply with the Public Health Regulation 2005.



### Surface sprays

Some domestic surface-sprays (indoor and outdoor) are registered for use against mosquitoes. Some formulations have been shown to kill larvae and pupae and resting adults for up to five months. Sustained use of surface sprays for mosquito control by the public is discouraged, due to concerns of the development of chemical resistance.

The bacterial insecticide VectoBac WG (dry or aqueous) can be used for residual control of *Ae. aegypti* or *Ae. albopictus* in small containers. Pretreatment of dry containers up to eight weeks before flooding will not impact the efficacy of the product. Importantly, if secondary vectors (other than *Ae. aegypti* and *Ae. albopictus*) are implicated in CHIKV transmission larval control strategies may need to be revised to incorporate additional measures which target the appropriate groundwater habitats.

#### 4.2.2 Adult chemical control

##### Interior residual spraying

The aim of IRS is to kill infected mosquitoes before they have time to incubate and transmit the virus. *Aedes aegypti* (and to a lesser extent *Ae. albopictus*) rest (harbour) between blood meals in dark areas inside and under houses and buildings. An effective way to target these adults is to apply residual insecticide (pyrethroid) to these surfaces.

*Aedes aegypti* prefer to rest:

- on the underside of furniture (tables, chairs, beds)
- in wardrobes and closets
- on piles of dirty laundry and shoes
- in other dark objects and in dark rooms.

Thus, IRS is a logical and effective treatment for premises associated with cases, particularly if it is applied during the EIP.

Interior residual spraying is relatively slow and labour intensive (approximately 10 minutes per house). Permission to spray inside a house must be granted by the occupant. For dengue control, IRS is usually limited to viraemic contact addresses, their nearest neighbours and other high-risk properties. Information about the specific chemical used and safety precautions must be provided in a pest control advice.

### Harbourage or barrier spraying

Barrier, or harbourage treatments involve the application of a pyrethroid insecticide to exposed surfaces around the area or property where mosquitoes may rest, creating a residual insecticidal barrier between the mosquito and human populations. Due to its association with sylvan habitats, harbourage spraying is particularly appropriate when targeting *Ae. albopictus*. For example, barrier treatments have also been employed successfully in reducing *Ae. albopictus* in areas of the Torres Strait by targeting bushland areas on the fringe of the community.

Extremely large numbers of endemic secondary vectors (e.g. *Ae. vigilax* etc.) at/near a contact address may warrant the application of ultra-low volume non-residual sprays (a process referred to as fogging) in nearby harbourage as a precautionary measure.

### Lethal ovitraps

Lethal ovitraps have been used with great success since 2004 for dengue control in north Queensland. They target gravid, blood-fed mosquitoes which may be carrying virus. Lethal ovitraps contain fabric strips that are impregnated with a pyrethroid (bifenthrin) which are contacted by gravid females seeking to lay eggs. As the incubation period of most viruses is longer than the time between blood feeding and egg laying, the traps kill blood-fed, infected mosquitoes before they are capable of transmitting disease. Operationally, lethal ovitraps are deployed in most yards within 100 to 200 metres of case addresses and collected after a month. Importantly, lethal ovitraps can provide a more rapid treatment method than IRS.

## 4.3 Possible future directions in biological control

Control strategies are continually evolving. For example, the Eliminate Dengue research group ([www.eliminatedengue.com](http://www.eliminatedengue.com)) is field trialling a novel biocontrol strategy that will reduce the ability of *Ae. aegypti* to transmit dengue. The approach is centred on releasing *Ae. aegypti* infected with selected strains of the bacterial endosymbiont *Wolbachia* which occurs naturally in up to 70 per cent of all insect species.

The strains of *Wolbachia* that reduce the ability to transmit dengue have been shown to likewise inhibit CHIKV transmission in the laboratory. Therefore, any implementation of *Wolbachia*-infected *Ae. aegypti* in north Queensland may have some indirect effect on future CHIKV transmission risk. Other research has also indicated a similar response in *Ae. albopictus*.



#### 4.4 Eradication programs for chikungunya vector species

Eradication programs for *Ae. aegypti* or *Ae. albopictus* would require a specific agreement between Queensland Health, local government and other key stakeholders to define roles and responsibilities. This is due to the high resource demands of funding the dedicated labour and equipment requirements. Such a program would also need ongoing surveillance and control measures to prevent re-invasion from other locations.

### 5.1 Routine disease surveillance

Chikungunya is a notifiable condition under the *Public Health Act 2005*. Routine disease surveillance is a key defence against chikungunya. Outbreaks in Queensland could cause significant morbidity as the general population is immunologically naive to CHIKV.

Outbreaks could be initiated by a viraemic traveller entering the country. Routine surveillance currently comprises laboratory notification of confirmed cases. While not a legislative requirement, general practitioners and emergency department doctors are encouraged to immediately report suspected cases of chikungunya to their local Public Health Unit.

#### 5.1.1 Clinical surveillance

Surveillance for clinically identified cases is important as early recognition and notification of cases enables action to be taken promptly to reduce the risk of local transmission in areas where CHIKV vectors are suspected or known to be present. If a person presents with a relevant clinical picture in an area where potential CHIKV vectors are suspected or known to be present, but does not have a recent travel history to an endemic country, this could indicate local transmission.

Early reporting of a suspected case can mean the difference between managing a single imported case or managing an outbreak with multiple cases. Therefore it is important that medical practitioners report suspected cases of chikungunya directly to their local Public Health Unit by telephone or fax immediately.

Typically cases will have a history of recent travel to an endemic country and present with fever following an incubation period of three to seven days. Viraemia typically lasts for approximately 4 to 6 days, however can persist for up to 12 days. The common clinical picture is one of abrupt onset of fever accompanied with polyarthralgia, backache and headache (Table 3), which can be similar to other non-encephalitic mosquito borne diseases such as Ross River virus (RRV), Barmah Forest virus (BFV) and dengue fever.

**Table 3 Clinical features of chikungunya**

Common	Infrequent	Rare in adults but sometimes seen in children
Abrupt onset of fever	Rash	Photophobia
Polyarthralgia	Stomatitis	Retro-orbital pain
Backache	Oral ulcers	Vomiting
Headache	Hyperpigmentation	Diarrhoea
	Exfoliative dermatitis	Meningeal syndrome
		Acute encephalopathy





Delays in presentation, diagnosis or notification can negatively impact on the effectiveness of outbreak management. Viraemic overseas visitors who do not have travel insurance to cover the costs associated with seeking medical assistance pose a significant problem and agreements with local hospitals are needed to ensure local arrangements are in place to mitigate this risk.

### 5.1.2 Laboratory surveillance

As chikungunya is a notifiable condition under the *Public Health Act 2005* in Queensland, laboratories are required to notify Queensland Health of positive chikungunya results. Forensic and Scientific Services (FSS) is the arbovirus reference laboratory for Queensland.

It is important that appropriate diagnostic tests are carried out at the appropriate time in relation to the onset of symptoms to ensure early identification and notification of cases. There are three categories of laboratory tests used for the diagnosis of CHIKV infections:

- serological tests to identify IgM and IgG antibodies
- RT-PCR (reverse transcriptase—polymerase chain reaction)
- virus isolation.

Nucleic acid sequencing and genotyping are also available to identify and differentiate virus strains, which is useful for the management and control of outbreaks and epidemiological studies.

Typically, CHIKV RNA can be detected by RT-PCR between day 0 to day five post onset of symptoms. While a ‘detected’ result is significant and is indicative of an acute infection, a ‘not detected’ result by RT-PCR cannot exclude infection. For this reason, all samples submitted to FSS for RT-PCR are also routinely tested for anti-CHIKV antibodies by serology. Viral cultures may also be undertaken at the same time as RT-PCR using the same specimen.

Detection of IgM antibodies by serology on a single specimen is suggestive of a recent infection. However, this should be confirmed by testing a second convalescent phase sample collected 10 to 14 days after the first. Pathology results provided by FSS will contain associated commentary to assist interpretation by clinicians (Appendix 3).

**Table 4 Chikungunya diagnostic tests**

Days post onset	Test
Day 0–5	RT-PCR Viral isolation IgM (baseline)
> Day 5	IgM
> Day 8	IgM IgG

### 5.1.3 Barriers to diagnosis and notification

The timely notification of chikungunya cases is essential in preventing and controlling outbreaks. Clinicians and public health practitioners should be aware of the barriers to early case identification and notification and work towards minimising delays.

Common barriers to early identification and notification of cases are:

- delayed case presentation
- lack of recognition of the risk of imported cases of chikungunya
- incorrect diagnostic tests undertaken in relation to date of onset of symptoms
- missed cases due to the lack of recognition of the range of symptoms
- high numbers of transient medical practitioners who may be unfamiliar with the disease.

## 5.2 Case investigation and response

### 5.2.1 Case investigation

The disease investigation and response for chikungunya cases is similar to that for dengue fever cases.

Public health unit staff should liaise with the treating medical practitioner and the laboratory to ensure that the appropriate laboratory test(s) are performed as soon as possible. FSS will provide test results.

For notifications in all areas an attempt should be made to interview the patient using the chikungunya case report form to determine the travel history, period of viraemia and areas visited during the viraemic period. The case report form (Appendix 4) records the patient details and other key information to determine the risk for local transmission including:

- clinical signs and symptoms
- laboratory tests ordered and results
- the patient's recent travel history (e.g. from CHIKV endemic countries)
- the patient's recent movements (e.g. to high risk premises).



The case investigation information should be passed to the medical entomologist or the relevant manager of environmental health services to determine the transmission risk and appropriate level of response.

Any person presenting with possible chikungunya should be advised to take measures to avoid being bitten by mosquitoes while they are unwell, particularly in CHIKV receptive areas.

### 5.2.2 Case response

When a viraemic imported case is confirmed in an area where CHIKV vectors are present, consideration should be given to informing medical practitioners in that area to consider chikungunya as a differential diagnosis for people presenting with a febrile illness, depending on assessed levels of transmission risk.

If a chikungunya case has been identified as locally acquired an outbreak should be declared and the incident management system established (see Section 6). The Senior Director, CDU will inform Communicable Diseases Network Australia at the national level.

# Managing chikungunya outbreaks

Activation of the Incident Management System is the framework endorsed by Queensland Health to support the operational functions necessary for effective management of outbreaks. An incident management team (IMT) would be established to oversee the ongoing management of the outbreak. The level of the incident response will be determined by the size and complexity of the outbreak.

## 6.1 Communications

The IMT would establish an appropriate and effective communication strategy which would inform relevant groups such as general practitioners, hospital emergency department staff, laboratory staff and infectious diseases physicians.

Situation reports should be issued to relevant stakeholders at regular intervals to provide information on the progress of the outbreak response.

Specific health protection advice and updates on an outbreak should be provided to the general public and residents in the chikungunya alert areas, for example through media releases.

## 6.2 Role of local government

Local government have the legislated authority under the Public Health Regulation 2005 to enforce legislation under which it is an offence for households to allow mosquito breeding on their premises.

During a chikungunya outbreak local government may be called upon to assist Queensland Health in minimising disease transmission by actively engaging and supporting the public and industry to reduce mosquito breeding sites in areas identified as actual and potential high risk for escalating and/or maintaining the outbreak.

## 6.3 Staffing requirements

Public health services should identify the staffing levels and skills mix required to lead the outbreak response. Staffing requirements and planning for vector control activities should be undertaken in collaboration with local government. Outbreaks can escalate very quickly, so ideally a pool of relief staff should be identified. It is essential that relief staff have the necessary skills and legislative authority, where required, to undertake the duties for which they have been assigned. Training of relief staff engaged in outbreak response should be developed.

Under the Queensland Government *Workplace Health and Safety Act 1995* employers have an obligation to ensure the health and safety of all employees in the workplace.



The public play an important role in the prevention of chikungunya by reducing potential container breeding mosquito habitats from domestic and workplace environments as well as adopting positive protective behaviours to avoid being bitten by mosquitoes, particularly when travelling in CHIKV endemic areas. Specifically prevention messages should include:

- use of personal insect repellent containing DEET or Picaridin, particularly during daylight hours when CHIKV vectors are most active
- wearing of long, loose fitting clothing to help protect from mosquito bites
- ensuring window and door screens are in good condition
- ensuring water tank screens are in good condition
- use of mosquito coils or plug-in mosquito repellent devices where appropriate.

To successfully achieve community support in both source reduction and personal protection individuals must be armed with relevant information and achievable means by which they are empowered to take positive action.

This can be achieved through targeted awareness campaigns and community engagement strategies. The success of these campaigns and strategies rests with utilising a combined and coordinated approach including health promotion, medical entomology and public health principles.

For community awareness and engagement strategies to be relevant and hence successful they should be planned and implemented in collaboration with key stakeholders, particularly local government and or Aboriginal and Torres Strait Islander community councils. Community engagement strategies can include formal agreements with government departments and industry representative bodies and partnership arrangements with key community groups to support simple, affordable and achievable source reduction in the workplace and home as well as adoption of personal protective measures.

During an outbreak public awareness programs should be intensified. The public should be informed of outbreak details and communication strategies should emphasise the immediate risk and motivate the public to take positive preventive action including early presentation to medical care if unwell with chikungunya symptoms. Geographic areas where local transmission has recently occurred should be specifically targeted, as well as high risk premises as outlined in 3.1 that have the potential to facilitate mosquito breeding and/or transmission.

In moderate or low risk areas there is also a need to inform the general public to adopt protective behaviours particularly when travelling to CHIKV endemic areas and to present early if unwell following travel.

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## Summary of the intrinsic and extrinsic factors that may influence the vectorial capacity of Australian mosquitoes for CHIKV.

Species	Alphaviruses <sup>a</sup>	Vector competence <sup>b</sup>	Host feeding patterns	Activity time	Distribution
<i>Aedes aegypti</i>	CHIKV	High	Human	Diurnal	North Queensland
<i>Ae. albopictus</i>		High	Opportunistic <sup>c</sup> / human	Diurnal	Torres Strait
<i>Ae. notoscriptus</i>	CHIKV, RRV	Low	Opportunistic	Crepuscular	Widespread
<i>Ae. procax</i>	RRV	High	Opportunistic	Crepuscular	Eastern coastal, south from central Queensland
<i>Ae. vigilax</i>	RRV, BFV	High	Opportunistic	Crepuscular	Widespread Coastal
<i>Coquillettidia linealis</i>	RRV, BFV	High	Opportunistic	Night with peak at dusk	Eastern Australia, south from central Queensland
<i>Culex. annulirostris</i>	RRV	Low	Opportunistic	Crepuscular	Widespread
<i>Cx. quinquefasciatus</i>	Nil	Refractory	Birds, humans	Nocturnal	Widespread
<i>Cx. sitiens</i>	RRV	Low	Opportunistic	Crepuscular	Widespread coastal
<i>Verrallina funerea</i>	RRV, BFV	Moderate	Opportunistic	Crepuscular	Northern coastal from NT to Northern NSW

<sup>a</sup>Association with alphaviruses as demonstrated by either virus isolation studies or vector competence experiments.

<sup>b</sup>Efficiency with which a given species can transmit CHIKV: high = > 60%; moderate = 30–59%; low = < 30%.

<sup>c</sup>Opportunistic feeding patterns denotes that a species feeds on a variety of hosts.

# Appendix 2

## Container inhabiting mosquito surveillance methods

Mosquito stage	Advantages	Disadvantages	Settings
<b>Eggs</b>			
Ovitrap	<ul style="list-style-type: none"> <li>• Simple to operate</li> <li>• Inexpensive</li> <li>• Sensitive for low population densities due to long sampling period (1–4 weeks)</li> <li>• Eggs simple to transport to central lab</li> </ul>	<ul style="list-style-type: none"> <li>• Labour and time intensive if rearing for morphological identification</li> <li>• High sample mortality</li> <li>• Delayed result (reduced early warning for exotics)</li> <li>• Ovipositing adults not killed or retained (exotics get away)</li> <li>• Containment/tracking issues during transport</li> <li>• Interference by animals, egg predators</li> <li>• Traps inactive when dry, water polluted or knocked over</li> <li>• Must recollect trap</li> </ul>	Suitable for remote areas due to ease of use and mailing of egg samples
Sentinel tyre/bucket	<ul style="list-style-type: none"> <li>• As above</li> <li>• Sensitive due to longer sampling period (4 weeks)</li> <li>• suitable for deployment in dry conditions</li> </ul>	<ul style="list-style-type: none"> <li>• As above (ovitrap)</li> <li>• Cleaning and maintenance</li> <li>• Further delay of results due to extended sampling period)</li> <li>• Bulky</li> </ul>	Dry/remote conditions Less regular checking
Lethal ovitrap	<ul style="list-style-type: none"> <li>• Kills adults —outbreak response when deployed in arrays</li> <li>• Inexpensive</li> </ul>	<ul style="list-style-type: none"> <li>• Adults not retained—no capacity to identify species</li> <li>• Contains insecticide</li> <li>• Moderate sensitivity</li> <li>• Interference by animals</li> <li>• Traps inactive when dry, water polluted or knocked over</li> <li>• Must recollect trap</li> </ul>	





Mosquito stage	Advantages	Disadvantages	Settings
<b>Larvae</b>			
Larval Survey—including various collection methods (bulb pipette, sieve, aquarium net, aspirator)	<ul style="list-style-type: none"> <li>• Immediate result</li> <li>• Identification of type and quantity of larval habitats</li> </ul>	<ul style="list-style-type: none"> <li>• Trained and skilled labour required for collection</li> <li>• Limited sampling period</li> <li>• Difficult to achieve large spatial coverage due to labour and time intensity</li> <li>• Potential environmental bias (e.g. rain)</li> <li>• Sample issues—transport and preservation</li> <li>• Extensive data recording requirements</li> <li>• Access constraints to cryptic, elevated, subterranean sites and locked or inaccessible premises</li> </ul>	Everywhere
<b>Adults</b>			
BG trap	<ul style="list-style-type: none"> <li>• Minimum 24 hours</li> <li>• Retains adults</li> <li>• Highly sensitive</li> <li>• Easy to use</li> <li>• Publicly accepted</li> <li>• Does not require CO<sub>2</sub></li> <li>• Portable</li> <li>• Fewer samples to identify</li> </ul>	<ul style="list-style-type: none"> <li>• Expensive</li> <li>• Power to mains or battery (short duration and heavy)</li> <li>• Specimens can be damaged during collection</li> <li>• Secure deployment location required</li> <li>• Maintenance costs</li> <li>• Specimens may become desiccated/damaged</li> </ul>	Domestic locations that are protected from rain e.g. carport, verandah
GAT	<ul style="list-style-type: none"> <li>• Sensitive</li> <li>• Easy to use</li> <li>• Publicly accepted</li> <li>• Does not require power</li> <li>• Does not require CO<sub>2</sub></li> <li>• Portable</li> <li>• Moderate expense</li> </ul>	<ul style="list-style-type: none"> <li>• Specimens may become desiccated/damaged</li> <li>• Secure deployment location required</li> </ul>	Protected area (from rain)

Mosquito stage	Advantages	Disadvantages	Settings
EVS/CDC trap	<ul style="list-style-type: none"> <li>• 24 hour deployment</li> <li>• Easy to use</li> <li>• Outdoor use</li> </ul>	<ul style="list-style-type: none"> <li>• Large number of species collected, but inefficient for primary vectors <i>Ae. aegypti</i> or <i>Ae. albopictus</i></li> <li>• Moderate cost</li> <li>• CO<sub>2</sub> required</li> <li>• Batteries required</li> <li>• Secure location required for deployment</li> <li>• Maintenance required</li> </ul>	Outdoors
Human landing catches	<ul style="list-style-type: none"> <li>• Immediate result</li> <li>• Sensitive</li> <li>• Inexpensive</li> <li>• No power/CO<sub>2</sub> required</li> </ul>	<ul style="list-style-type: none"> <li>• Collector exposure to mosquito bites (and potential virus)</li> <li>• Human ethics considerations (approval required)</li> <li>• Difficult to standardise</li> </ul>	
Backpack aspirators, sweep net, mechanical aspirator	<ul style="list-style-type: none"> <li>• Immediate result</li> <li>• Target specific resting sites</li> </ul>	<ul style="list-style-type: none"> <li>• Intrusive for residents</li> <li>• Less sensitive than BG trap</li> <li>• Heavy to carry</li> <li>• Mosquito has to be present at same time as operator, therefore timing can be critical</li> </ul>	Indoors/outdoors
<b>Sample identification</b>			
Morphological identification	<ul style="list-style-type: none"> <li>• Cheap</li> <li>• Can be done in the field/onsite</li> <li>• Immediate identification</li> </ul>	<ul style="list-style-type: none"> <li>• Requires expertise</li> <li>• Difficult/unreliable if samples are damaged or if larvae are early instars</li> <li>• Unreliable if considering morphologically similar species</li> <li>• Impractical for eggs or pupae (require rearing)</li> </ul>	NA
Molecular identification (PCR)	<ul style="list-style-type: none"> <li>• Can be used for all life stages</li> <li>• Can pool large numbers of specimens or samples into one sample for analysis, reducing cost and time required to identify</li> <li>• Useful validation tool for absence of target species</li> </ul>	<ul style="list-style-type: none"> <li>• Requires technical expertise</li> <li>• Cost (particularly in areas where sample pooling not appropriate)</li> <li>• Time delay</li> <li>• Available only in central laboratory facilities (transport implications)</li> </ul>	



## Diagnostic chikungunya virus tests

Test	Details	Location
Haemagglutination inhibition test (HAI)	This test is performed as an alphavirus group test incorporating RRV, BFV, SINV and CHIKV. It detects total antibodies and can detect seroconversion when pair sera are tested in parallel. This test can differentiate CHIKV infections in most cases though cross-reactions with the other viruses can occur. Where a four-fold or higher titre to CHIKV is detected over the other viruses, infection with CHIKV is indicated. Where a four-fold or greater rise in titre is detected between paired sera, recent infection is confirmed.	FSS Public Health Virology Laboratory, Brisbane Other interstate laboratories
Alphavirus microsphere immunoassay (Luminex)	This test is also performed as an alphavirus group test using individual microspheres coupled to RRV, BFV, SINV and CHIKV. The test tests for IgG and IgM separately. Differentiation of infecting viruses is often possible, particularly with the IgM assay.	FSS Public Health Virology Laboratory, Brisbane
In house IgG and IgM ELISA	Assays developed by each laboratory	Interstate reference labs
Euroimmun IgG and IgM IFA	Commercial IFA	Unknown
CTK biotech Onsite IgM rapid test	Commercial rapid test	Unknown
NovaLisa IgG Capture and IgM ELISA	Commercial ELISA	Unknown

Test	Details	Location
RT-PCR	<p>The CHIKV real-time TaqMan (reverse transcriptase polymerase chain reaction) RT-PCR test is a very rapid and specific test for CHIKV that is based on detection of viral nucleic acid (RNA). The RT-PCR targeting the envelope 1 gene (E1), is usually only useful during the first week of the illness (0–5 days following onset of symptoms) before rising neutralising antibodies clear the virus from circulation. The sensitivity of the test can be affected by transport and storage conditions and it is preferred that samples be kept cold at 4 degrees Celsius during transit.</p> <p>Suitable specimens for this test include serum, CSF, tissue and synovial fluid. FSS will also test EDTA blood, but serum should be collected wherever possible. It is preferable to obtain a minimum of 0.5 mL of any of the liquid sample types to enable initial and repeat testing if required.</p> <p>A ‘detected’ CHIKV PCR test is definitive and confirmation of an acute, recent CHIKV infection. A ‘not detected’ result however, must be interpreted with caution and in conjunction with serology findings. Hence all samples submitted for CHIKV RT-PCR testing will automatically be scheduled for serological investigation. Where clinical suspicion of CHIKV infection is high, a second sample should be collected to look for a seroconversion and rise or fall in IgM/IgG antibodies.</p> <p>Currently CHIKV is not endemic in Australia, however there have been several human cases identified following the return of viraemic travellers. Frequency of detection has recently escalated with cheaper airfares and an increase in direct flights to CHIKV endemic locations. During an outbreak, RT-PCR tests play an important part in the diagnosis of CHIKV infections which at presentation, can be confused clinically with other illnesses such as dengue. A positive RT-PCR result may also provide a definitive result in the absence of a specific serology result (due to cross-reactivity with other alphaviruses e.g. Ross River virus, Barmah Forest virus, and Sindbis virus) or when only a presumptive IgM from a single sample is obtained.</p> <p>Early detection and diagnosis by RT-PCR and/or virus isolation can greatly assist Public Health management and vector control strategies. Public Health virology can also perform specific Ross River virus, Barmah Forest virus, Sindbis virus and dengue TaqMan RT-PCR for exclusion purposes. In addition to these, conventional alphavirus group or CHIKV RT-PCR (gel-based) may be performed to assist diagnosis or facilitate sequencing investigations.</p>	FSS Public Health Virology Laboratory Brisbane



Test	Details	Location
RT-PCR (cont)	Early detection and diagnosis by RT-PCR and/or virus isolation can greatly assist Public Health management and vector control strategies. Public Health virology can also perform specific Ross River virus, Barmah Forest virus, Sindbis virus and dengue TaqMan RT-PCR for exclusion purposes. In addition to these, conventional alphavirus group or CHIKV RT-PCR (gel-based) may be performed to assist diagnosis or facilitate sequencing investigations.	
Virus isolation	Acute phase samples submitted for CHIKV testing are also suitable for virus isolation via cell culture. Sample types are the same as given for CHIKV RT-PCR. CHIKV is currently classified in Australia as a PC3 (physical containment level 3) pathogen and its manipulation and growth is restricted to a limited number of certified laboratories. Although virus isolation may take as long as 3-4 weeks to perform, recovery of the infecting agent from the patient sample provides a definitive diagnosis of an acute infection. In rare cases, mutations of the viral genome may affect the sensitivity of molecular investigations such as RT-PCR. Viral culture can be used to amplify the virus and provide additional stocks of the pathogen for diagnostics. Recovery of CHIKV isolates is also valuable for maintaining an historical arbovirus reference collection that is vital for future research and test development.	FSS Public Health Virology Laboratory Brisbane
Nucleic Acid Sequencing and Genotyping	Detection of specific CHIKV RNA via RT-PCR or recovery of live virus following isolation/culture will enable nucleic acid sequencing and determination of viral genomic signatures. Further molecular investigations can be performed to ascertain specific virus strain and genotypic classification. Current genotype designations for CHIKV include Central/East/South African, Asian and West African groupings. CHIKV strains implicated in the recent Indian Ocean/Mauritius outbreak of 2005/2006 belong to the Central/East/South African genotype, whilst representative East Timor and Indonesian CHIKV strains have grouped in the Asian genotype. FSS has recently isolated CHIKV belonging to both of these genotypes from viraemic patients.	FSS Public Health Virology Laboratory Brisbane





Case name: ..... First name ..... Surname ..... DOB ...../...../..... Notification ID: .....

**NOTIFICATION DECISION:**  Confirmed case .....  Probable case  
 Invalidated case – specify .....

Outcome:  Survived  Died Date of death: ...../...../.....  Died of condition  Unknown

**EXPOSURE PERIOD:** ..... to .....  
 (Onset date – 12 days) (Onset date – 2 days)

Travel history: ..... Date of arrival in Queensland: ...../...../.....

Was the case in Northern Queensland or overseas 1 – 12 days prior to symptom onset?  Yes  No  Unknown

Date of travel: ..... to ..... Places visited: .....

During this time was there contact with confirmed/suspected case(s)?  Yes  No  Unknown

Name / NID: ..... Telephone: ..... Contact type: .....

Name / NID: ..... Telephone: ..... Contact type: .....

Details: .....

Home address: .....  Screens  Air con  Day Mozzies

Work address: .....  Screens  Air con  Day Mozzies

Other significant address:

1. ....  Screens  Air con  Day Mozzies

2. ....  Screens  Air con  Day Mozzies

3. ....  Screens  Air con  Day Mozzies

**PLACE ACQUIRED:**

Queensland  Other Australian state/territory – specify .....

Unknown  Other country – specify .....

**VIRAEMIC PERIOD:** ..... to .....  
 (Onset date) (Onset date + 12 days)

Home address: .....  Screens  Air con  Day Mozzies

Work address: .....  Screens  Air con  Day Mozzies

Other main addresses:

1. ....  Screens  Air con  Day Mozzies

2. ....  Screens  Air con  Day Mozzies

3. ....  Screens  Air con  Day Mozzies

Precautions discussed:  Yes  No

**CONTACTS:**

Name	Age	Recent febrile illness	Fact Sheet Sent	Date Fact Sheet Sent
.....	.....	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	...../...../.....
.....	.....	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	...../...../.....
.....	.....	<input type="checkbox"/> Yes <input type="checkbox"/> No	<input type="checkbox"/> Yes <input type="checkbox"/> No	...../...../.....

Risk of local transmission? (Consult with Environmental Health Officer or Medical Entomologist)  Yes  No  Unknown

**COMMENTS:**

