Framework for the surveillance, prevention and control of dengue virus infection in Australia

This framework has been developed by the National Arbovirus and Malaria Advisory Committee (NAMAC), endorsed by the Communicable Diseases Network Australia (CDNA) and noted by the Australian Health Protection Principal Committee (AHPPC). The purpose of the framework is to provide nationally consistent guidance on the prevention and control of dengue. This information supplements the information provided in the Series of National Guidelines ('SoNGs') document for dengue virus (DENV) infection.

This framework captures the knowledge of experienced professionals, and provides guidance on best practice based upon the best available evidence at the time of completion.

Readers should not rely solely on the information contained within these guidelines. Guideline information is not intended to be a substitute for advice from other relevant sources including, but not limited to, the advice from a health professional. Professional judgement and discretion may be required in the interpretation and application of these guidelines.

The membership of the NAMAC, CDNA and the AHPPC, and the Commonwealth of Australia as represented by the Department of Health (Health), do not warrant or represent that the information contained in the Guidelines is accurate, current or complete. The CDNA, the AHPPC and Health do not accept any legal liability or responsibility for any loss, damages, costs or expenses incurred by the use of, or reliance on, or interpretation of, the information contained in the framework.

Endorsed by NAMAC: 27 June 2014
Endorsed by CDNA: 22 May 2015
Noted by AHPPC: 29 June 2015
Released by Health: 31 July 2015

Revision history

Version	Date	Revised by
1.0	22 May 2015	Original version developed by Dengue SoNG working group

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Introduction

Purpose

The purpose of this national framework for DENV infection is to reduce the risk of local transmission of DENV and prevent the ongoing establishment of the virus in Australia (endemicity) by:

- Strengthening monitoring of cases for any evidence of locally-acquired cases (those acquired in Australia) and information sharing between jurisdictions on cases that may have been acquired in another state/territory;
- Emphasising the need for confirmation of diagnoses for locally-acquired cases;
- Encouraging the monitoring of overseas-acquired cases and patterns of disease occurrence in other countries;
- Outlining generic messages for educating public health professionals in differential diagnoses (chikungunya, dengue, Zika virus, Barmah Forest virus, etc.);
- Documenting the risks of exotic mosquito incursions (specifically of the vectors of DENV) and define receptive areas;
- Describing surveillance for the vectors of DENV;
- Encouraging strain differentiation and the monitoring of viral evolution;
- Providing a generic response plan to facilitate the effective eradication of vectors, and prevention of transmission staged according to risk of establishment;
- Outlining research priorities and highlighting new developments in the control of the mosquito vectors of dengue, or of its transmission.

Timeframe

It is anticipated that the timeframe for this framework be five years (2014 to 2019).

Governance and legislative frameworks

The roles and responsibilities for communicable disease control in Australia are shared between the Commonwealth, State, Territory, and Local Governments, each supported by relevant legislative frameworks. State and Territory Health Departments have primary responsibility for communicable disease prevention and control programs, and response to notifications of all notifiable diseases, including DENV infection.

At the national level, the Commonwealth Department of Health (Health) works to coordinate communicable disease control activities and health emergency responses across the country, and provide public health leadership on matters of national importance. The development of a national DENV infection framework is consistent with the requirements for the National Health Emergency Response Arrangements to provide sub-plans for communicable diseases of national significance. The *National Health Security Act 2007* provides the legislative basis for communicable disease notifications in Australia and the exchange of health information between jurisdictions and the Commonwealth. The Act provides for the establishment of the National Notifiable Disease List (NNDL), which specifies the diseases about which personal information can be provided to government departments. The National Health Security Agreement supports the practical operation of the *National Health Security Act 2007* including the transfer information of disease notifications from jurisdictions to the Commonwealth.

Commonwealth legislation is implemented through the Australian Health Ministers Advisory Committee (AHMAC) and its principal committee, the Australian Health Protection Principal Committee (AHPPC). AHPPC is supported by six national expert standing committees – the Communicable Disease Network Australia (CDNA), the Public Health Laboratory Network (PHLN), the Environmental Health committee, the National Health Emergency Management subcommittee, Antimicrobial

Resistance subcommittee and the Blood Borne Virus and Sexually Transmissible Infections subcommittee. CDNA coordinates national surveillance and response to communicable disease outbreaks of national importance.

In 2001, Health established the National Arbovirus Advisory Committee (NAAC) as a technical advisory group to CDNA. In March 2003, NAAC became the National Arbovirus and Malaria Advisory Committee (NAMAC) when malaria was included in its terms of reference. NAMAC monitors arbovirus and malaria surveillance, strategic arbovirus and malaria disease management and vector control, and has a key role in making recommendations on the management of mosquito-borne disease. NAMAC provides expert technical advice to AHPPC through CDNA. It also assists in the detection, management and control of actual or potential outbreaks of arboviral and malarial disease. Members of the Committee have expertise in disease surveillance, virology, vector surveillance, vector control and quarantine, and represent agencies with a substantial interest in the area.

The role of states and territories, as agreed in the National Health Security Agreement, is to develop, strengthen and maintain the capacity of the health sector to detect, report and respond to public health events; maintain communication networks with agencies and organizations within their jurisdictions to ensure an effective response to public health events and to receive information about events requiring a nationally coordinated public health response. The public health and communicable disease responsibilities for each state and territory of Australia are enacted by their own pieces of public health legislation, typically Public Health Acts. Accordingly, the primary responsibility for public health action from a notification resides with State and Territory health departments.

Complementing the national role of NAMAC, most State and Territories manage their own mosquito-control and mosquito-borne disease programs and maintain interdepartmental taskforces or committees as part of a comprehensive response to vector borne diseases.

The Series of National Guidelines (SoNGs) have been developed by CDNA to support states and territories. The purpose of the SoNGs Guidelines is to provide nationally consistent guidance to public health units (PHUs) in responding to a notifiable disease event. These guidelines capture the knowledge of experienced professionals, and provide guidance on best practice based upon the evidence available at the time of completion. This framework includes a national guideline for DENV infection (Appendix 2 DENV infection SoNG).

The public health role of some local government is most often stated in terms of environmental health and engineering activities, for example waste management, prevention of infectious disease (including mosquito and vermin control), food safety and ensuring drinking water quality. These traditional concerns of local government are widely recognised and contribute to protecting the health of their communities. State and territory Public Health Acts confer certain powers and responsibilities to local government, and there is significant variation between jurisdictions in both public health and local government legislation. With reference to DENV infection, many state/territory governments fund local government for a range of routine environmental health measures to mitigate the risk of mosquito-borne disease, however, the vectors of DENV are absent from most of Australia, thus these species are not targeted as part of routine mosquito control programs.

Disease background

Geographic distribution

Dengue is distributed throughout the tropical and subtropical world, with an estimated 2.5 billion people being at risk of infection. About half of these people live in urban areas in tropical and subtropical regions of Asia, the Pacific and the Americas.[1] The distribution of dengue was previously more extensive, with range reductions observed in North America and Australia in particular in the last century.[2]

The distribution of dengue is limited by not only the physiological limits of the vector mosquitoes (*Aedes aegypti* and *Aedes albopictus*) and DENV, but by the availability of suitable breeding habitat

and the nature of the built human environment, which may limit contact between mosquitoes and humans.

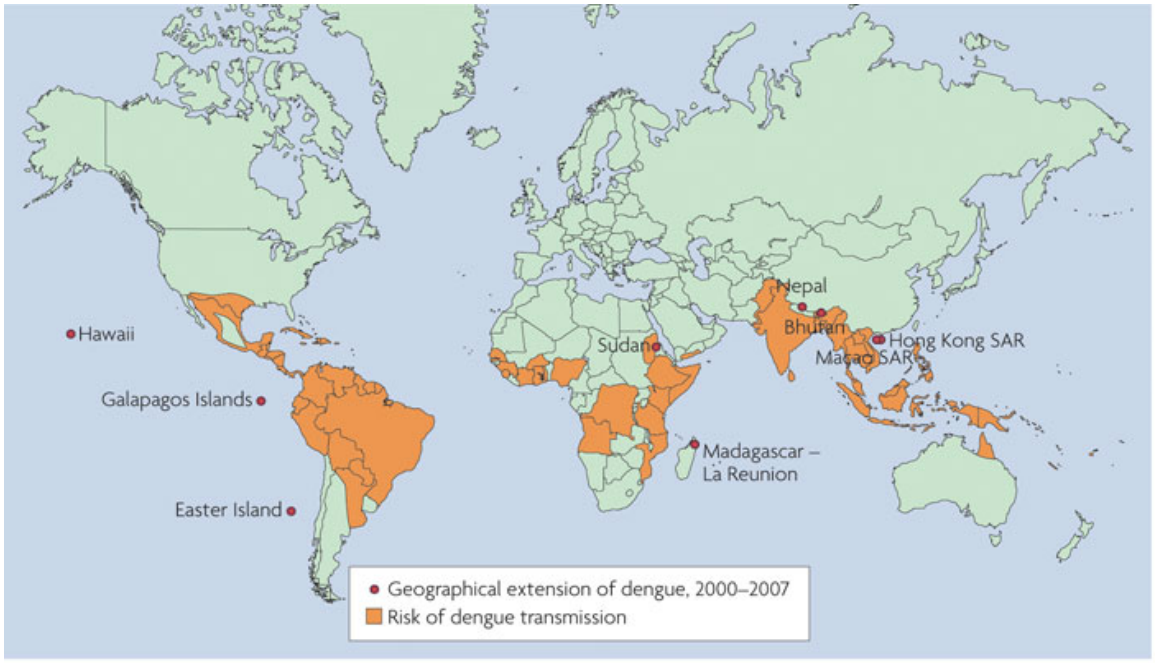
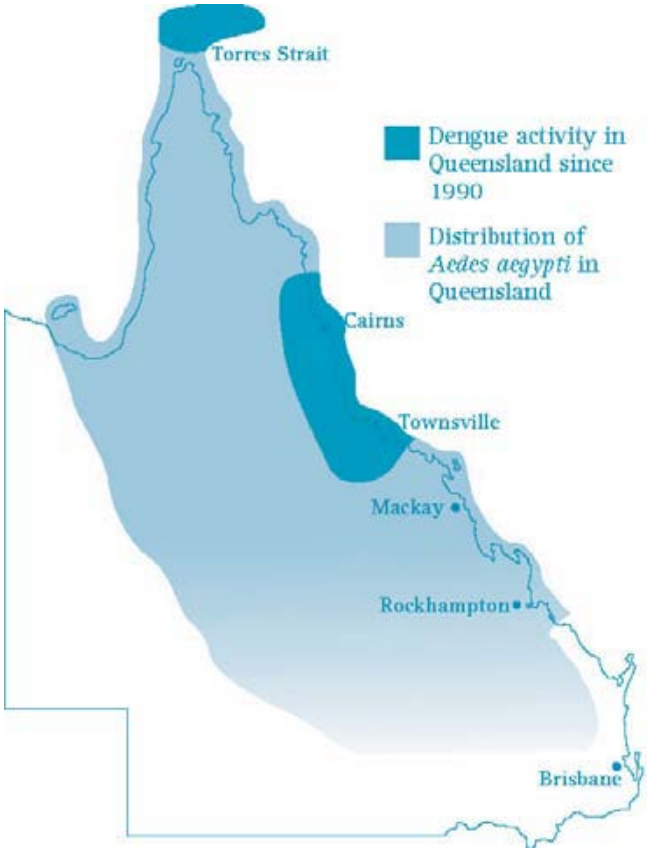


Figure 1.The global range of dengue transmission. Source: Guzman et al. 2010[1]

In Australia, DENV infection can be imported, and consequently reported, from any state or territory. However, local transmission of DENV can technically occur in any region where there are viraemic humans, competent vectors (*Ae. aegypti* and *Ae. albopictus*), and sufficient contact between them. The range in which *Ae. aegypti* occurs is extensive (Fig. 2), although it has retracted in recent decades.[2] Indeed, in recent decades, local transmission has only been reported from north Queensland, and from the Torres Strait Islands (Fig. 2).

The geographic region in which DENV transmission can occur is the 'dengue receptive range'. That is, if DENV is imported into that range, local transmission could occur. Definition of this range should be limited to the region where local transmission has been shown to occur recently (darkly shaded area of Fig. 2).

However, it remains possible that transmission could occur in other regions where the vector is present (lightly shaded area of Fig. 2). Transmission in these areas would have a lower probability of occurring.



**Note:*

- Only urban or residential environments within the shaded areas are potential receptive areas
- Data on vector distribution are patchy and subject to change

Figure 2. The distribution of *Aedes aegypti* and DENV activity in Queensland* (Source: Queensland Dengue Management Plan 2010-2015[3]).

Virology, transmission and life cycle

DENV is a flavivirus. Four serotypes of DENV have been described - dengue 1, 2, 3 and 4. Each of the 4 serotypes is capable of causing the full spectrum of clinical manifestations following DENV infection. A fifth serotype was identified in Malaysia in 2013; however the human impact of this serotype has not yet been determined.

Reservoir

Humans; non-human primates such as monkeys maintain the virus in limited forest settings of Asia and Africa.

Mode of transmission

There is no direct person-to-person transmission of DENV, but transfusion related cases can occur. Transmission is via the bite of an infective female mosquito, principally *Ae. aegypti*, which is a highly domesticated urban mosquito found in the tropics and subtropics.

Incubation period

The illness typically starts from 4 to 7 days after a person is bitten by an infected mosquito, but it can range from 3-14 days. The extrinsic incubation period (the incubation period in the mosquito) is from 8-12 days, although shorter EIPs (as low as 5 days) have been reported, leading to explosive outbreaks.[4]

Infectious period

A person with DENV infection can transmit the virus to mosquitoes from shortly before the onset of symptoms (and febrile period) to the cessation of symptoms: usually 3-5 days but can be as long as 12 days. Therefore, to reliably trace possible infectiousness to local vectors, a longer duration of viraemia is assumed, from one day before until 12 days after the onset of symptoms in the case. An infected mosquito can transmit DENV until it dies. The Australian Red Cross excludes dengue cases from donating blood until four weeks after the resolution of symptoms, and restricts donations of whole blood from areas of north Queensland whilst they are affected by dengue outbreaks.

Mosquito vectors

In Australia, DENV is almost exclusively transmitted by the highly domestic *Ae. aegypti* mosquito, which is only present in Queensland. It is prevalent in north coastal Queensland communities and been recorded in many townships in central and southern Queensland but has not been detected for several decades in south-east Queensland. *Aedes aegypti* is unusual in that is associated with domestic environments and does not often bite at night. Eggs are laid and larvae develop in artificial water-holding containers (such as buckets, tyres, pot-plant bases, roof gutters, rainwater tanks) close to or inside people's homes. *Ae. aegypti* is a non-aggressive day-biting species, with increased biting activity for 2 hours after sunrise and several hours before sunset. Humans are the preferred source of blood meals for *Ae. aegypti.*

Ae. albopictus can also transmit DENV. It is a highly invasive species and is found in some temperate regions of the world as well as the tropics and subtropics. This species is also of concern because there is a risk that it may colonise mainland Queensland and Australia. It has established in the Torres Strait following the first detection in May 2005), despite the efforts of a mosquito control program by Queensland Health and the Australian Government. *Ae. albopictus* is an aggressive day-biting species that also lives around people's homes. It breeds in artificial containers and some naturally occurring sites such as tree holes and coconut shells. Adults prefer to rest in heavily-shaded outdoor sites; and the female takes blood from a wide range of mammals.

Susceptible hosts

Humans. There are also both Old and New World non-human primates that can develop disease and maintain sylvan (forest) transmission cycles in parts of Asia and the Americas.

Factors affecting the dengue life cycle

Factors affecting the life cycle of dengue and the risk of human infections include vector density, the presence of viraemic cases, human population density and demographics. In Australia, DENV is only transmitted in regions where *Ae. aegypti* and, potentially, *Ae. albopictus* is present. Currently this is limited to urban areas in Queensland north of Charters Towers. The geographic range of these two mosquito species is subject to change, as the action of climatic change or human agency may lead to contraction or expansion of these species' ranges. Such alterations may impact the seasonality, distribution and intensity of DENV transmission in the future. The EIP of DENV is temperature dependent, with higher temperature increasing the rate of virus dissemination and subsequent transmission.

Epidemiology

Dengue has been nationally notifiable since 1991, with imported cases being reported from Australian jurisdictions each year since that time (except that the Australian Capital Territory did not report in 1991 and 1992). Larger peaks in incidence are apparent every 4-6 years, with national incidence typically less than 5 per 100,000 (Fig. 3). Incidence in Queensland has followed a similar pattern of peaks through time, although the incidence is notably higher, occasionally more than 20 per 100,000. Incidence in smaller regional centres where DENV may be locally transmitted (cities such as Cairns and Townsville) will be much higher again. Notified cases reported in Fig. 1 are a mixture of imported

and locally acquired cases (restricted to Queensland). Peaks in Queensland reflect local transmission outbreaks. Noteworthy amongst these was the 2008-09 outbreak, comprising more than 1000 locally-acquired cases. Since 2009, there has been an upwards trend in DENV notifications Australia-wide, which is related to increases in notifications of overseas-acquired dengue infection, particularly infections acquired in Indonesia.[5]

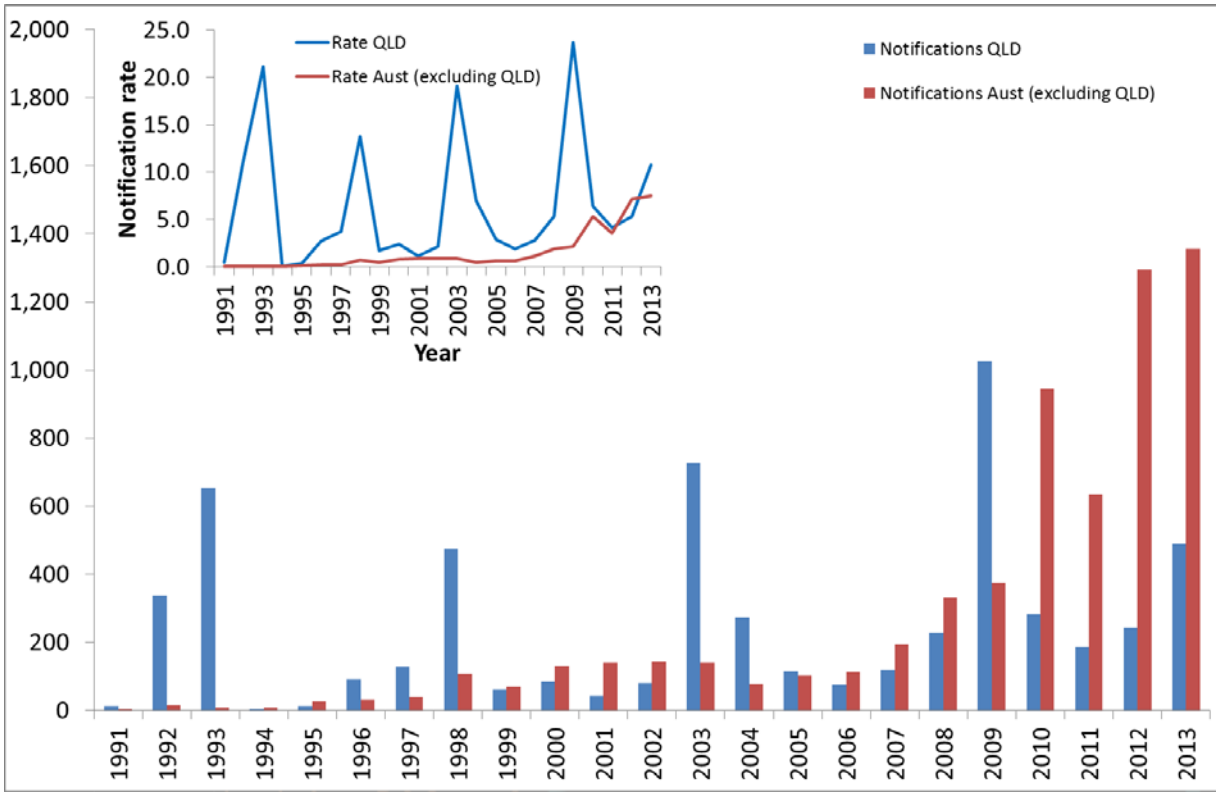


Figure 3. Incidence of DENV infection notifications in Australia and Queensland, 1991-2013. Source: National Notifiable Diseases System (data retrieved 17 March 2014).

Clinical features and natural history of disease

Infection with DENV can produce a wide clinical spectrum of disease, ranging from a mild febrile illness through to a severe, even fatal condition such as dengue haemorrhagic fever (DHF) or severe dengue. The clinical syndrome experienced can be influenced by both age and immunological status.[1, 6] Most children infected with DENV experience mild, undifferentiated febrile illness or asymptomatic infection. For those that develop recognisable signs and symptoms, the clinical course and severity of the disease can be difficult to predict early in DENV infection.[1, 6] Typical symptoms of classical dengue include the sudden onset of fever (up to 40°C) accompanied by headache, retro-orbital pain, muscle pains in back and limbs and rash (erythematous, maculopapular or petechial). Other symptoms include lethargy, weakness, depression, anorexia, taste aberrations (e.g., an unpleasant metallic taste), sore throat, cough, vomiting, abdominal pain and possibly minor haemorrhagic manifestations such as epistaxis, menorrhagia, haematuria and gingival bleeding. Hospitalisation may be required depending on signs of severity such as dehydration, bleeding or comorbidities. Hepatitis is a frequent complication. DHF and severe dengue generally manifest as plasma leakage leading to shock and can be fatal, and occurs more frequently among children and young adults.

Laboratory diagnosis

<u>Testing for dengue disease in humans</u>

There are a number of diagnostic options for dengue disease in humans and the choice of test varies depending on the number of days post onset, and diagnosing laboratory practice. These include:

NS1 antigen test: a highly sensitive and specific test for DENV, this can be used to detect very early infections (as early as 1 day post-infection). However, as an antigen test it cannot detect past (historical) infections (> 18 d). The non-structural antigen (NS1) test can be used to differentiate from other suspected flavivirus infections due to its specificity. It does not distinguish between dengue serotypes.

ELISA kits for DENV antibodies: Enzyme linked immunosorbent assay (ELISA) can provide a rapid result but is not specific for dengue; a positive result could indicate a cross-reaction or a recent flavivirus infection other than dengue. IgG ELISA is used for detection of recent or past dengue infections in acute and convalescent paired sera but is not specific for dengue and should be interpreted carefully within the context of the clinical illness and exposure history.

In Australia, much of the testing of human sera for evidence of DENV infection in a variety of State Pathology and private diagnostic laboratories involves the use of commercially-available antibody kits. Detection of IgM by enzyme immunoassay (EIA) is usually positive if samples are taken 5 days or more after onset of fever, and it persists for several months. Dengue IgG appears shortly afterwards and persists indefinitely. Whilst these kits measure antibodies to DENV, flavivirus IgG is highly cross-reactive, so the tests will also be positive as a result of a range of other flavivirus infections. IgM is more specific, but still shows substantial cross-reactivity with IgM due to other flavivirus infections. A significant rise in IgG or seroconversion indicates recent infection, but is not specific for dengue unless confirmed by a specific IgG test such as neutralizing antibody titres. Neutralizing titres can also be used to identify the infecting serotype and to distinguish between primary and secondary dengue. In the latter situation the acute serum will contain antibody to the previously infecting serotype, while the convalescent serum will demonstrate a rise in antibody to the currently infecting serotype.

Test results should be interpreted carefully within the context of the clinical illness and exposure history. These kits are useful for diagnosing DENV infection in regions where the virus is endemic or during proven epidemics, when the likelihood of illness being due to dengue is relatively high. In Australia, where DENV is not endemic and prevalence of past infection is much lower, the use of such kits with low specificity increase the risk of false positive results that may be misleading for health authorities. Wherever possible they should be confirmed by NS1 antigen or PCR positivity.

In-house EIAs have been developed in some Australian laboratories and the interpretation depends on the design and performance characteristics of those assays. Currently there are no EIA assays that can reliably distinguish between dengue antibody and that due to other flaviviruses.

Nucleic acid testing: PCR diagnosis for dengue is now common and is performed by reference laboratories. PCR can provide a rapid result (within a day of receipt) and allows the infecting serotype to be identified. Its sensitivity is high (80-100%) in detecting virus during the acute phase of the illness although the viral RNA is affected by transport and storage conditions. Therefore specimens of whole blood, serum, plasma and tissues for PCR need to be refrigerated at 4 to 8°C. A 'detected' dengue PCR test is confirmation of a recent dengue virus infection. A 'not detected' result however, must be interpreted with caution and in conjunction with antigen detection, IgM and IgG results.

Testing for dengue virus in vectors

Adult female *Ae. aegypti* can be tested for DENV by PCR. Methods of collecting mosquitoes are described below.

Surveillance in humans and virus surveillance

Surveillance for dengue in humans is primarily by notification of infections by medical practitioners and laboratories. Clinical surveillance is effected by medical staff recognising dengue symptoms, assessing the likelihood of exposure through recent travel history or proximity to a known local outbreak, ordering the correct test at the appropriate time in relation to the onset of the illness, and notifying vector control staff for timely deployment of vector control. The development of other virus

surveillance measures, such as detection of virus in the field in collections of mosquitoes or preservation of virus in nucleic acid preserving cards is plausible but not yet developed.

National Surveillance Case Definition for Dengue

The National surveillance case definition for dengue is available on the Department of Health's website.

Vector surveillance

Monitoring for *Ae. aegypti* and *Ae. albopictus* breeding can be conducted using adult or egg traps (ovitraps) or sampling flooded containers (tyres, buckets, birdbaths, sump pits, rainwater tanks, etc.). With the exception of monitoring programs at international ports, most Australian communities will not need a dedicated *Ae. aegypti* and/or *Ae. albopictus* monitoring program as the vectors are not currently present. Nevertheless, surveillance for early detection of vectors in susceptible locations is a priority. In areas of high risk for importation and establishment of these two species, state government and/or local authorities should establish regular surveys.

In areas of high risk or where *Ae. aegypti* (or *Ae. albopictus*) is already present, frequent surveys should be conducted. Traps that target adult *Ae. aegypti and Ae. albopictus* include the BGS trap, sticky ovitraps and the Gravid Aedes Trap (GAT). Standard ovitraps harvest eggs laid by gravid females. Sweepnet sampling has been used to capture *Ae. albopictus* in the Torres Strait.

High population densities of vectors should trigger container surveys and source reduction (see Vector Control). Promotional campaigns and social media could also help elicit reports and photographs of potential day-biting *Ae. aegypti* and *Ae. albopictus* that could be followed up by health workers.

Vertebrate, vector and climate surveillance in States and Territories

General information about mosquito-borne disease surveillance and control activities in each jurisdiction is summarised in the NAMAC Annual Report, published in the *Communicable Diseases Intelligence* journal.

For more detailed information, local jurisdictions should be contacted (see Appendix 6).

Prevention and Control

In dengue receptive regions of Queensland the activation of seasonal 'authorised prevention and control programs' is vital in providing health authorities (State and/or local) access into yards of residential and commercial premises.

Vector control

In dengue receptive areas, an outbreak prompts urgent and intensive mosquito control activities in and around contact addresses identified by the travel history and where the cases may have been viraemic. This aims to eradicate virus by killing infected and infective adult females within a radius of about 200 metres – the distance a vector might fly.[3] The primary dengue vector, *Ae. aegypti*, is highly urbanised and bloodfeeds and harbours within premises. Thus, control measures consist of indoor residual spraying using synthetic pyrethroid insecticides such as bifenthrin and deltamethrin. Truck mounted outdoor ultra-low volume or thermal foggers are not effective against *Ae. aegypti* hidden indoors. Water filled containers are treated with insect growth regulators (e.g. methoprene pellets), Bti or pesticide sprays. Tipping out or removal of containers (source reduction) is effective but laborious and not efficient during large outbreaks. It will not address breeding sites that are cryptic (e.g. drain sumps, roof gutters, telecommunication pits) or rainwater tanks. The response when an outbreak occurs is outlined in Appendix 3 and documented in the Queensland Dengue Management Plan (DMP).[3]

The DMP also outlines vector control strategies for point source versus large widespread outbreaks. This is critical because dengue can spread very rapidly, and lack of case presentation and/or diagnosis and delays in notification r have led to explosive outbreaks.

If the exotic *Ae. albopictus* is a suspected vector, outdoor ULV and harbourage/barrier sprays of well-shaded leaf litter and undergrowth using residual pyrethroids is effective. Larvae should be controlled as with Ae. aegypti, although natural containers such as treeholes and coconut husks should also be treated.

Public Health Response Plans

General principles of responding to dengue surveillance signals

Dengue can be imported via viraemic travellers into any region of Australia. Travellers may have visited a region internationally with known dengue activity, or been in parts of north Queensland where local transmission is known to occur each year. However, the public health response to the arrival of these travellers should be different for different parts of Australia, depending on the presence or absence of suitable dengue vectors.

Responding to dengue surveillance signals in Queensland

In Queensland, the risks and nature of appropriate responses is described in the Queensland Dengue Management Plan, and this document should be used to guide responses in dengue receptive areas. However, the risk of transmission is not homogeneous throughout the State and response protocols are based on tropical coastal north Queensland, where *Ae. aegypti* is ubiquitous and seasonally abundant. The dengue receptive area (defined in Fig. 2 above) is restricted to areas where the vectors, *Ae. aegypti* and *Ae. albopictus* currently exist.

Other areas in Queensland where *Ae. aegypti* exists but no recent local dengue transmission has been recorded may present a finite, albeit small risk of on-going transmission. The determination of transmission risk for central and southern Queensland is difficult due to the lack of vector population data for most locations, beyond occasional and *ad hoc* larval surveys that do not reflect the dynamic nature of risk based on environmental and behavioural variables. The inadequacy of using larval indices to generate disease transmission risk is well documented overseas. Queensland Health is in the process of transitioning to the use of adult traps (including Gravid Aedes Traps) to provide a mechanism for assessing vector abundance in regional areas and to enable localised assessments where and when virus has entered the community.

Further challenges to the quantification of transmission risk may require the use of models that incorporate climatic and biological variables (e.g. mosquito longevity, abundance, dispersal capability, type and abundance of breeding sites and virus incubation periods).

Local dengue transmission in SE Qld would require the validation of suspect vectors, and activate emergency eradication plans for *Ae. aegypti* and exotic vectors, particularly *Ae. albopictus*.

Responding to dengue surveillance signals in other states and territories

Any case of dengue in Australia requires a public health unit to investigate the likely source of the infection, whether overseas or in Australia, and if within Australia, the specific region of acquisition. Therefore, all cases must be interviewed. The lack of reported dengue transmission outside of Queensland in the last 60 years should not be interpreted as a permanent circumstance. The increased frequency of dengue importations, the proliferation of rainwater tanks in urban areas and the persistence of *Ae. albopictus* in the Torres Strait indicate that the risk of dengue transmission may change with the importation and establishment of suitable vectors, changes to environment and climate, and various other anthropogenic factors that may increase vector abundance and distribution. Indeed, the geographic range of dengue transmission throughout Australia has

historically been much more extensive than at present.[7] An overview of public health interventions in response to these dengue surveillance signals is described in Figure 4.

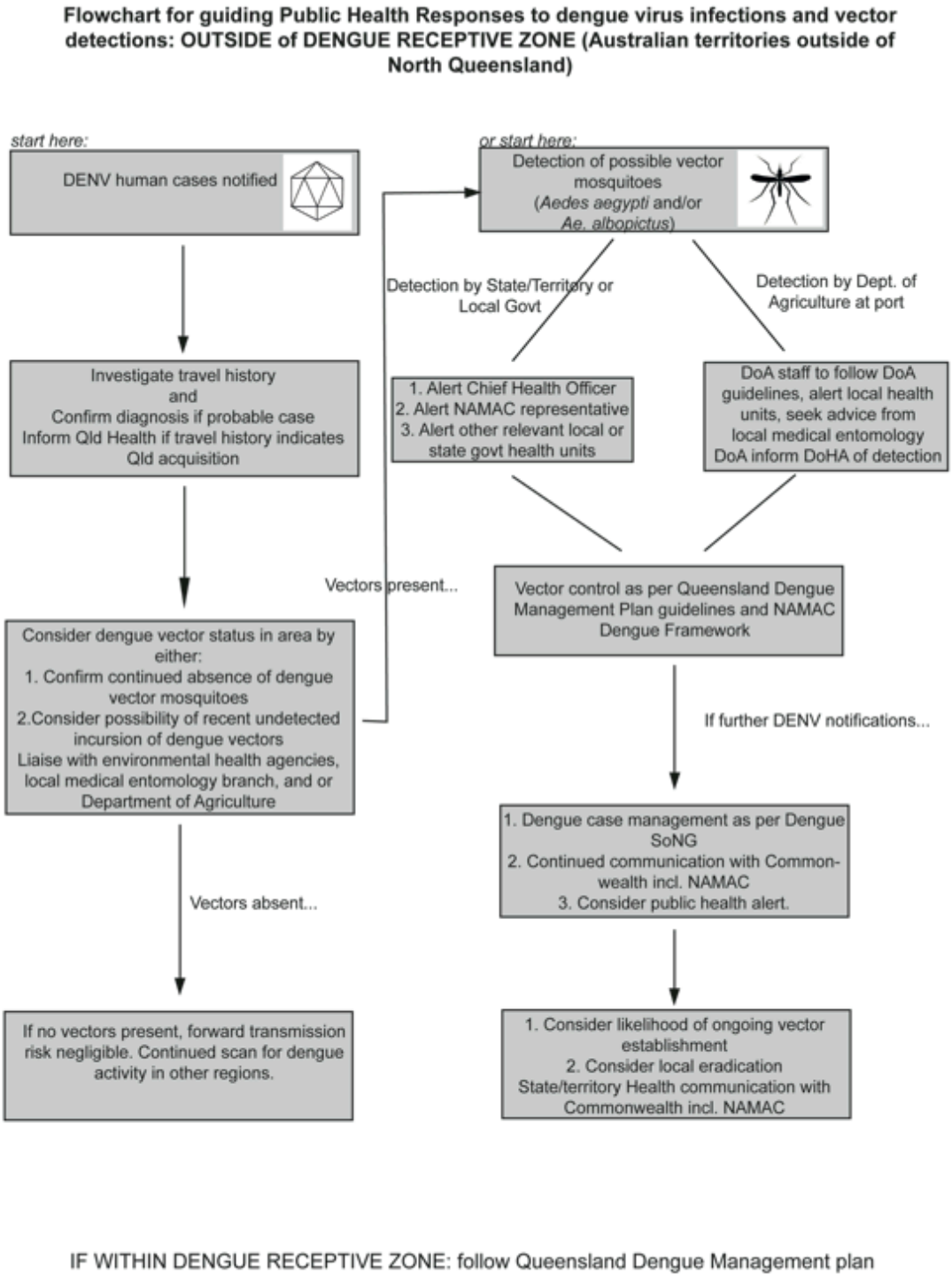


Figure 4. Flowchart for guidance of public health unit responses to dengue surveillance signals.

Outbreaks and epidemics

Where a case of dengue is acquired in Queensland and diagnosed in another state or territory, the public health response will be initiated by the diagnosing state or territory advising Queensland Health

of the case. An outbreak response is also required for any detection of local transmission outside of Queensland (such isolated instances have previously been described). There is also the possibility of outbreaks of local infection where there is an incursion of mosquito vectors. The steps of defining and closing an outbreak (Figure 5) are outlined below.

Figure 5: Declaring and closing outbreaks outside of dengue receptive and dengue potential areas (responses in north Queensland and areas in Qld where *Ae. aegypti* is endemic should refer to the Queensland dengue management plan)

Define an outbreak

1. Assembling outbreak response team

Consider assembling an outbreak response team. In States or Territories this may consist of Public Health staff, medical entomologists, and state or local government EHOs and the Australian Government Department of Agriculture. Staff experienced in arbovirus control should be consulted. Should the outbreak response team require expert advice it can contact NAMAC through the secretariat.

2. Defining outbreak response teams

Define outbreak response team, regional and State/Territory reporting lines, roles and responsibilities. An outbreak management team (OMT) ideally would include essential stakeholders from disease control, epidemiology, medical entomology, vector-control, environmental health, infectious disease, primary health care, laboratory, health promotion and communications personnel.

Outbreak closure

Three considerations for outbreak closure are: scaling down the response based on outbreak information, deciding when to declare an outbreak is over, and planning operational debrief including an outbreak report.

Scaling down response: Pool information from collaborating agencies to determine when risk has declined sufficiently.

When/how to conclude: No evidence of new human infections acquired in the preceding 6 weeks; AND/OR; eradication of mosquito vectors.

Debrief: Within a reasonable time frame of the outbreak concluding, all parties involved in the outbreak should meet to debrief and determine possible improvements for future responses. In the case of an outbreak in multiple jurisdictions, the debrief should be coordinated by CDNA or AHPPC as appropriate. Outbreak closure should include a write-up of the debrief. A descriptive report and a publication of the outbreak should take place if noteworthy.

Appendix 4 contains a brief guide to outbreak investigation and management. This is supported by Appendix 5, which contains examples of escalating public health warnings or measures in an outbreak setting.

Roles and responsibilities in an outbreak of national concern

In situations where locally-acquired human cases of dengue are occurring in multiple jurisdictions or extensively in south eastern Australia, there will be a need for national leadership and coordination by AHPPC, CDNA and Health.

The *National Health Security Act 2007* provides for the National Health Security Agreement between the Commonwealth and State and Territory governments, setting out arrangements to support its practical operation. The Agreement has been developed to establish a framework for events requiring

a coordinated national response and describes the roles of the States and Territories, Commonwealth and AHPPC (including its sub-committees) in coordinating a national response.

If considered a national outbreak (large outbreak of national importance or multiple States/Territories involved):

- AHPPC coordinates a strategic response, convenes outbreak management team or emergency response committee
- CDNA coordinates and implements surveillance and response
- Health coordinates national data management and reporting to support CDNA surveillance and response
- States and Territories are responsible for operations in their jurisdictions
- NAMAC provides expert advice to AHPPC, through CDNA.
- Health coordinates liaison with Department of Agriculture Biosecurity officers
- Health coordinates media and communication
- If requested by States/Territories, Health coordinates additional resources

The National Health Emergency Arrangements (NatHealth)

The NatHealth Arrangements direct how the Australian health sector (incorporating state and territory health authorities and relevant Commonwealth Agencies) would work cooperatively and collaboratively to contribute to the response to, and recovery from, emergencies of national consequence.

The NatHealth Arrangements may be utilised in response to a domestic or international event that:

- impacts or threatens to impact two or more states and/or territories and across jurisdictional borders;
- has the potential to overwhelm or exhaust a state and/or territory's health assets and resources; or
- its scale or complexity warrants a nationally coordinated response.

The NatHealth Arrangements may also be utilised for an international health emergency such as a border health event or overseas health emergency affecting Australian interests, Australian nationals or other designated persons.

Policy and Research

Evidence-based public health policy is essential for development and delivery of disease prevention measures, reductions in health disparities and improvements in the health of vulnerable populations. Policy development is linked to continued investment in research and applied research that allows evaluation of current measures and promotes innovation of new disease prevention interventions.

Policy

National and jurisdictional policy for arboviral disease control needs to be evidence based, coordinated, relevant and supported by legislative frameworks. Considerable progress has been made in the last decade including the establishment of NAMAC, introduction of legislation that supports

sharing of information and national coordination of outbreaks, and the development of national surveillance case definitions and nationally consistent response guidelines for public health units managing human cases of dengue. States and Territories have continued to support and improve their own dengue surveillance, prevention and control activities.

Policy framework

A jurisdictional arbovirus or dengue policy or plan would ideally address the following:

- Formal establishment of an interdepartmental committee or taskforce (by agreement or Memorandum of Understanding) to oversight surveillance, prevention and control of mosquito-borne disease, including dengue. Membership should represent Medical Entomology, laboratory representatives and public health authorities

- Coordination of human and vector surveillance activities including mechanisms for cross-border surveillance

- Coordination of laboratory capacity and sharing of resources between laboratories

- Communication protocols in response to certain events (i.e. surveillance signals) – to intrastate, interstate and/or national counterparts

- Standard outbreak management plans including roles and responsibilities, allocation of funds for investigation and response

- Mechanisms to coordinate human, vector and ecological research priorities

Research

A detailed description of the proposed research activities is given in Appendix 5.

References

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Appendices

1. Dengue SoNG: Guidelines for public health units in responding to notified case of dengue disease in humans
2. Emergency interventions and control for environmental health practitioners
3. Outbreak investigation and management
4. Triggers for escalation of public messages (example)
5. Dengue research priorities
6. List of reference laboratories for identification of dengue vector mosquitoes

Appendix 1 Dengue SoNG Guidelines for public health units in responding to notified case of dengue in humans

The purpose of the SoNGs Guidelines is to provide nationally consistent guidance to public health units (PHUs) in responding to a notifiable disease event. These guidelines capture the knowledge of experienced professionals, and provide guidance on best practice based upon the evidence available at the time of completion. This framework includes a national guideline for dengue infection.

Appendix 2 Emergency interventions and control for public health practitioners

The Queensland Dengue Management plan describes intervention and control methodology for dengue outbreaks.

Appendix 3 Outbreak investigation and management

Define an outbreak

1. Assembling outbreak response team

Consider assembling an outbreak response team. In states or territories this may consist of Public Health staff, medical entomologists, and state or local government EHOs. Staff experienced in arbovirus control should be consulted. If the outbreak response team require expert advice it can contact NAMAC through the secretariat.

2. Defining outbreak response teams

Define outbreak response team, regional and state/territory reporting lines, roles and responsibilities. An outbreak management team (OMT) ideally would include essential stakeholders from disease control, epidemiology, medical entomology, vector-control, environmental health, infectious disease, primary health care, laboratory, health promotion and communications personnel.

Responding to outbreaks includes investigation and management. Although they occur concurrently, they are presented separately.

Outbreak investigation

The goal of the investigation is to identify the source of infection and potential risk factors for illness, thereby informing public health action.

Below are the steps to be taken in identifying the source of an outbreak. Most of these steps will occur concurrently.

1. Humans

<u>1.1 Assessment of a possible case should include:</u>

- Clinical presentation: Signs and symptoms and their compatibility with dengue
- Laboratory tests: Ensure that relevant tests are conducted and confirm results by utilising multiple testing methods and/or have a second laboratory perform diagnostics on samples. Consider the need for confirmatory laboratory tests in a second laboratory. A differential diagnosis of CHIKV or ZIKV should also be considered.
- Patient interview and Contact tracing by a public health nurse to determine likely address and date of acquisition, travel history, mosquito biting, whether case is locally acquired or imported, other addresses and other acquaintances who may be ill.

<u>1.2 Case finding/enhanced surveillance:</u>

- Consider conducting risk assessment to define the population at risk.
- Contact local hospitals and general practices to advise them of the case/s and to ascertain whether other people are possibly affected, noting usual symptoms.
- Consider media involvement to assist in alerting the community to the case/s.

2. Vectors

- Review any previous surveys of vector species and their spatial and temporal abundance to attempt to identify at-risk areas (data may not be available).
- Consider an extension of any routine surveillance (e.g. additional sites, more extensive or frequent sampling).
- Evaluate relative numbers and population densities of vector species in at-risk areas.
- Ascertain the results of any virus isolations (by tissue culture or viral antigen detection by PCR) that have been done from these mosquito-trapping locations.

3. Virus: isolates in human and vector species

- Analyse previous virus isolation from region.
- Isolate and identify virus from patients to determine dengue type
- Consider molecular analysis of virus isolates to match with known isolates (dendrogram) to identify the source of the dengue virus.

4. Environmental factors

- Examine relevant weather data including local and regional rainfall and temperature. Periods of high temperature (> 32°C) shorten the EIP and speed dengue transmission leading to large outbreaks (Ritchie et al. 2013 http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0068137.

Outbreak management

Management is differentiated from investigation in these guidelines, although both are likely to occur concurrently. Below are the actions that should be taken to prevent further spread of the outbreak.

1. Human disease management

No specific treatment is available for DENV infection and care is largely supportive. Management of patients should be discussed with a physician with experience in DENV infection, and if indicated, general clinical guidelines should be developed, in collaboration with infectious diseases physicians.

2. Reducing/preventing transmission

To reduce/prevent virus transmission, interruption of human/mosquito contact should be attempted by:

2.1 Vector control

The aim of vector control for dengue is to eliminate exotic mosquito vectors following an incursion, or, in areas where *Ae. aegypti* is known to occur, to eradicate virus by reducing the numbers of this vector in dengue response zones.

Goals are as follows:

- Rapidly reduce adult populations of the Aedes vector using IRS or harbourage spray. Adult populations should decrease by at least 80% for 4-6 weeks within a week of treatment.

- Consider concurrent deployment of an extensive array of traps to kill adults (e.g. lethal ovitraps).

- Concurrently conduct thorough larval control sweeps, treating artificial containers. .

- Map control data in a GIS or similar database.

- Monitor adult *Ae. aegypti* or *Ae. albopictus* in treated areas to confirm efficacy (NB not usually done in each dengue response zone in N Qld).

- Maintain close links and communication with public health clinicians about any suspected dengue cases. Ensure appropriate training of staff likely to be deployed. Consideration should be given to doing this prior to an outbreak (if one is predicted or expected).

2.2 Human avoidance of mosquitoes

Mosquito avoidance messaging is generally only relevant in north Queensland, but may be useful outside of north Queensland for localised public health messaging in local areas in the event of an incursion of DENV vectors. Consider involvement of the media to help inform people on how to avoid mosquito contact. Media methods could include social media, posters in public places, newspaper articles and commercials on TV or radio. Given public resistance to current dengue media prevention messages in north Queensland, further in-depth social research is required to understand the drivers underpinning community behaviours.

Information to be communicated by media and others involved in the outbreak response could include:

- Employ personal protection measures, such as using repellent, coil and plug in insecticide vaporisers, during the day especially indoors.

- Spray dark areas inside premises (such as inside wardrobes, behind entertainment centres, under tables and beds) with a residual surface spray.

- Notify the public of any enacted legislation that may provide health worker right-of-entry to their property.

- Please let health workers conduct interior residual sprays inside your home or building.

- Inspect yard and remove or empty any containers holding water.

- Ensure roof gutters, sump pits and rain water tanks are appropriately cleaned and/or sealed (and notify of any penalties).

- Ensure window and doors screens are in good condition.

- Consider closing outdoor recreation areas at night.

2.3 Enhancing surveillance

- Human surveillance should be enhanced to help identify new cases.

- Vector surveillance should also be enhanced where relevant; consider collection of adult females for PCR testing.

- Encourage people with symptoms to present to a doctor.

In the event of an outbreak of DENV infection in a particular area or region outside of north Queensland, health departments and the *International Health Regulations* (2005) National Focal Point in the Department of Health (health.ops@health.gov.au) should be notified so that further investigation of potential vectors, reservoirs and co-infected people can be organised. The National Focal Point will assess the need to notify the WHO of the outbreak under the IHR (2005).

Appendix 4 Triggers for escalation of public messages (example)

During an expanding outbreak, public health authorities might need to escalate recommended public health measures and associated public messaging. The potential triggers or decision points are provided below as an example.

Example triggers for escalation of public messages outside of north Queensland

<table>
<tr><th>Example Scenario</th><th>Requirement for public health messaging</th><th>Messages</th></tr>
<tr><td>Isolated DENV case with known travel history to endemic areas</td><td rowspan="3">Nil</td><td rowspan="3">Nil</td></tr>
<tr><td>Incursion of vector within a contained area within a Port</td></tr>
<tr><td>Sporadic notifications of overseas acquired infections at expected levels</td></tr>
<tr><td>One case of DENV infection in a given area with no history of travel</td><td rowspan="2">Local area messaging</td><td>May initiate public health messaging to find further cases</td></tr>
<tr><td>Localised incursion of mosquito vector, or higher than usual vector activity in areas where Ae. aegypti is known to occur</td><td>Mosquito avoidance, control of breeding sites.</td></tr>
<tr><td>Confirmed local transmission of dengue</td><td rowspan="3">Regional/state/national messaging</td><td>Raise awareness in order to find further cases</td></tr>
<tr><td>Mosquito vectors have become established locally, or multiple incursion sites in areas in proximity to residential areas.</td><td>Mosquito avoidance, control of breeding sites.

Emphasise avoiding outdoor events in the late afternoon and early morning.</td></tr>
<tr><td>Increased notifications of dengue acquired overseas, particularly if a large number of cases from a new area.</td><td>Mosquito avoidance, seeking medical advice if unwell on return from overseas</td></tr>
</table>

Appendix 5 Dengue research priorities

Virological studies:

- Isolate and sequence active DENV, and relate to virulence and EIP
- Describe epidemiology of notable outbreaks

Entomological studies:

- Optimisation of surveillance activities in locations at risk of incursion of vectors, including investment in the translation of operational research outcomes to field adoption.
- Evaluate the role of *Wolbachia* infections in limiting dengue outbreaks following releases.
- Evaluate the use of wMelPop *Wolbachia* infections for engineering local eradication of *Ae. aegypti* in Queensland towns, particularly in Central and Southern Queensland.
- Develop auto-dissemination tools for use of the IGR pyriproxyfen for control of cryptic breeding sites.
- Develop new control methods for adult *Aedes*, particularly use of metofluthrin to prevent biting and kill *Aedes* inside homes.
- Development of new monitoring tools and networks for *Ae. aegypti* and *Ae. albopictus*, with initial field trials of the GAT to replace standard ovitraps.
- Enhancement of genetic marker technologies and increase reference collection of DNA-sequenced *Ae. aegypti and Ae. albopictus* to trace the origins of mosquito incursions.
- As resistance to the pyrethroids have been described in *Ae. aegypti*, consider adding resistance monitoring.

Climate and environmental studies:

Climate and environmental studies to inform modelling of the future range of mosquito vectors.

Laboratory aspects:

Development of robust serological assays, including developing the ability to distinguish between primary and secondary infections.

Publicity and Communication Interventions:

Develop and test use of media and social media to monitor for exotic *Aedes.*

Appendix 6 Public health reference laboratories for diagnosing human infections, and entomology reference laboratories for confirmation of vector identification

Commonwealth Scientific and industrial Research Organisation (CSIRO)

CSIRO Australian Animal Health Laboratory
Private Bag 24 (5 Portarlington Road)
Geelong Victoria 3220
Phone: (03) 5227 5000

Web site (http://www.csiro.au/Organisation-Structure/National-Facilities/AAHL.aspx)

New South Wales

Serology Section, CIDMLS
Institute of Clinical Pathology and Medical Research (ICPMR)
Westmead Hospital
Locked Bag 9001
Westmead NSW 2145
Phone: (02) 9845 6255

Department of Medical Entomology, CIDMLS
Institute of Clinical Pathology and Medical Research (ICPMR)
Westmead Hospital
Locked Bag 9001
Westmead, New South Wales 2145
Phone:(02) 9845 7265

Web site (http://medent.usyd.edu.au/)

Northern Territory

Department of Primary Industries and Fisheries (DPIF)
Makagon Rd, Berrimah, Darwin
Northern Territory 0828
Phone: (08) 8999 5511

Web site (http://www.nt.gov.au/d/Primary_Industry/)

Medical Entomology
Department of Health
Royal Darwin Hospital
PO Box 41326
Casuarina NT 0811

Queensland

Qld Health Forensic and Scientific Services
39 Kessells Road
Coopers Plains
PO Box 594 Archerfield Qld 4108
Phone: (07) 3274 9151

Web site (http://www.health.qld.gov.au/qhcss/qhss/)

South Australia

Mosquitoes and Public Health Research Group (entomology)
School of Pharmacy and Medical Sciences
University of South Australia
North Terrace Adelaide
South Australia 5001
Phone: (08) 8302 1906

Web site (http://www.unisa.edu.au/research/sansom-institute-for-health-research/research-at-the-sansom/research-concentrations/mosquitoes-and-public-health-research-group/)

Victoria

Victorian Infectious Diseases Reference Laboratory (Human)
10 Wreckyn Street
North Melbourne Victoria 3051
Phone: (03) 9342 2600
Web site (http://www.vidrl.org.au/)

Department of Economic Development, Jobs, Transport and Resources
AgrioBio, Latrobe University
5 Ring Road
Bundoora Victoria 3086
Phone: (03) 9208 3333

Web site (www.economicdevelopment.vic.gov.au)

Western Australia

PathWest Laboratory Medicine WA
Division of Microbiology and Infectious Diseases (Human)
Hospital Avenue
Nedlands Western Australia 6009
Phone: (08) 9346 3122

Web site (http://www.pathwest.com.au/index.asp)

Arbovirus Surveillance and Research Laboratory
Discipline of Microbiology and Immunology (animal/vector)
School of Pathology and Laboratory Medicine
The University of Western Australia
35 Stirling Highway
Crawley Western Australia 6009
Phone: (08) 9346 2212

Web site (http://www.marshallcentre.uwa.edu.au/research/arbovirus)