

# Dengue Control in North Queensland, Australia: Case Recognition and Selective Indoor Residual Spraying

by

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## Abstract

A large epidemic of dengue in Townsville and Charters Towers, north Queensland, Australia, initiated the development of a Dengue Fever Management Plan for north Queensland (DFMP) in 1994. The DFMP integrated disease surveillance, vector control and health promotion activities to prevent dengue outbreaks. While initially successful in preventing the recurrence of epidemic dengue in north Queensland, a protracted epidemic of DEN-3 in the Cairns area led to a revision of the DFMP in 2000. The revised DFMP placed emphasis on the early recognition of cases and development of a specialized Dengue Action Response Team (DART) to conduct selective indoor residual spraying with pyrethroid insecticides to control the vector, *Aedes aegypti*. Since the launch of the DFMP 2000, dengue outbreaks have been contained in terms of the areas affected, duration of the outbreak and the total number of cases despite an increase in recognized dengue activity.

**Keywords:** Dengue epidemic, DEN-3, Dengue Action Response Team, selective indoor residual spray, *Aedes aegypti*, Australia.

## Introduction

North Queensland, Australia, has been subjected to outbreaks of dengue since the late 19th century<sup>(1)</sup>. Following a large outbreak of DEN-1 in 1981, an *Aedes aegypti* control programme was implemented in north Queensland between 1982 and 1985<sup>(2)</sup>. Although the populations

of *Ae. aegypti* were reduced, funding for the programme ceased in 1985. Coincidentally, international airports were opened in the cities of Cairns and, later, Townsville in north Queensland at about that time. This increased the likelihood of viraemic travellers arriving from endemic countries directly into urban centres in the dengue receptive region of Australia.

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Therefore, it was not surprising that, with no organized dengue control programme in place, an unrecognized importation of DEN-2 into Townsville in 1992 led to an explosive (and very large) epidemic in that city<sup>(3)</sup>. It ultimately spread to the nearby town of Charters Towers, where an estimated 26% of the population was infected<sup>(4)</sup>.

## The 1994 Dengue Fever Management Plan for north Queensland

Following the 1992-93 dengue epidemics, Queensland Health, in collaboration with Dr Duane G Gubler of the Centers for Disease Control and Prevention, along with a range of stakeholders including local government, medical, laboratory and academics, developed a structured Dengue Fever Management Plan (DFMP) for north Queensland. The plan detailed integrated strategies, namely, disease surveillance, vector control and health promotion, to prevent dengue outbreaks and to ensure that the virus was eliminated from north Queensland, preferably before local transmission had occurred. Underpinning the plan was the need for laboratory surveillance for the early detection of cases, particularly imported ones, followed up with rapid and thorough vector control. The ultimate success of the plan relied upon successful vector control through a collaborative effort between local government environmental health officers and Queensland Health personnel. The strategies and the collaborative efforts successfully limited an outbreak of DEN-2 in Cairns in 1995 to only four cases<sup>(5)</sup>.

As an alternative to outdoor ultra-low volume spraying, selective indoor residual

spraying of households of cases was first utilized in north Queensland during a large outbreak of DEN-2 in the Torres Strait in 1996-97<sup>(6)</sup>. *Ae. aegypti* harbours in dark, sheltered areas such as under beds and tables and inside closets in premises<sup>(7)</sup>. Selectively treating these sites with a residual pyrethroid insecticide, such as deltamethrin or lambda-cyhalothrin, effectively reduced *Ae. aegypti* activity, and therefore dengue virus transmission, in foci of dengue activity during the outbreak<sup>(8,9)</sup>. Furthermore, the residual activity of lambda-cyhalothrin is high. In a field bioassay, 10 female *Ae. aegypti* in WHO bioassay cones were exposed to wood and a cotton/polyester cloth treated with lambda-cyhalothrin (Demand SC 2.5% AI diluted at 16 ml/litre water) for 10 minutes; over 90% mortality was achieved up to 45 days post-treatment (S Ritchie and S Long, unpublished data).

## The 1997-1999 DEN-3 Epidemic

Although the strategies in the 1994 DFMP had been satisfactory for nearly five years, a large and protracted epidemic of DEN-3 in Cairns, Port Douglas and Mossman in 1997-1999 proved very difficult to control<sup>(8)</sup>. The epidemic demonstrated that the dengue virus could spread very rapidly via the movements of viraemic individuals to initiate multiple foci of the disease that could not be adequately controlled using conventional methods. It also demonstrated the importance of 'ignition' premises, such as backpacker hostels, that catered to a rapid turnover of a high volume population of travellers who could import the virus, and of 'dissemination' premises, such as schools, that could lead to the rapid dispersal of the dengue virus throughout a community via

infected students and staff. Cryptic breeding sites, including subterranean sites such as sump pits<sup>(10)</sup> and elevated roof gutters<sup>(11)</sup>, were an important source of *Ae. aegypti*. Not surprisingly perhaps, the DEN-3 virus evaded eradication, and eventually this led to staff 'burnout' and staff shortages that, in turn, severely hampered the vector control activities. During the outbreak, it was demonstrated that a single treatment of *Ae. aegypti* resting places<sup>(7)</sup> (e.g. dark, protected areas such as under tables and beds, inside wardrobes, etc.) inside premises using lambda-cyhalothrin (Demand SC, 2.5% AI at 16 ml/litre water) effectively reduced *Ae. aegypti* populations; the mean number of *Ae. aegypti* eggs per ovitrap in treated vs. untreated areas was 2.2 vs. 12.5, respectively, a significant ( $P < 0.05$ ) difference<sup>(8)</sup>.

## The Dengue Action Response Team

In December 1998, Queensland Health established the Dengue Action Response Team (DART), a trained specialist team of three personnel. The sole responsibility of the DART was to implement *Ae. aegypti* prevention and control strategies, including, where necessary, the selective indoor residual spraying of premises. The DEN-3 epidemic ended within three months of the DART commencing activities.

## Elements of the current DF management plan for north Queensland

In 2000, a revised DFMP ("Dengue Fever Management Plan for North Queensland,

2000-2005") (DFMP 2000) was launched to incorporate new strategies, including those to be implemented by the DART. The objectives of the DFMP 2000 are: (i) to recognize dengue cases as rapidly as possible through not only laboratory but also clinical surveillance; (ii) to respond to dengue cases, both imported and locally-acquired, with thorough and sustained vector control aimed at eliminating the dengue virus before it can spread to other urban foci; and (iii) to use a variety of education initiatives to maintain community awareness of dengue, its mode of transmission, and the need for individuals to take action to prevent *Ae. aegypti* breeding in households and business premises.

## Disease surveillance

Between December 1994 and May 2002, there were 69 notifications of the importation of dengue where the traveller was viraemic (and therefore infectious to *Ae. aegypti*) while in north Queensland. All four serotypes of the dengue virus were imported during this time. The numerous outbreaks in the 1990s (Figure) reflect the necessity to identify imported viraemic cases as quickly as possible. Dengue is a notifiable disease in Australia, and as such, the Tropical Public Health Unit (TPHU) should be notified of a case by laboratories or physicians. Because many imported viraemic cases are not promptly notified to the TPHU<sup>(12)</sup>, local *Ae. aegypti* may be infected and on the wing before control measures can be initiated. Furthermore, several of the dengue outbreaks had no known origin, indicating that many imported dengue cases go unrecognized.

Although serologically false positive results remain a problem, the timeliness of

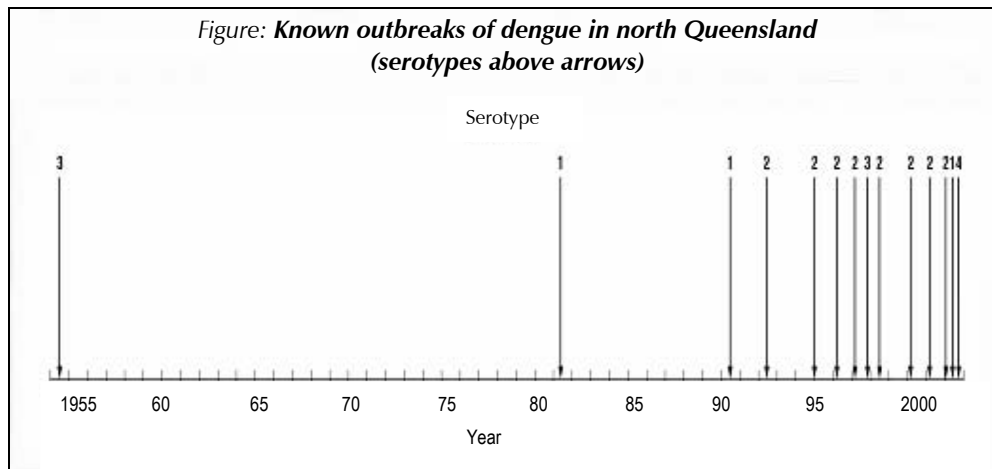
laboratory testing for dengue has improved in recent years. Serological tests have been augmented by rapid immunochromatographic card or dipstick tests, while the polymerase chain reaction test has supplanted virus culture to detect dengue virus in serum, giving quicker results yet still providing valuable genetic sequencing information. Finally, careful patient interviews by public health nurses are needed to establish the patient's travel history, particularly whether a case is imported or locally acquired, and points of contact where the patient may have infected mosquitoes.

## Vector control

Upon the notification of either a dengue IgM +ve test result or a suspected imported case, the DART makes an immediate response. The points of contact (usually the case's residence and place of work) are mapped, and the intended vector control activities detailed. The DART conducts selective indoor residual spraying and larval

control/source reduction activities within 100 metres of a contact point, while local government personnel conduct larval control in a zone 100-200 m from these premises. Larval control includes removal of small containers while larger containers are treated with S-methoprene pellets<sup>(13)</sup> or sprayed with aerosol surface sprays<sup>(14)</sup>. Particular care is placed upon the identification and treatment of cryptic subterranean<sup>(10)</sup> and elevated<sup>(9,11)</sup> breeding sites, such as sump pits and roof gutters, respectively. If multiple dengue cases are reported in a particular area, the response zone is expanded. Field data are recorded onto a palm-top computer, then imported onto a Geographical Information System (GIS) for mapping response activities, the latter particularly useful for follow-up treatments.

Between outbreaks, the DART conducts preventive larval control activities at ignition and dissemination premises, such as backpacker accommodation and schools, respectively.



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## Health promotion

Health promotion plays two critical roles in the DFMP 2000. Firstly, during a dengue outbreak, publicity in the form of media advisories, delivered by local media, are used to inform the public about areas with active dengue transmission. Residents are advised to take precautions by clearing households and backyards of any obvious breeding sites, using surface sprays to kill adult *Ae. aegypti* and taking personal protective measures to avoid being bitten. Secondly, a television-based mass media campaign is run on a paid schedule during the wet season to educate the public about dengue<sup>(15)</sup>. The domestic habits of the vector and how to control it are discussed, along with symptoms and consequences of the disease. Programmes to educate school children have also been developed.

## Success of the DFMP 2000

Since the implementation of the DFMP 2000, five outbreaks of dengue that occurred in north Queensland have all been

relatively easily contained, and very little locally-acquired dengue has been detected beyond the initial focus of activity (Tables 1, 2). Furthermore, the number of cases acquired after the initiation of control efforts has been limited and the duration of outbreaks reduced. The latter is critical in helping to maintain a focused effort by dengue control staff; the burnout during the 70-week DEN-3 epidemic in 1997-99 contributed to the duration and spread of the outbreak<sup>(8)</sup>. We consider that early case recognition, coupled with selective indoor residual spraying of cryptic resting sites and intense larval control efforts, are instrumental in the success of the plan to date.

The utility of the current DFMP was also evident in early 2000 when approximately 2000 Australian Defence Force personnel and aid workers returned from duty in East Timor to north Queensland. Despite at least eight viraemic importations of dengue occurring in these personnel, focused and collaborative responses ensured that not one of these cases led to subsequent local transmission<sup>(9)</sup>.

**Table 1:** Dengue outbreaks in north Queensland before the revised (2000) Dengue Fever Management Plan for north Queensland

Dengue serotype	Affected areas, dates (reference)	Duration (weeks)*	Cases before control measures	Cases after control measures began	Total no. of cases	No. of foci of transmission
2	Cairns, Feb 1995 <sup>(5)</sup>	6	1	3	4	1
2	Torres Strait, Dec 96-Feb 97 <sup>(6)</sup>	29	49	159	208	6
2	Cairns, Dec 97-Feb 98 <sup>(9)</sup>	11	6	6	12	3
3	Cairns, Port Douglas, Mossman Dec 97-March 99 <sup>(8)</sup>	70	20	478	498	15

\* Time in weeks from onset of first case until onset of last known case.

**Table 2:** Dengue outbreaks in north Queensland after the revised (2000) Dengue Fever Management Plan for north Queensland

Dengue serotype	Affected areas, dates (reference)	Duration (weeks)*	Cases before control measures	Cases after control measures	Total no. of cases	No. of foci of transmission
2	Cairns, Feb 2000 <sup>(9)</sup>	6.7	17	33	50	1
2	Townsville, April-May 2001 <sup>(16)</sup>	3.2	09	0	09	2
2	Kuranda, March-April 2002	9.0	18	3	21	1
1	Townsville, April 2002	0.4	02	0	02	1
4	Cairns, May 2002	3.0	02	0	02	1

\* Time in weeks from onset of first case until onset known case.

## Future challenges

A substantial risk of outbreaks of dengue in north Queensland remains despite the success of the DFMP 2000. Up to June, three albeit small outbreaks occurred in 2002 in north Queensland (Figure). Significantly, they were all of different origin and, indeed, involved different serotypes of dengue viruses (DEN 1, 2 and 4). In addition, over the same five months, there were five viraemic importations notified. None of these importations was associated with the three outbreaks; it is likely that significant numbers of importations go unrecognized. Can the intensity demanded by the DFMP, and the resurgence of dengue activity since 2000, be maintained by DART and other TPHU staff? Will the public get fatigued of the dengue education campaigns and outbreak alerts? Will selective indoor residual spraying lead to insecticide resistance in *Ae. aegypti* and can novel

control methods, such as removal trapping, be used to counter insecticide resistance? These are some of the issues that will challenge health staff in their efforts to continue to control dengue in north Queensland.

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