Rafael Maciel-de-Freitas & Denise Valle

Dengue vector control, Boa Vista, Brazil

Challenges encountered using standard vector control measures for dengue in Boa Vista, Brazil

Rafael Maciel-de-Freitas\textsuperscript{a} & Denise Valle\textsuperscript{b}

\textsuperscript{a}Laboratório de Transmissores de Hematozoários, Instituto Oswaldo Cruz-Fiocruz, Fiocruz, Av. Brasil, 4365, Manguinhos, Rio de Janeiro, Brazil, CEP 21040-360.

\textsuperscript{b}Laboratório de Biologia Molecular de Flavivirus, Instituto Oswaldo Cruz-Fiocruz, Rio de Janeiro, Brazil.

Correspondence to Rafael Maciel-de-Freitas (email: macieldefreitas@gmail.com).

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Abstract

\textbf{Problem} In 2010, dengue virus (DENV) serotype–4 was detected during a dengue outbreak in the Amazonian city of Boa Vista. At that time Brazil was already endemic for DENV-1, DENV-2 and DENV-3. This was the first time DENV-4 was observed in the country after it was initially detected and eliminated in 1981.

\textbf{Approach} To hinder the spread of DENV-4 throughout Brazil, standard vector control measures were intensified. Vector control professionals visited 56 837 households in 22 out of 31 districts of Boa Vista, to eliminate mosquito-breeding sites. Water storage containers were treated with the larvicide diflubenzuron, and deltamethrin was sprayed for adult \textit{Aedes aegypti} mosquitoes. Fifteen days later, a second larvae survey and additional deltamethrin applications were performed.

\textbf{Local setting} In Brazil, dengue vector control is managed at all three government levels. Regular surveillance of \textit{Aedes aegypti} is done four to six times a year to strengthen mosquito control activities in areas with high-vector density. Educational dengue control campaigns in communities are scarce, especially between outbreaks.

\textbf{Relevant changes} In spite of extensive implementation of all standard control actions recommended by the Brazilian dengue control programme, only a slight decrease in mosquito density was detected.

\textbf{Lessons learnt} There is a need to redesign all levels of dengue control. Public consultation and engagement, behaviour change and actions that go beyond technical impositions are required. Vector control programme managers need to reflect on what constitutes good practices and whether information campaigns are effective measures for dengue prevention and control.
Introduction

Dengue is currently the arbovirus affecting the highest number of people worldwide. The World Health Organization (WHO) estimates that 50–100 million dengue infections occur annually, and that about 2.5 billion people are at risk of infection.\(^1\) Currently, there are four distinct serotypes of the dengue virus (DENV) that infect humans.\(^1\) Infection of one dengue serotype induces permanent immunity against that serotype, but not against the others. A person infected with the virus for the first time can develop high fever together with rash or headache and eye, joint, muscle or bone pain. However, a sequential infection with another serotype increases the risk of developing severe dengue, with potentially deadly complications.

In 1981, a dengue outbreak caused by DENV-1 and DENV-4 occurred in Boa Vista in northern Brazil. Local vector control measures were able to contain the virus, probably because of the geographic isolation of Boa Vista at that time. However, since the introduction of DENV-1 into the State of Rio de Janeiro in 1986, dengue has become a nationwide public health problem, with more than 60% of all Latin American cases of dengue occurring in Brazil.\(^2\) Since then, also DENV-2 and DENV-3 have been detected in Rio de Janeiro State first, highlighting this area as the port of entry and dissemination of DENV in Brazil.\(^3\)

In a 2010 dengue outbreak in Boa Vista, DENV-1 and DENV-2 were co-circulating. At the end of the outbreak, DENV-4 was detected in the serum sample from a patient who had presented clinical symptoms seven weeks before (Fig. 1). This was the first time DENV-4 was observed in Brazil after it was initially detected in Boa Vista in 1981.\(^4,5\)

Approach

Immediately after the confirmation of DENV-4, intensification of regular vector control actions were started in Boa Vista to reduce the density of *Aedes aegypti* and hinder dissemination of this serotype in the country. Standard vector control protocols, recommended by the Brazilian dengue control programme, were followed.\(^6\) Source reduction was performed in all houses in 22 out of 31 districts of Boa Vista. These districts, which covered 75% of all habitations, included all those where DENV-4 cases had been diagnosed or there had been a history of repeated dengue outbreaks. After householders had given oral consent, all potential breeding sites
identified in each dwelling were inspected for larvae by vector control professionals. Whenever possible, potential breeding sites were removed, as recommended by WHO.7 Permanent water containers (e.g. tanks, wells and pools) were treated with diflubenzuron.8 Larvae samples were brought to the laboratory to identify the species. A second larval survey was conducted 15 days later in 10% of the habitations of the same 22 districts. As in the first survey, these actions were accompanied by vehicle-mounted ultra-low volume sprayer to administer 2% deltamethrin against adult mosquitoes.9

Local settings
All three government levels (federal, state and municipality) share the responsibility for dengue control in Brazil. The federal level provides guidelines for vector control, allocates resources to the states and purchases insecticides and equipment, such as vehicles and ultra-low volume sprayer to support chemical control. The states assist and supervise municipalities, acquire consumables and small equipment, such as nylon nets or lids for water tanks or mosquito traps, and gather information about the municipalities to notify the Health Ministry. The municipality is responsible for operations such as management of vector control professionals and actions, following central level recommendations. In practice, this shared responsibility can reduce the efficiency of vector control; for example, decision-making processes can be bureaucratic and time-consuming.

In Brazil, routine surveillance of Ae. aegypti is based on the larval index rapid Aedes assay. This assay consists of random sampling of a proportion of dwellings (3.5–4%) per district over a period of up to one week and is performed to get a snapshot of the infestation scenario. The assay is performed four to six times each year in the municipalities most affected by dengue. Larval registers are used as an Ae. aegypti infestation indicator.10 These registers take into account both house index (i.e. number of positive houses per total of inspected houses) and Breteau index (i.e. number of breeding sites per total of inspected houses). Mosquito control activities are then strengthened in the areas with higher mosquito density.

In Brazil, ultra-low volume space spraying is recommended only during dengue outbreaks.7 However, mosquito adulticides are used as the primary vector-control tool in some municipalities, resulting in high pyrethroid resistance rates.11
leading to decreased chemical control effects during outbreaks when the adulticides are most needed.

During periods between epidemics, few resources are allocated to increase awareness of the affected communities regarding the importance of dengue prevention and almost no regular educational efforts are conducted. One exception was the “D-Day Against Dengue”, a mobilization initiative originally performed once a year, just before the dengue season. This campaign was abandoned because it encouraged people to have good dengue practices on one day each year, rather than continually.

**Relevant changes**

Confirmation of DENV-4 in Boa Vista led to the rapid formation of a committee with municipal, state and federal health secretaries, which ensured that all standard control actions recommended by the Brazilian dengue control programme were accomplished.

Intensification of vector control in Boa Vista included inspection of 56,837 houses, 10% of them visited again 15 days later. 94,325 containers were removed from these houses or treated with diflubenzuron. Most positive containers (601/1017) were classified as miscellaneous receptacles (usually domestic garbage items that could become small isolated breeding sites). Concomitantly, ultra-low volume deltamethrin spraying was done in the affected areas. However, only a slight decrease in vector density was detected; the house index was reduced from 1.7 before interventions to 1.37 immediately after the second survey. This reduction did not result in a significant change in the seasonal dynamics of dengue, when taking into account the history of cases in the municipality (Fig. 1). This could be due to highly-productive cryptic containers that were not inspected by vector control professionals. Additionally, the rapid twofold to threefold increase in the resistance rate of the local *Ae. aegypti* adults indicates a strong selection of resistant mosquito populations due to intense insecticide application. These results highlight the low efficacy of standard recommended vector control measures.

**Lessons learnt**

In Boa Vista, simply intensifying routine vector control measures to stop DENV-4 spreading throughout Brazil was unsuccessful. The low efficacy of these measures in reducing *Ae. aegypti* density points to the need to change the control programme at all
levels (Box 1). There are no simple solutions, but it is expected that the basis of effective actions for prevention and control will be changes in behaviours and attitudes of both dengue control managers and the affected population, with a strong commitment to eliminating breeding sites and avoidance of contact with mosquitoes. An example of more effective dengue control measures comes from Singapore, where in 2004–2005, a massive community initiative was carried out by volunteers from government agencies and nongovernmental organizations to eliminate breeding habitats. This initiative was coupled to a strong interagency dengue task force and is a well known example of a powerful reduction of infestation levels and, consequently, of a highly-significant decrease in the incidence of dengue outbreaks.\(^12\)

The challenge in rapid, efficient and large-scale control of *Ae. aegypti* is to change current strategies and what are seen as good practices. For instance, where insecticide resistance is high at baseline, insecticide use during an outbreak should be reconsidered. Also, assuming that insecticides will be the primary means of vector control delivers a false sense of security to the local community and confuses overall vector control with chemical vector control. The use of insecticides must be considered as just one of the available measures for vector control and not the primary strategy to keep vector density low. Currently, new approaches to reducing dengue transmission are being tested, such as an endosymbiotic bacterium or transgenic mosquitoes.\(^13,14\) Although development of such strategies must be encouraged, it should not be forgotten that these complement good sanitation and health behaviour practices.

Brazil’s current dengue vector control programme is designed and run by the government and individuals are not usually encouraged to take responsibility for appropriate and continuous dengue control in their own dwellings. Given the *Ae. aegypti* life-cycle, inspection of all houses in all metropolitan regions is not feasible and vertically structured programmes have proved to have a low chance of success.\(^15\)

Using current standard measures to urgently control for infestation during a dengue outbreak has been shown not to work. Effective control throughout the year will be achieved only if dengue control moves towards a more participative focus. Starting community-based control programmes in the low-transmission season may also help to keep mosquito density below a critical threshold during periods of high transmission.
In Boa Vista, as in several other municipalities, most receptacles containing larvae are small containers (i.e. domestic garbage cans). Therefore, community engagement efforts that focus on waste reduction, allied with appropriate removal of garbage, would decrease the availability of these breeding sites and, potentially, *Ae. aegypti* density.

Local input is needed to identify the best way to raise awareness and empower residents to accomplish effective and sustainable dengue prevention. Where a local community joins dengue-prevention activities, highlighting practical actions in their own dwellings and neighbourhoods, vector control efforts will improve. Effective dengue control requires public engagement with committed vector control professionals.

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None declared.
References


**Box 1. Summary of main lessons learnt**

- A proactive attitude of both public health managers and the general population towards the correct identification and elimination of vector breeding sites is still the cornerstone of dengue prevention.

- In *Ae. aegypti* control, the complementary nature of chemical insecticides and new technologies against adult mosquitoes must be kept in perspective to avoid the loss of the effectiveness of such tools.

- Attempts to block outbreaks using insecticides in locations where resistance has been detected previously will rapidly increase and disseminate resistant vectors, hampering the effectiveness of insecticides for a long time.
Fig. 1. Dengue in the city of Boa Vista, Brazil, 2004–2013

Notes: Bars indicate the number of confirmed dengue cases per epidemiological week in 2010. The numbers above the bars represent persons reporting the first symptoms of dengue that were later confirmed as dengue-4. The first dengue-4 case was confirmed at week 31. The line represents mean dengue incidence in Boa Vista between 2004 and 2013.