

# Changing Pattern of Dengue Transmission in Singapore

by

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## Abstract

Dengue is a re-emerging disease of concern in many parts of the world. In Singapore, an integrated vector control programme, incorporating source reduction, law enforcement and public education, has been in place since 1970. This programme resulted in a period of very low incidence of dengue in Singapore between 1974 and 1985. From 1986, however, there has been a resurgence of the disease where the trend of the annual incidences is similar to that of other countries in the region. This occurred despite the vector control programme. Two epidemiological features were observed during this period. Firstly, the resurgence affected mainly adults with very few cases among children. Secondly, there were about 1.6 times more male than female cases. A recent seroepidemiological study carried out to investigate the low incidence of dengue in children found a very low seroconversion rate. More interestingly, the results suggested that the transmission of dengue in Singapore was occurring in non-residential areas. This study examined the preponderance of male dengue cases in the Singapore population between the years 1998 and 2000.

**Keywords:** DF/DHF, morbidity male/female, transmission, residential/non-residential areas, Singapore

## Introduction

Dengue fever (DF) and dengue haemorrhagic fever (DHF) are caused by dengue viruses, of which there are four antigenically related but distinct serotypes. They belong to the genus *Flavivirus*. Dengue is an important mosquito-borne viral disease that is re-emerging in many parts of the world<sup>(1)</sup>. The viruses are transmitted by the

*Aedes* mosquitoes, principally *Aedes aegypti*. In the absence of an effective dengue vaccine and antiviral drug, reduction of the *Aedes aegypti* population is the method of choice for controlling dengue.

In Singapore, a well-established mosquito-control programme, incorporating source reduction, public-health education and law enforcement, has been in place

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since the 1970s. This resulted in a period of very low dengue incidence between 1974 and 1985<sup>(2)</sup>. There was, however, a resurgence of dengue from 1986 onwards despite the control measures where the national *Aedes* spp House index (HI), which is a measure of the percentage of houses positive for *Aedes* breeding, remained below 2%. Most of the reported cases were in the young adult population with a very low incidence rate in young children. Over 70% of the cases in the year 2000 were aged 25 years and above. This was in contrast to the late 1970s where only approximately 30% of the cases were aged 25 years and above.

To explain this epidemiological observation, Goh suggested that the successful mosquito control measures resulted in a population of young adults with low herd immunity to dengue viruses<sup>(3)</sup>. That, however, does not explain why children, who are most susceptible to infection, are not presenting with the disease. A recent serological study<sup>(4)</sup> showed that this low dengue incidence rate in young children was not due to asymptomatic infection but that children were not being infected. Furthermore, there was a significant rise in the seroconversion rate in children aged 6 years and older and this coincided with the start of formal schooling. This result suggests that there may be a change in the location where dengue is acquired whereby those that spend more time away from home are at greater risk of dengue infection<sup>(4)</sup>.

Besides affecting mainly adults, it has also been observed that there are more male than female dengue cases reported in

Singapore where the male to female morbidity ratio for dengue was 1.6:1 in this period of resurgence<sup>(5)</sup>. Until now, there has been no study conducted to explain this epidemiological observation. Since the pathogenesis of the dengue disease could be due to the immune response to the viral infection, it is possible that the difference in the incidence rates of dengue in males and females in Singapore is due to the physiological differences between males and females. However, based on the findings of the serological study<sup>(4)</sup>, we hypothesize that the transmission of dengue viruses is occurring in places away from residences and that the preponderance of male cases is a consequence of the social structure of the society.

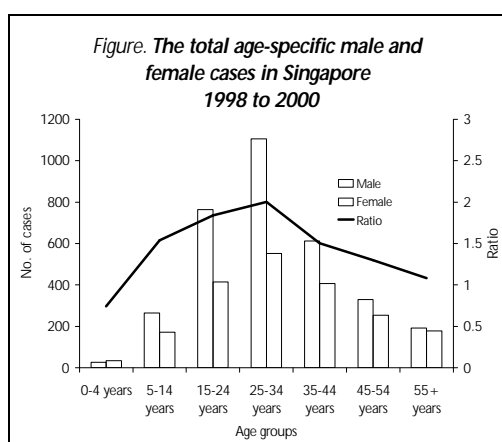
## Methods

Dengue was made a legally notifiable disease since 1967. Since 1998, however, the details of the reported cases are captured in an electronic database maintained by the Quarantine and Epidemiology Department, Ministry of the Environment. In this study, all cases of dengue among local residents from 1998 to 2000 were included. The cases were categorized according to age groups and gender.

A nationwide population census was conducted in 2000. The census reported details of the structure of the Singapore population, including the population demographics of our workforce. Advance release of the data collected during this census is available at the Department of Statistics' website.

## Results

The total number of cases included in this study was 5,310, of which 3,297 were males and 2,013 females. The overall male to female ratio was 1.6:1. However, in the age groups 0 to 4 years and 55 years and above, the ratios were 0.7:1 and 1.1:1, respectively (Figure). These populations consist of young children and largely retirees who are likely to spend more of their time at home. In contrast, the age groups between 15 and 54 years showed a large male preponderance (Figure) with an overall male to female ratio of cases of 1.7:1 (Table).



Data from the population census conducted by the Singapore Department of Statistics in 2000 showed that there are almost equal numbers of males and females in Singapore. In total, there are 1,630,293 males and 1,632,916 females (male to female ratio = 0.99:1). This indicates that the difference in the proportion of male to female cases was not due to the difference in the proportion of males and females in the total Singapore population. The census also reported more males than females in the working population. The number of

working males was 876,050 as compared to 569,550 working females. This population had an age range from 15 years onwards, with the majority between 25 and 54 years.

**Table.** Analysis of the dengue cases in the working age group

Morbidity features	Male	Female
Total cases among 15 to 54-year-olds	2813	1628
Ratio of male cases to female cases	1.73	1
Total working population	876,050	569,550
Ratio of total cases among working males to total cases among working females	1.1	1

The data were then analyzed using the gender-specific working population numbers as the denominators instead of the total male/female population. The calculated dengue morbidity rates for those aged between 15 to 54 years and the male to female ratio of dengue rates was nearly equal (1.1:1) (Table). This indicated that the difference in the male to female morbidity ratio for dengue was due largely to the difference in the proportion of males and females in the workforce.

## Discussion

Singapore is a city-state where the majority of the population in the working age group is employed. Most of the population lives in high-rise apartments. The workday commonly starts at around 8.30 am and ends in the early evening. This implies that

during the peak biting periods of the *Aedes* mosquitoes, which is in mid-morning and early afternoon, most of the adult population would either be on the way to work or at work. Our findings in this study, as well as those in the earlier serological study, indicated that the likelihood of dengue infection increased with more time being spent away from home.

The reason for the change in the places where the transmission of dengue occurs could be due to our vector control programme. Extensive studies done by Chan and colleagues<sup>(6)</sup> showed that most of the *Aedes* breeding occurred in residences as indicated by the HI data collected in 1966-68: slum houses, 27.2%; shop houses, 16.4%; and apartments, 5.0%. In contrast the HI data published in 1997<sup>(7)</sup> showed that most of the breeding was in non-residential areas such as construction sites, 8.3%; factories, 7.8%; and vacant premises, 14.6%. The residential properties had very low HI: landed residences, 2.1%; apartments, 0.6%. It may thus be possible that the vector control programme has successfully reduced the *Aedes* mosquito density in residences. In response, however, the mosquitoes have adapted to the vector control programme and now breed and hence feed in places other than residences.

Some authors have reported a slight excess of adult females cases as compared to males in dengue outbreaks<sup>(8,9)</sup>, while others have found varying male to female morbidity ratios<sup>(10,11)</sup>. Excess of cases in females and pre-school children have been attributed to the dengue transmission occurring at home, while other findings have not been fully explored. This is the first report studying the predominance of male cases in Singapore.

The resurgence of dengue in Singapore from 1986 affected mainly adults and spared the children. Together with our previous study<sup>(4)</sup>, the results from this study strongly indicated that dengue transmission in Singapore may occur largely away from home.

In conclusion, the difference in the male to female morbidity rates was associated with the difference in the proportion of working males and females, indicating thereby that the risk of dengue increased with the increasing time spent away from home.

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