

Epidemiology of Dengue in Singapore - Current Situation

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Abstract : There has been a resurgence of dengue fever/dengue haemorrhagic fever (DF/DHF) cases in Singapore in recent years. Following the large outbreak in 1973 with 1,187 cases and 27 deaths, the incidence of DF/DHF declined with minor bi-annual outbreaks occurring in 1978, 1980 and 1982. Beginning from 1986, however, the DF/DHF situation changed for the worse when outbreaks of increasing size occurred almost annually. In the past 3 years, there were 1,733 cases in 1990, 2,179 cases in 1991 and 2,878 cases in 1992. In the 1991 and 1992 outbreaks, 93–95% of the notified cases required hospitalization and 92–95% of them were serologically confirmed by the IgM capture ELISA and/or the commercial Dengue Blot assay. The number of fatal cases, however, remained low with 3–6 reported deaths in the three outbreaks.

All age groups were affected with the highest morbidity rate in children and young adults between 15 and 24 years of age. In contrast, in the earlier 1973 and 1978 outbreaks, more patients below the age of 15 years were observed. There was a slight predominance among males and Chinese had the highest morbidity rate compared with Malays and Indians.

The recent outbreaks occurred mainly in highly populated urban and suburban areas in the eastern, northeastern and southeastern parts of the island. Patients living in landed property such as compound houses had a 9X higher morbidity rate than those living in high-rise flats.

Cases were reported throughout the year and the number increased during May and June. The increased DF/DHF incidence was preceded by an increase in the *Aedes* mosquito population. In the 1991 and 1992 outbreaks, although the overall *Aedes* house index was <1 for both *Ae aegypti* and *Ae albopictus* higher indices were detected in localized areas with high dengue transmission. The proportion of compound houses found breeding *Ae aegypti* was 3–4 times and *Ae albopictus* 7–10 times higher than that of flats. The major breeding habitats were ornamental and domestic containers and discarded receptacles.

INTRODUCTION

Singapore is experiencing a resurgence of major outbreaks of dengue fever/dengue haemorrhagic fever (DF/DHF) and a changing epidemiology of the disease. Following the

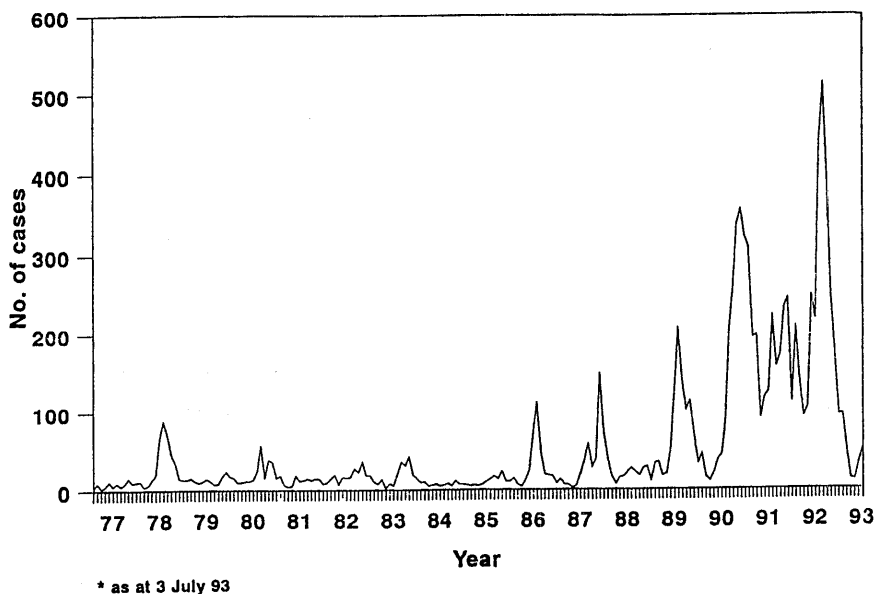


Fig. 1. Reported incidence of dengue fever/dengue haemorrhagic fever in Singapore*
* as at 3 July 1993.

large outbreak in 1973 with 1,187 cases and 27 deaths, the incidence of DF/DHF declined with only small outbreaks occurring every alternate year in 1978 (352 cases with 2 deaths), 1980 (253 cases with 1 death), 1982 (216 cases with no deaths) and in 1983 (205 cases with 2 deaths) [Fig. 1].

RECENT OUTBREAKS (1989-1992)

Beginning from 1986, however, the DF/DHF situation changed for the worse when progressively larger outbreaks began to occur (Fig. 1). In the past four years, there were 944 cases, with 2 deaths in 1989, 1,733 cases with 3 deaths in 1990, 2,179 cases with 6 deaths in 1991 and 2,878 cases with 6 deaths in 1992.

In the 1991 and 1992 outbreaks, more than 90% of the notified cases were hospitalized and confirmed serologically. The number of deaths, however, remained low. Ten of the 12 reported deaths from dengue shock syndrome were confirmed serologically.

All age groups were affected with the highest morbidity rates in teenagers and young adults between 15 and 24 years of age. There has been a shift in age towards older patients since the outbreaks in 1960s and 1973. Fifty per cent of the patients in the 1964 and 1973 outbreaks were below the age of 14 years as compared to 17-18% in the outbreaks from 1990 to 1992 (Table 1).

In the 1973 outbreak, 85% of the fatal cases were below 15 years of age. In the 1991 and 1992 outbreaks, 8 of the 10 serologically confirmed deaths were 21 years and above ;

the other 2 deaths were aged 20 months and 13 years.

There was a slight predominance among male patients. Among the three major ethnic groups, Chinese had the highest morbidity rate compared with that of Malays and Indians.

The recent DF/DHF outbreaks, as in previous years, occurred mainly in highly populated urban and suburban areas located in the eastern, northeastern and southeastern parts of the island (Fig. 2). In the 1991 and 1992 outbreaks, patients who lived in compound houses (with garden) had a 9 times higher morbidity rate than those living in high-rise government flats where more than 85% of the general population now live.

Limited virological studies of patients showed that all four dengue virus serotypes circulated in 1990 with dengue-2 being the predominant virus isolated. In the 1991 outbreak, dengue-2 virus was also the predominant serotype circulating but dengue-3 was also present. Dengue serotypes 1, 2 and 3 viruses were isolated in the 1992 outbreak but the predominant serotype was dengue-3 virus.

Table 1. Age distribution of DF/DHF patients

Age group	1964	1973	1990	1991	1992
0- 4	12.0*	11.3	2.1	1.7	2.5
5-14	51.5	49.5	17.9	16.9	17.5
15-24	81.3	84.8	52.9	53.3	48.1
25-34	92.8	95.2	77.4	79.6	73.4
35-44		98.0	91.9	93.3	90.2

* Cumulative percentage

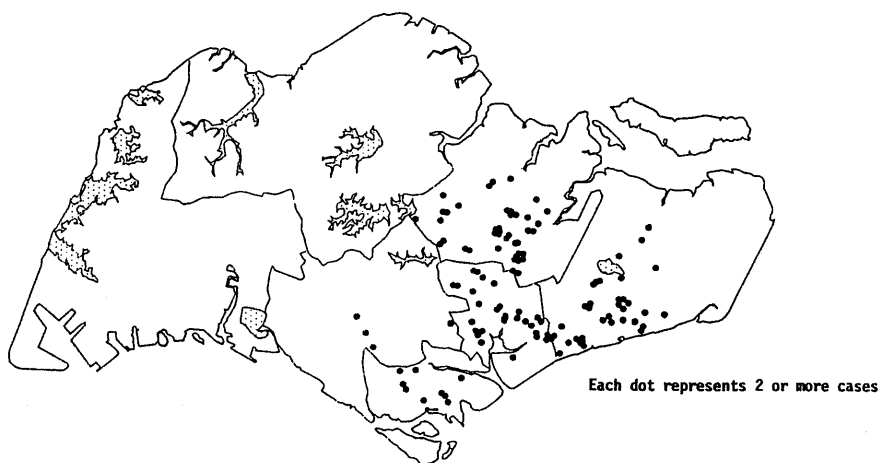


Fig. 2. Foci of transmission of reported DF/DHF cases 1992

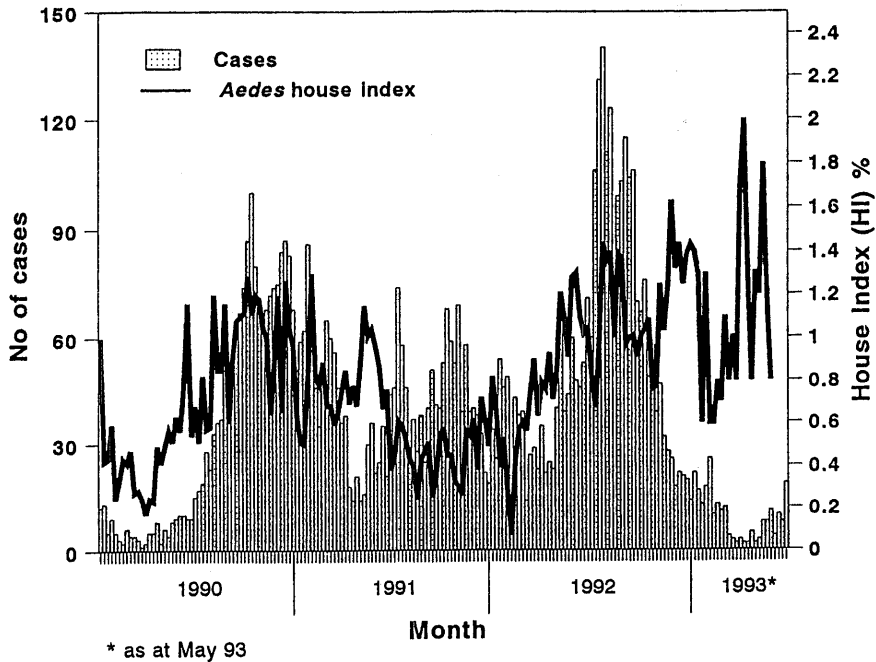


Fig. 3. Relationship between *Aedes* house index and reported DF/DHF cases 1990-1993*
* as at May 1993

The upsurge of DF/DHF cases in recent years occurred at a time when the average *Aedes* house index (AHI) for the country was below 2%. Throughout 1992, for example, the AHI fluctuated between 0.07% and 1.63%. However, within the outbreak area, AHI as high as 12% was detected. Both *Ae aegypti* and *Ae albopictus* appeared to be involved in the recent outbreaks. In the 1991 and 1992 outbreaks, the AHI for *Ae aegypti* were 0.36% and 0.5%, and *Ae albopictus* were 0.37% and 0.6%, respectively. The proportion of compound houses breeding *Ae aegypti* was 3-4 times and *Ae albopictus* 7-10 times higher than that of flats in the two years, respectively.

DF/DHF cases were reported throughout the year. Increased incidence was observed in May and June and it was preceded by a steep rise in AHI (Fig. 3).

WHY IS SINGAPORE EXPERIENCING MAJOR DF/DHF OUTBREAKS NOW ?

There is no simple answer, and a combination of factors is probably involved. We believe that the three most important contributing factors are :

- (1) The dengue virus serotype (s) circulating in the community and in the region
- (2) The susceptibility or herd immunity of the human population
- (3) The presence of undetected *Aedes* breeding sites in localized areas

Dengue virus serotype (s). Although there have been no extensive virological studies

made since 1965, it is still possible to determine the probable dengue virus serotype (s) involved in past DF/DHF outbreaks from the occasional virus isolation and the dengue serotypes circulating in the region at the time, particularly in Malaysia, Indonesia and Thailand.

The large outbreak in 1973 was probably due to dengue-3 virus which was isolated together with dengue-1 during the outbreak. Dengue-3 virus first appeared in Singapore in 1963 and again in 1965. Children born after 1965 would have no immunity to this virus and be most affected, accounting for the high morbidity rates in children below 10 years old in this outbreak and the large number of cases.

The dengue virus serotype responsible for the 1978 outbreak could not be determined. Indonesia reported the circulation of all four dengue serotypes with dengue-2 and dengue-3 as the predominant viruses from 1975 to 1979.

In the 1986 outbreak, both dengue-1 and dengue-2 viruses were isolated. Dengue-1 virus was the predominant serotype causing outbreaks in Malaysia from 1986 to 1988, and presumably also the serotype responsible for the Singapore outbreak.

The 1989 outbreak was probably due to dengue-4 virus which was the only serotype isolated. Dengue-4 virus first appeared in Singapore in 1961 and this serotype was also circulating in Indonesia in 1989.

Dengue-2 was the predominant serotype isolated in 1990 and 1991 and most likely responsible for the large outbreaks in these two years. Malaysia, Indonesia and Thailand also reported dengue-2 as the predominant serotype in their countries.

The 1992 outbreak was caused by dengue-3 although dengue-1 and dengue-2 viruses were also isolated. Dengue-3 virus was also the predominant serotype isolated from the 1992 outbreak in Malaysia. The last dengue-3 outbreak in Singapore was in 1973, and in the 1992 outbreak the highest morbidity rate was in the 15-24 years age-group.

Herd immunity. Several serological surveys by the haemagglutination inhibition (HI) test have been conducted over the years. Although these surveys were not representative of the general population, the results seemed to show that a large proportion of the population have not been exposed to dengue virus infection. The 1982-1984 survey of healthy blood donors, national servicemen, students and pre-school children showed that 54% of them had no HI antibodies to dengue-2 antigen. More than 90% of children below the age of 10 years were seronegative.

That there has been a build-up of a large susceptible population over the years is also borne out by the findings in 1985, 1987 and 1989 that 40-43% of the DF/DHF patients had primary dengue infections. The low herd immunity in the community is likely to be due to the localised nature of the dengue outbreaks resulting from the vigorous *Aedes* control measures carried out since the 1973 outbreak. In a post-outbreak survey in an outbreak area in 1987, only 71% of the population showed evidence of a past dengue infection and more than 60% of children and young adults below 20 years of age had not been exposed to dengue virus. During the 1990 outbreak, a serosurvey of healthy children and adults between 6 months and 50 years and older showed that only 44% of the sample

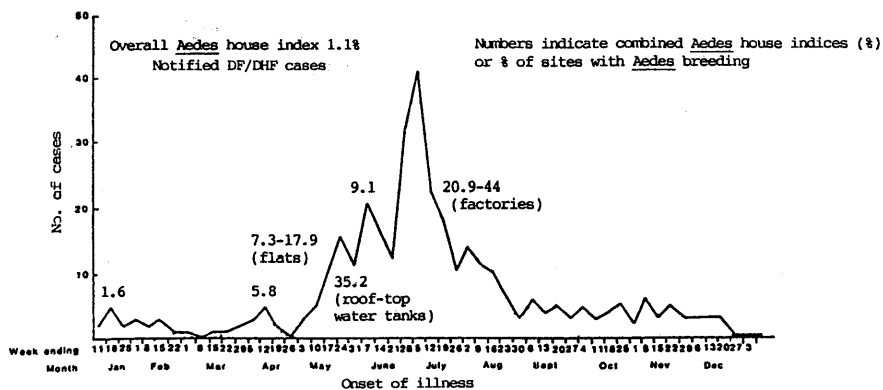


Fig. 4. Dengue fever/dengue haemorrhagic fever surveillance in Singapore, 1986.

had evidence of dengue infection by the HI test. All the children below 5 years of age were seronegative. These results showed that dengue virus transmission was very limited even in an outbreak and infection involved mainly adults rather than children.

The continuous existence of a large susceptible population particularly in children is the reason why we are witnessing larger outbreaks in recent years and the shift in age of patients to young adults.

Undetected Aedes breeding. The combined *Aedes* (*Ae aegypti* and *Ae albopictus*) house index (AHI) is the principal measure used to monitor the *Aedes* mosquito population in surveillance and control. Whatever its inherent shortcomings, the AHI can provide information on mosquito population fluctuations over time. In the years following the 1973 DF/DHF outbreak, intensive surveillance and control measures have brought the average AHI to a low level of 1-2% for the entire country. Observations made during outbreaks showed that increased disease incidence was generally preceded by a steep increase in the average AHI for several weeks although still below the 2% level. In the outbreak areas, however, very much higher *Aedes* population could be found. The AHI recorded during the 1986 outbreak illustrates this (Fig. 4).

In the country-wide outbreak of 1986, the overall AHI was only 1.1%. In some blocks of flats in the outbreak area, however, the AHI reached as high as 17.9%. In addition, *Aedes* breeding was found in 35% of roof-top water tanks in the area. These localized intense *Aedes* breeding in both traditional breeding sites such as ornamental and domestic containers as well as a large variety of non-traditional ones were responsible for the tremendous increase in mosquito population in the area which was not reflected in the average AHI for the country.