



PERSPECTIVES

Characteristics of dengue epidemics in Taiwan

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Dengue fever is caused by dengue viruses (DENVs) and is the most common arboviral disease in tropical and subtropical regions of the world, with more than 50 million cases recorded every year. Dengue viruses (serotypes 1–4) are mosquito-borne members of the genus *Flavivirus* in the family *Flaviviridae*. In recent decades, the number of dengue cases reported worldwide and the number of countries with endemic dengue has increased dramatically because of the enlarging habitat of the mosquito vectors *Aedes* sp, growing numbers of susceptible human hosts, and increasing spread of DENVs through rapid and frequent global travel.^{1,2} Dengue disease can manifest in the form of the mild dengue fever or the more severe and potentially fatal dengue hemorrhagic fever/dengue shock syndrome, which has a fatality rate as high as 10–15% depending on the availability of health care. Currently there is no vaccine or therapeutic agent available against dengue fever.

Dengue is not considered endemic in Taiwan and the constant importation of DENVs from the neighboring Southeast Asian countries through close commercial links and air travel is responsible for the local outbreaks each year.^{3,4} The dengue hemorrhagic fever cases in Taiwan are highly correlated with advanced age and secondary DENV infection. Studies on molecular epidemiology and phylogenetic analyses of dengue genome sequences reveal that each local outbreak was caused by a single imported DENV strain that disappears with the ending of each outbreak. Table 1 shows the serotype and genotype of DENVs isolated from major dengue epidemics (with more than 10

indigenous dengue cases) in Taiwan during 1987 to 2010. All the epidemic DENV strains were different in each outbreak and are closely related to virus strains imported from Thailand, the Philippines, Vietnam, Indonesia, and Cambodia, indicating multiple introductions of DENV strains from neighboring southeast Asian countries. Notably, among 149 imported dengue cases identified during 1989–1995, 73 (49.0%) are from Thailand, 29 (19.5%) from the Philippines, and 18 (12.1%) from Indonesia, and among 1328 imported cases identified during 2002–2010, 362 (27.3%) are from Indonesia, 347 (26.1%) from Vietnam, 161 (12.1%) from Thailand, 157 (11.8%) from the Philippines, and 77 (5.8%) from Cambodia. Further analysis showed that the main purpose for travel was tourism in the 1990s and the major destinations were Thailand and the Philippines. More recently, the main purposes for travel were associated with family visit of new immigrants, business-related travel, tourism, and foreign labor; the major destinations were Vietnam, Indonesia, Thailand, Cambodia, and the Philippines.⁵

Dengue outbreaks occur mainly in southern Taiwan, where *Aedes aegypti* and *Aedes albopictus* coexist; these outbreaks rarely occur in central, northern, and eastern Taiwan, where only *A. albopictus* exists. Dengue outbreaks usually peak in summer and fall seasons. Because of the low mosquito density in the winters through waves of relatively cold temperatures below 10 °C, outbreaks during winter were rare. However, three overwinter outbreaks occurred in Taiwan during 1987–2010. A DENV-1 overwinter outbreak in southern Taiwan during 1987–1988 was the largest epidemic since World War II, with an estimated 100,000 dengue cases. The outbreak began in November 1987 in Donggang Township of Pingtung County, a coastal town on the southwestern coast of Taiwan, and

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Table 1 Major dengue outbreaks in Taiwan between 1981 and 2010.

Year	Epidemic area	Epidemic DENV serotype	Epidemic DENV genotype	Possible source of epidemic virus	No. of indigenous cases	No. of Imported cases
1981	Pingtung County	DENV-2	Asian 2	Philippines	>8000	—
1987	Pingtung County & Kaohsiung City	DENV-1^a	I	Thailand	527	—
	Kaohsiung City	DENV-2	Asian 2	Philippines		
1988	Southern Taiwan	DENV-1	I	Thailand	4389	—
1989	—	—	—	—	16	19
1990	—	—	—	—	0	10
1991	Kaohsiung City	DENV-1	I	Thailand	149	26
1992	—	—	—	—	4	19
1993	—	—	—	—	0	13
1994	Kaohsiung City	DENV-3	I	Philippines	222	22
	Tainan City	DENV-1	I	Vietnam		
1995	New Taipei City	DENV-1	I	Vietnam	329	40
	Pingtung County	DENV-1	II	Malaysia		
	Kaohsiung City	DENV-3	I	Philippines		
1996	Taipei City	DENV-1	I	Thailand	20	35
1997	Tainan City	DENV-2	Cosmopolitan	Indonesia	19	57
1998	Tainan City	DENV-3	II	Thailand	238	110
	Kaohsiung City	DENV-2	Asian 1	Thailand		
	Kaohsiung City	DENV-2	Cosmopolitan	Indonesia		
1999	Kaohsiung City	DENV-1	I	Vietnam	42	26
2000	Tainan City	DENV-4	II	Thailand	113	26
2001	Kaohsiung City	DENV-2	Cosmopolitan	Philippines	227	54
2002	Southern Taiwan	DENV-2	Cosmopolitan	Philippines	5336	52
	Pingtung County & Kaohsiung City	DENV-1	II	Indonesia		
2003	Pingtung County & Kaohsiung City	DENV-2	Cosmopolitan	Philippines	86	59
2004	Pingtung County & Kaohsiung City	DENV-1	II	Philippines	336	91
	Pingtung County	DENV-4	I	Vietnam		
2005	Kaohsiung City	DENV-3	I	Philippines	202	104
	Tainan City	DENV-2	Asian/American	Vietnam		
	Kaohsiung City	DENV-3	II	Vietnam		
2006	Kaohsiung City	DENV-3	II	Cambodia	965	109
	Kaohsiung City	DENV-3	II	Cambodia		
	Kaohsiung City	DENV-2	Asian 1	Vietnam		
2007	Tainan City	DENV-1	I	Thailand	2000	179
	Tainan City	DENV-2	Asian 1	Vietnam		
2008	Kaohsiung City	DENV-1	I	Vietnam	488	226
	Kaohsiung City	DENV-1	I	Thailand		
	Kaohsiung City	DENV-2	Asian 1	Cambodia		
	Taipei City	DENV-1	I	Vietnam		
2009	Southern Taiwan	DENV-3	I	Philippines	848	204
	Pingtung County	DENV-2	Asian 1	Vietnam		
	Changhua County	DENV-1	I	Thailand		
2010	Kaohsiung City	DENV-3	I	Philippines	1592	304
	Tainan City	DENV-4	II	Indonesia		
	Kaohsiung City	DENV-2	Cosmopolitan	Philippines		
	Tainan City	DENV-1	I	Vietnam		
	New Taipei City	DENV-1	I	Cambodia		

^a Boldface indicates the same epidemic strains responsible for each overwinter dengue outbreak. The designations of DENV genotypes are based on the classification of A-Nuegoonpipat et al., Twiddy et al, Lanciotti et al., and Klunthong et al. for DENV-1, DENV-2, DENV-3, and DENV-4, respectively, as described in reference 5.

later spread to Kaohsiung City, and it persisted throughout the following year.⁶ Another overwinter outbreak occurred in southern Taiwan during 2001-2002, with more than 5000 cases. The outbreak occurred mainly in the Qianzhen District of Kaohsiung City in 2001 and the peak month was

November, with a decline in December 2001. Low transmission activity was observed during January to May in 2002. Cases began to increase in the Qianzhen and Fengshan Districts of Kaohsiung City in June 2002, and later spread to the entire Kaohsiung City, Pingtung County, and

Tainan City. The epidemic had come to an end by February 2003. The third overwinter outbreak occurred during 2009-2010, with more than 1400 confirmed cases, and was caused by a DENV-3 genotype I strain. The outbreak began in the Xiaogang and Qianzhen Districts of Kaohsiung City in August 2009, and later spread to the Sanmin, Lingya, Fengshan, and Gushan Districts of Kaohsiung City. November was the peak month of the outbreak in 2009, with a decline in the number of dengue cases in the cold season. However, although the number of cases was low, transmission was maintained during the winter. Dengue cases were continuously identified during February to July of 2010 in the Gushan and Lingya Districts of Kaohsiung City; the number of cases began to rise again in August in 2010 and continued transmission until the end of 2010.

Although dengue outbreak occurred mainly in southern Taiwan, a few outbreaks occurred in central and northern Taiwan. The largest outbreak in northern Taiwan occurred in the Zhonghe District of New Taipei City in 1995, with 179 confirmed dengue cases. Another small outbreak occurred in the Xitun District of Taichung City in 1995, with at least eight cases. In 1996, a small outbreak occurred in the Xinyi District of Taipei City with more than 10 cases. More recently, an outbreak occurred in the Shilin District of Taipei City in August 2008, with at least 20 cases. Another DENV-1 outbreak occurred in Shetou Township of Changhua County, with at least 10 cases. In addition, a DENV-1 outbreak occurred in the Wugu District of New Taipei City in 2010 with more than 12 cases. These results indicated that sporadic dengue outbreaks could occur in central and northern parts of Taiwan.

Dengue has been classified as class 2 notifiable infectious disease, demanding that suspected cases be reported within 24 hours of clinical diagnosis. As the growing global threat of dengue in a new era occurs with unparalleled human movement and geographic expansion of DENVs and their vectors, more effective and efficient integrated dengue control programs that include various surveillance systems, a network of rapid diagnostic laboratories, and rapid response carried out by central and local health departments would be needed to control dengue and maintain Taiwan as a nonendemic country.

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