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Epidemiological trends and the effect of airport fever screening on prevention of domestic dengue fever outbreaks in Taiwan, 1998–2007

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SUMMARY

Objective: This study aimed to examine the epidemiological trends in dengue infection and the impact of imported cases and airport fever screening on community transmission in Taiwan, a dengue non-endemic island.

Methods: All of the dengue case data were obtained from the surveillance system of the Taiwan Center for Disease Control and were analyzed by Pearson correlations, linear regression, and geographical information system (GIS)-based mapping. The impact of implementing airport fever screening was evaluated using the Student's *t*-test and two-way analysis of variance.

Results: A total of 10 351 dengue cases, including 7.1% of imported cases were investigated between 1998 and 2007. The majority of indigenous dengue cases (98.5%) were significantly clustered in southern Taiwan; 62.9% occurred in the metropolitan areas. The seasonality of dengue cases showed a peak from September to November. Airport fever screening was successful in identifying 45% (244/542 ; 95% confidence interval 33.1–57.8%) of imported dengue cases with fever. However, no statistical difference was found regarding the impact on community transmission when comparing the presence and absence of airport fever screening.

Conclusions: Our results show that airport fever screening had a positive effect on partially blocking the local transmission of imported dengue cases, while those undetected cases due to latent or asymptomatic infection would be the source of new dengue outbreaks each year.

1. Introduction

Dengue fever is one of the most widespread viral diseases transmitted by Aedes mosquitoes, and about 2.5 billion people globally, living in more than 100 epidemic countries, are at risk of dengue infection.[1,2] The reasons for the global emergence of dengue epidemics are not fully understood, but demographic and social changes,[1–3] including the increase in population flow, population growth, rural–urban migration, inadequate basic urban infrastructure, and exponential growth in consumerism are important factors responsible for the increased transmission of dengue fever.[1–3] Since there is no vaccine or specific therapy available for dengue fever, current methods for preventing the disease involve vector control strategies and health education, which require the identification of high-risk areas and periods for control intervention.

The island of Taiwan is located in the Pacific Ocean and a Northern Tropic line crosses the middle of the island, dividing it geographically into a subtropical zone (north of 23.5°N) and a tropical zone (south of 23.5°N). These two areas have distinct ecological characteristics, including the climate, distribution of mosquito vectors, and human population density.[4–6] We used geographical information systems (GIS) to map the geographic distribution of dengue cases recorded by the Taiwan Centers for Disease Control (CDC) surveillance system and examined the epidemiological features of recorded outbreaks during the past decade.

Dengue is considered an imported disease in Taiwan. Local outbreaks usually start in the summer following the importation of dengue virus (DENV) strains, reach a peak in October and November, and then slow down and cease in the winter of each year. Therefore, dengue is listed as a quarantine agent at the international airports in Taiwan, and in 2003 active surveillance for dengue was integrated into the airport fever screening program to reduce the importation of DENV strains. An empirical investigation into the impact of this intervention has not been carried out to

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date. In this study, we evaluated the effect of this intervention on community transmission. The findings of this study will contribute towards our understanding of dengue epidemics in Taiwan and this information may be applied in other epidemic areas to develop effective control measures in the future.

2. Methods

2.1. Data sources and definition of cases

Human dengue case data were acquired through multiple sources via the surveillance systems of the Taiwan CDC. The Taiwan CDC has a standard case definition of DENV infection, which includes clinical symptoms and laboratory confirmation. The surveillance systems included a national notifiable disease surveillance system. All of the dengue cases were confirmed by a reference laboratory at the Research and Diagnostic Center of the Taiwan CDC and tested positive for DENV isolation, DENV RNA detection using real-time reverse transcriptase polymerase chain reaction (real-time RT-PCR), and/or serological diagnosis by capture IgM/IgG ELISA.[7,8] The annual incidences were calculated from the number of cases in each city or county divided by the live population in the same year for 1998–2007. The annual incidences were expressed as the number of cases per million live-population. The imported cases were defined as cases reported by local clinics or airport fever screening with a travel history in the previous 2 weeks, whereas the indigenous cases were defined as cases reported by local clinics without any travel history.

2.2. Airport fever screening

During 1998–2002, airport screening for DENV was implemented in the form of a questionnaire filled out by all passengers. However, from 2003 to 2007, following the severe acute respiratory syndrome (SARS) outbreak, airport screening for DENV was implemented in the form of airport fever screening in combination with symptomatic passengers filling out a questionnaire.[9,10] Following thermal scanning by non-contact infrared thermometers[7] to detect those whose body temperature was >37.5 °C, blood specimens were sampled and tested by molecular and/or serological diagnosis for DENV infection.[7,8]

2.3. Statistical analysis

Analysis of annual and monthly cycles was based on the number of cases accumulated over the time period of the analysis. The association of indigenous cases and imported cases (R_{ID-IP}), as well as population density (R_{ID-PD}) and population numbers (R_{ID-PN}), were measured using the Pearson product moment correlations test ($R < 0.3$ was considered to show no statistical association) and/or the linear regression test. The effect of airport screening was analyzed by several methods including the Student's *t*-test, the positive predictive value, and two-way analysis of variance (ANOVA), assuming the number of imported cases as the independent variable, the number of indigenous cases as the dependent variable, and the implementation of airport screening during 2003–2007 and no airport screening during 1998–2002.

3. Results

3.1. Annual trends and seasonality of DENV infection

A total of 10 351 confirmed dengue cases including 9616 (92.9%) indigenous cases and 735 (7.1%) imported cases were recorded in the Taiwan CDC surveillance system from January 1998 to December 2007. There were three epidemic years in which the number of annual dengue cases reached 1000 or more, i.e., 5336 cases in 2002, 2000 cases in 2007, and 965 cases in 2006, with two additional small outbreaks in 2004 with 336 cases and 2005 with 202 cases. The yearly epidemic events showed epidemiological diversity in the site of occurrence and the DENV serotypes circulating, which differed from those of the previous or following epidemic years in 2002, 2006, and 2007 (Table 1). For example,

Table 1
The spatial heterogeneity of dengue cases and the various dominant serotypes in local outbreaks in Taiwan during the periods 1998–2002, prior to airport fever screening and 2003–2007, after implementation of airport fever screening

Year	Regions	Indigenous cases (%)	Imported cases (fever screening)	Incidence rate (cases/million)	Density (persons per km^2)	Population (×100 000)	Serotype				
							I	II	III	IV	ND
1998	Taiwan	309	35	17	510	181.6	5	16	23	2	225
1999	Taiwan	42	26	2	511	182.0	2	5	4	0	46
2000	Taiwan	113	26	6	512	182.8	0	1	2	0	79
2001	Taiwan	227	54	12	514	183.0	7	85	1	2	218
2002	Taiwan	5336	52	291	514	183.0	9	2386	2	2	3371
	TP City[a]	7 (0.1)	16	27	9720	2.6	1	4	0	0	30
	TC City[a]	1 (0.02)	7	1	6098	9.9	1	1	0	1	7
	TN County[b]	18 (0.3)	2	16	549	7.5	0	5	0	0	24
	TN City[b]	66 (1.2)	3	89	4242	11.1	1	22	0	0	57
	KS County[b]	1979 (37.1)	0	1605	442	12.3	0	891	0	0	201
	KS City[b]	2832 (53.1)	2	1874	9827	15.1	1	1254	0	0	757
	PT County[b]	308 (5.8)	5	340	326	9.1	2	190	0	1	216
2003	Taiwan	86	59 (18)	5	515	184.2	11	28	4	5	138
2004	Taiwan	336	91 (57)	52	519	184.8	193	25	5	18	248
	PT County[b]	281 (83.6)	7	148	324	19	171	1	0	16	205
2005	Taiwan	202	104 (46)	11	522	185.6	6	16	43	0	198
	TN County[b]	3 (1.5)	2	3	549	7.5	0	0	0	0	8
	TN City[b]	57 (28.2)	2	75	4309	11.1	1	12	0	0	57
	KS County[b]	44 (21.8)	1	37	445	12.4	5	2	11	0	41
	KS City[b]	92 (45.5)	7	61	9835	15.1	2	5	31	0	95
2006	Taiwan	965	109 (48)	52	524	186.4	23	34	396	0	1127
	KS County[b]	185 (19.2)	4 (1)	148	446	12.5	0	1	95	0	170
	KS City[b]	757 (78.4)	10	498	9862	15.2	0	33	276	0	934
2007	Taiwan	2000	179 (75)	107	526	187.2	1095	75	0	0	1544
	TN County[b]	345 (17.3)	12 (4)	448	548	7.7	101	71	1	0	392
	TN City[b]	1459 (72.9)	21 (13)	1303	4353	11.2	916	6	0	0	937

[a] Taipei (TP) and Taichung (TC) are located in north of 23.58°N (northern and subtropical Taiwan).
[b] Kaohsiung (KS), Tainan (TN), and Pingtung (PT) are located in south of 23.58°N (southern and tropical Taiwan).