

Introduction

In the last 20 years, the number of outgoing/incoming travelers and imported dengue fever cases has shown an increasing tendency since the policies of foreign labors, tourism, and immigration have loosened and the impacts of globalization and climate change become more obvious. The World Health Organization (WHO) indicated that dengue fever has ranked as the fastest spreading vector-borne disease in 2012, registering a 30-fold increase in disease incidence over the past 50 years [1]. This implies that the risk of importing dengue fever virus will likely increase yearly. In addition, Taiwan is geographically located at the areas crossing tropical and subtropical regions where *Aedes albopictus* are commonly surviving in resort places at elevations under 1000 meter above sea level and even can be found in sites at an elevation of 1760 meter above sea level [2]. Therefore, an imported dengue fever case is very likely to spread the virus and cause infection among indigenous population if relevant prevention and control measures are not fully implemented at very early stage of the infection.

To reduce the impacts of imported cases on prevention and control of infectious diseases in Taiwan, the government has set up infrared thermometers at international ports to conduct fever screening since 2003, so that we can early detect dengue fever cases that possibly occurred among incoming travelers and minimize the risk of dengue fever infection for local population. Several previous studies show that fever screening has effectively decreased the risk of spreading dengue fever virus into the community [3-8]. Moreover, in order to rapidly make confirmation of suspected dengue fever cases, the DENV NS1 Ag strip rapid test kit has been developed and routinely applied for confirmation of dengue fever cases screened out in Taoyuan International Airport and Kaohsiung International Airport since 2008. The confirmation time of dengue fever is largely shortened from 1-2 days to 1-2 hours in using the new test method. This has effectively elevated the efficiency of disease control. Although the border quarantine can detect dengue fever in its early stage and decrease the impacts of imported cases on disease control, we are unable to completely block the entry of dengue fever virus because of the incubation period and asymptomatic infections of the disease. In addition, we have only limited quarantine capacity and laboratory resources and we need to consider the efficiency of customs clearance processes. Therefore, how to maximize the efficiency with limited resources to assure the control of infectious disease and national securities and to ensure convenient customs clearance processes is really a challenge of quarantine practices. The objective of this study was to identify population at high risk of importing dengue fever virus so that we can maximize the effectiveness of disease control with limited resources.

Materials and Methods

A. Source of data and study samples

1. Source of data: data were collected from Symptom Surveillance System, travelers enter Taiwan between 2008 and 2011, were reported from international port quarantine stations, and have provided blood specimens (serum or whole blood) for dengue virus testing.

2. Study samples: Suspected dengue fever cases found from incoming passengers by quarantine officials, based on prevent and control processes of the Quarantine Implementation Manual [9], would be included into the study. These cases might be found through infrared fever screening procedure, infectious disease investigation form, or reporting by passengers themselves, and would have been collected specimens for dengue fever testing when physical evaluation showed it is necessary.

B. Statistics and data analysis

After the data had been checked for errors, SPSS 14.0 software were used to conducted statistical analysis for epidemiologic and laboratory data

Results

A. Analysis on traveling reasons for incoming/outgoing suspected dengue fever passengers identified by quarantine

A total of 17,862 suspected dengue fever cases were screened out by quarantine procedures among incoming travelers during 2008-2011 and were considered as travel-associated infections based on the overall evaluation of the symptoms, travel destination, and travel records. The analysis shows that the major reason for traveling into/out Taiwan was to travel for tourism(including backpacking trips or tourist groups), accounting for more than half (53.8%) of the suspected dengue fever cases, followed by travel for business activities by individual or group (17.6%), and for visiting relatives by individual or group (15.7%). The detailed statistical analysis is shown in Table 1.

Table 1. Analysis on suspected dengue fever cases identified by quarantine during 2008-2011, by reasons for travelling into Taiwan

Traveling reasons	Excluded cases		Confirmed cases		Suspected cases		Positive rate	RR ⁽²⁾ (95% CI)
	No.	%	No.	%	No.	%		
Individual business activities	2,836	16.3	101	22.7	2,937	16.4	3.4%	7.4 (4.9~11.3)
Group business activities	201	1.2	6	1.3	207	1.2	2.9%	6.3 (2.6~14.9)
Individual relatives-visiting	2,575	14.8	130	29.2	2,705	15.1	4.8%	10.4 (6.9~15.6)
Group relatives-visiting	102	0.6	3	0.7	105	0.6	2.9%	6.2 (1.9~20.0)
Backpacking trips	3,475	20.0	77	17.3	3,552	19.9	2.2%	4.7 (3.1~7.2)
Tourist groups	6,032	34.6	28	6.3	6,060	33.9	0.5% ⁽¹⁾	—
Others ⁽³⁾	2,196	12.6	100	22.5	2,296	12.9	4.4%	9.4 (6.2~14.3)
Total	17,417	100.0	445	100.0	17,862	100.0	2.5%	—

Notes :

(1)The positive rate for tourist groups was calculated by $(28/6,060) \times 100\% = 0.46\% \approx 0.5\%$.

(2)The relative risk (RR) for each item of traveling reasons was calculated by comparing the positive rate with that of tourist groups.

(3)The confirmed cases for “others” were mainly foreign workers, will discuss in the following section.

445 confirmed dengue fever cases have been identified by quarantine implementation from 2008 to 2011. About thirty percent (29.9%) of them were travelling into/out Taiwan for visiting relatives, followed by travel for business activities (24.0%) and for tourism (23.6%). The analysis shows that the passengers traveling for tourism accounted for more than half (53.8%) of the suspected dengue fever cases identified by quarantine while those traveling for visiting relatives recorded about thirty percent (29.9%) of the confirmed dengue fever cases.

The positive rate shows that tourism (included backpacking trips and tourist groups) is the only item that positive rate is less than the average value, 2.5% (the positive rate for backpacking trips and tourist groups are 2.2% and 0.5%, respectively). To travel for visiting relatives by individual is the item having the highest positive rate, which the relative risk of infection was 10.4 times (95% CI: 6.9~15.6%) higher, as compared with tourist groups. Other items, such as travel for business activities, visiting relatives by group, and backpacking trips, also have a higher risk of infection with dengue fever than tourist groups and the difference between them is statistically significant.

B. About one eight of the suspected dengue fever cases but only 0.7% of the confirmed case identified by quarantine from China

Analysis on the countries where the passengers came from shows that the suspected dengue fever cases identified by quarantine mainly came from Thailand, Indonesia, Vietnam, China, and Philippines, accounting for 73.5% (13,136 cases) of the suspected cases. However, the confirmed dengue cases arrived primarily from Indonesia, Vietnam, Thailand, Philippines, and Malaysia, accounting for 84.5% (376 cases) of the confirmed cases. The passengers coming from Indonesia and Vietnam have the highest positive rates, with 4.2% for both countries. Of the 2,303 suspected cases, accounting for 12.9% of the suspected cases, coming from China, only 3 cases were confirmed, accounting for 0.7% of the confirmed cases, with a positive rate of 0.1%, which is much lower than those from other Southeast Asian countries. Table 2 presents the analysis on suspected dengue fever cases identified by quarantine based on countries where the cases came from and that have more than 1,000 cases.

Table 2. Analysis on suspected dengue fever cases identified by quarantine during 2008-2011, by countries with more than 1,000 cases

Countries	Excluded cases		Confirmed cases		Suspected cases		Positive rate
	No.	%	No.	%	No.	%	
Thailand	3,293	18.9	59	13.3	3,352	18.8	1.8%
Indonesia	3,152	18.1	138	31.0	3,290	18.4	4.2%
Vietnam	2,255	12.9	98	22.0	2,353	13.2	4.2%
China	2,300	13.2	3	0.7	2,303	12.9	0.1%
Philippines	1,785	10.2	53	11.9	1,838	10.3	2.9%
Malaysia	1,721	9.9	28	6.3	1,749	9.8	1.6%
Singapore	1,025	5.9	15	3.4	1,040	5.8	1.4%
Others	1,886	10.8	51	11.5	1,937	10.8	2.6%
Total	17,417	100.0	445	100.0	17,862	100.0	2.5%

C. A half of imported dengue fever cases being identified by quarantine procedures and half of them being positive by NS1 antigen rapid test

There are 891 confirmed imported dengue fever cases during 2008-2011 according to the statistics in the Dengue Control Guideline [10], 445 of them were identified by quarantine procedures, accounting for about half (49.9%) of the all imported dengue fever cases. The rest of the confirmed imported cases were found either through report by physicians or expanded epidemiological investigation conducted for dengue fever confirmed cases. These statistics shows that the infrared fever screening measures for quarantine at international ports are highly effective in terms of dengue fever control. In addition, half (51.7%) of the confirmed dengue fever cases identified by quarantine had positive results by rapid serologic test (testing for dengue virus non-structural protein 1, simply referred to as DNV NS1 antigen rapid test) performed at Taoyuan International Airport and Kaohsiung International Airport. This indicated that to conduct DNV NS1 antigen (Ag) rapid test at international airports for confirmation of suspected dengue fever cases can largely decrease the time interval for waiting laboratory testing, and can actually shorten the time interval for initiating control activities to promote efficiency of disease control.

Table 3. Analysis on confirmed imported dengue fever cases during 2008-2011

Years	Number of confirmed imported cases	Cases identified at international ports ⁽¹⁾		Cases identified at international airports ⁽²⁾ by NS1 Ag rapid test	
	No. (a)	No. (b)	Ratio (b/a)	No. (c)	Ratio (c/b)
2008	226	115	50.9%	36	31.3%
2009	204	116	56.9%	72	62.1%
2010	304	133	43.8%	75	56.4%
2011	157	81	51.6%	47	58.0%
Total	891	445	49.9%	230	51.7%

Note:

(1)Including international seaports and international airports nationwide

(2)Taoyuan International Airport and Kaohsiung International Airport

Discussions

Previous studies conducted in Taiwan showed [3-8] that quarantine procedures performed at international ports can effectively screen out dengue fever virus that might be imported by incoming passengers. These have decreased the impacts of imported cases on the prevention and control of indigenous dengue fever cases. However, other studies [11] indicated that 11,080 New Taiwan Dollars (TWD) will be spent on the implementation of fever screening at the international airports in order to prevent the occurrence of just one indigenous dengue case.

In addition, another 558,952 TWD will be spent to avoid the occurrence of disability-adjusted life years (DALYs) lost caused by a single dengue fever case. This amount was equivalent to the value of GDP (gross domestic product) per capita, 551,458 TWD in 2007. This showed that quarantine was not a cost-effective measure in terms of dengue fever control. Nevertheless, the studies indicated that the evaluation about the impacts of fever screening on the occurrence of indigenous dengue cases was conducted in some ways more conservative. When the public perception (for example, to display that the government actively implemented disease control measures, and a higher level of disease control system can be immediately initiated in case international epidemic occurs) was included into the evaluation, the fever screening at the international airports is still cost-effective. In recent years, the number of incoming and outgoing passengers has been increasing continuously because of the policy of enlarging global interaction and moving international tourism activities. However, the resources for prevention and control of infectious diseases were not increased simultaneously. Therefore, we should appropriately allocate the limited resources to elevate effectiveness in disease control.

The majority (33.9%) of the suspected dengue fever cases detected at international ports were travelers participating in tourist groups while only 6.3% of the confirmed dengue fever cases found at international ports belong to these people, with a positive rate of 0.5%. In contrast, the number of passengers traveling into/out for individual relatives-visiting was less than half (15.1%) of those for tourist groups but the positive rate of dengue fever infections among these people was as high as 4.8%. The risk of contracting dengue fever (relative risk) for people traveling for individual relatives-visiting was 10.4 times higher, as compared with those for tourist groups. These findings highlighted the fact that the risk of infecting with dengue fever for people traveling for individual relatives-visiting was significantly higher than those for tourist groups. These findings were consistent with those obtained in previous studies [12-13]. The reasons that people traveling for tourist groups have a relatively lower risk of infecting with dengue fever, as compared with those for individual relatives-visiting, might be because the tourists usually go to popular tourist attractions where the environmental sanitation conditions are better than general residential areas, stay for just a short time, and are more concerned about personal prevention measures. On the contrary, people who travel for individual relatives-visiting are almost immigrants or workers from Southeast Asian countries where the residential areas are usually in poor sanitary conditions, adding that they usually stay for a longer time and are more likely to ignore personal prevention practices in their own hometowns. The majority of suspected dengue fever cases found by fever screening at international ports were the passengers traveling for tourist groups, which a total of 6,060 (33.9%) passengers have provided specimens and the positive rate was only 0.5%. This means that if we did not collect specimens from these passengers, one-third of the expenditure for laboratory testing would be saved and the positive rate will be largely elevated from 2.5% to 3.5% (the difference of 445 and 28 divided by the difference of 17,862 and 6,060). However, 28 confirmed dengue fever cases will be missed from quarantine procedures at international ports, accounting for 3.1% of the 891 confirmed imported dengue fever cases occurred during these four years.

Countries at Southeast Asia are dengue fever epidemic areas and the regions in southeastern China also have sporadic dengue fever cases. As expected, the analysis of the study showed that the passengers arriving from Indonesia and Vietnam have the highest positive rate, reaching 4.2% for both, of the suspected dengue fever cases who were detected at international ports and from whom the specimens were taken based on the evaluation of the symptoms and traveling records (Table 2). Indonesia was the major labor-exporting country to Taiwan, accounting for about 40% of total number of the foreign labors in Taiwan [14]. Vietnam was the major country where the foreign spouse were coming from, accounting for more than half (around 57%) of total number of foreign spouse in Taiwan if we excluded the number of foreign spouse from China [15]. Therefore, a higher percentage of travelers arriving from Indonesia and Vietnam were labors who either come to Taiwan to work for the first time or return after visiting their relatives in the hometown, as compared with those from other Southeast Asian countries such as Thailand, Singapore, and Malaysia. These outcomes were similar to previous studies. Therefore, the new immigrants and foreign labors have a higher risk of dengue fever infection when they return to their hometown than general incoming travelers who went abroad just for tourist groups [12-13]. In addition, although dengue fever infections have occurred in Guangdong Province, Hainan Province and Yunnan Province of China, the epidemic situations were much milder than those occurred in Southeast Asian countries, according to the data published by the WHO [16-17]. Therefore, the travelers arriving from China have the relatively low risk of dengue fever infection. However, this scenario might be changed, depending on the circumstance of dengue fever epidemic in China.

Around 25% (100 cases) of the confirmed imported dengue fever cases are categorized as 'others' in the reason of coming to Taiwan. Since this might influence the analysis, we have conducted further analysis by examining the records in the remarks column in the Symptom Surveillance System. Of the 100 cases, 80 cases came to Taiwan for working, 8 cases returned Taiwan after visiting their relatives in the hometown (including 6 foreign labors returning after visiting relatives in their hometown for a short time), and 1 case was a traveler of tourist groups. Other 17 cases were passengers entering Taiwan not for working, or returning from relatives-visiting or tourist groups, but for studying, preaching, or unknown reasons. Of the 80 cases coming Taiwan for working, 98.8% (79 cases) are foreign labors and 39% (31 cases) of the 79 cases were coming Taiwan for the first time according to the records in surveillance system. When the 80 cases were considered as the travelers coming into Taiwan for business activities, the number of cases identified at international ports among the travelers for business activities will reach 42% of total confirmed imported dengue fever cases. When the number of excluded cases were added to the numerator and denominator, the positive rate of travelers for business activities (including individual and group) were slightly increased (from 3.4% to 3.8%). However, the risk of infection with dengue fever in travelers for business activities is still lower than that for relatives-visiting.

The methods for laboratory diagnosis of dengue fever virus infection in Taiwan include molecular biology technique, such as the polymerase chain reaction (PCR), and NS1 Ag strip rapid test, DNV-specific antibody testing, and DNV isolation [18]. Therefore, to complete the laboratory diagnosis process of specimens collected at international ports, from specimen collection, transportation, laboratory tests, and test result input, takes an average of 1-2 days. However, when the NS1 Ag strip rapid test was applied for testing of DNV at Taoyuan International Airport and Kaohsiung International Airport, the length of time for laboratory diagnosis of dengue fever virus was largely reduced to 1-2 hours. Moreover, this study also found that more than half (51.7%) of the confirmed dengue fever cases identified at international airports were positive for dengue fever virus by NS1 Ag strip rapid test conducted at both Airports. These support that to conduct NS1 Ag strip rapid test at international airports not only can largely reduce the time interval for laboratory diagnosis but also can really screen out the confirmed cases earlier, to eliminate the risks of the introduction of the imported dengue fever virus to communities.

Conclusions and Recommendations

A. To provide suspected dengue fever cases detected from tourist groups or from China with health education and to require them seeking medical services instead of collecting specimens

For the sake of the incubation period and asymptomatic infections of dengue fever, it is impossible to detect all imported cases by quarantine. The statistics indicated that the travelers of tourist groups or from China have a lower risk of infection with dengue fever virus, as compared with those travelling to Southeast Asian areas for visiting relatives, business activities, or backpacking trips. Moreover, 33.9% of the suspected dengue fever cases detected at international ports were from travelers of tourist groups and 12.9% from China. Therefore, we recommend that the suspected dengue fever cases of tourist groups or from China should be provided with health education instead of collecting specimens for testing of dengue fever virus, also they should be required to seek medical services as soon as possible after coming back to the communities. This change will lead to a decrease of a total of 7,854 specimens (accounting for 44% of the suspected dengue fever cases) among those collected at international ports and, in turn, will effectively reduce the costs for specimen collection, laboratory materials, and manpower for quarantine and laboratory analysis. In addition, 44% of the travelers with fever or other symptoms suspected to be dengue fever will no longer delay in their itinerary that happened before due to epidemiological investigation and specimen collection. However, 3.4% (30 cases, including one traveler from China) of the confirmed imported dengue fever cases will not be screened out at international airports and can only be notified by practicing physicians making the diagnosis.

B. To keep performing NS1 Ag strip rapid test at Taoyuan and Kaohsiung International Airports since it can increase the efficiency of the confirmation process

The period of dengue fever viremia in human typically starts from one day before onset of symptoms until five days after onset. The mosquitoes might be infected with dengue fever virus and spread the virus if they take their blood meal from an infected person during the viremic period. The ill person detected at international ports usually has appeared symptoms suspected to be dengue fever. Therefore, the application of the NS1 Ag strip rapid test could effectively decrease the risk of the introduction of dengue fever cases into the communities during their viremia period except largely reducing the time interval for laboratory analysis for about 1-2 days. In addition, more than half of the confirmed cases identified at international ports have positive results by NS1 Ag strip rapid test. This indicates that the NS1 Ag strip rapid test has good sensitivity and can really make the disease control measures be triggered as early as possible. We, therefore, recommend that the NS1 Ag strip rapid test should be performed continually at international airports.

C. To provide health education specifically for the population at high risk of infection, such as new immigrants, so as to promote the effectiveness in dissemination efforts for disease control

Currently, the health education on prevention of travel-associated infectious diseases mainly focuses on travelers leaving for other countries, and is implemented mainly at international ports by different methods or tools, such as flier distribution, poster displaying, or use of moving LED display, to incoming/outgoing travelers. In addition, lectures on prevention of travel-associated infectious diseases are given to tour leaders and tour guides in the training course for obtaining professional license. Travel agents are constantly provided with information on status of international infectious disease epidemic and are required to teach their clients to fully implement self-protection measures. Moreover, travel agents are asked to well organize the tour itinerary so that the travelers will not become infected with dengue fever or other infectious diseases, and to immediately report to quarantine officers in case symptoms suspected to be infectious disease occurred among members of the tour group. Since both previous studies and this study have found that travelers returning their home countries for visiting relatives are at a higher risk of infecting with dengue fever than travelers participating in tourist groups because they are less concerned about the information on epidemic situation of infectious disease in their hometowns, we recommend that educational fliers with information on travel-associated infectious diseases in multi-national languages can be made and disseminated to foreign couple through non-government organizations, such as the Foreign Couple Counseling Association and Foreign Couple Care Association, so that the limited resources could be effectively used in population at high risk of infection to maximize the effectiveness of dissemination efforts.

Limitations

When the suspected cases were ruled out dengue fever infection based on laboratory test results, a further epidemiological investigation will not be conducted for these cases. To ensure the comparability between the suspected dengue fever cases providing specimens, the item of “country you are coming from” was defined as the country visited on this trip prior to Taiwan arrival, but not the country or area where they might be infected with dengue fever based on epidemiological investigation.

Final remarks

Since March 2012, the quarantine measures have been adjusted for travelers with symptoms suspected to be dengue fever infection if they are either coming from China or returning Taiwan from tourist groups. They are no longer required to be collected specimens, except when necessary to do so based on professional evaluation conducted by quarantine personnel, but will be given health education opportunities and asked to seek medical services as soon as possible after returning to their communities.

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The Study of Dengue Vector Distribution in Taiwan from 2009 to 2011

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Abstract

This study was a part of dengue vector surveillance from 2009 to 2011 conducted by requesting local health bureau to submit at least 100 *Aedes* larvae or pupae for species identification to understand the distribution of dengue vectors in Taiwan. Additionally, 2 locations each in low and high sea level were also included each year from northern, central, southern, and eastern Taiwan for larval and adult survey. A total of 1,105,408 mosquito larvae or pupae and 9,667 non-mosquitoes were identified, which collected from 7,141 villages, 365 townships, and 22 counties/cities. Among the 77,470 found of *Ae. aegypti*, these were existed only in Tainan, Kaohsiung, Pingtung, Taitung, and Penghu. Compared to the previous surveys on 1988-1996 and 2003-2004, the distribution of this species was decreased in 31 townships and increased in 6 townships, including Gaoshu Township, Pingtung County; Nanhua, Baihe, and Danei Districts, Tainan City; and Wangan and Xiyu Townships, Penghu County. Among the 735,235 found of *Ae. albopictus*, these occurred in all surveyed townships except Juguang Township, Lienchiang County with the sea level up to 1,760 m.

Keywords: Dengue vectors, *Aedes aegypti*, *Aedes albopictus*, distribution, Taiwan

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