Outbreak Response to Locally-acquired Dengue Fever in the Kaohsiung City-Kaohsiung County-Pingtung County (K-K-P) Region in 2006

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From Chinese version, pp,3-21

Abstract:

This research describes local laboratory-confirmed cases of dengue fever and dengue hemorrhagic fever in the Kaohsiung City-Kaohsiung County-Pingtung County (K-K-P) region during 2006. It focuses on the scale of the outbreak by analyzing factors such as the distribution of cases, source of reporting, virus serotype, case population demographics, number of medical visits, and examination results. The study also determines the correlation of average weekly temperature and rainfall with vectors. Finally, it evaluates the impact of

Received: Nov 2, 2007 ; Accepted: Dec 12 2007.

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container reduction policies on the outbreak.

Results showed that 952 locally-acquired cases of dengue fever were reported in the K-K-P region during 2006, with the peak of 87 cases occurring in Week 43. Most of the cases were distributed in the Cianjhen, Sanmin and Lingya districts of Kaohsiung City and the city of Fongshan in Kaohsiung County. Most cases were reported from hospitals, followed by expanded serum collection activities and then clinics. Of the 406 specimens that were examined using nucleic acid sequencing, 371 cases belonged to dengue virus serotype 3. Among confirmed cases, 442 were male while 510 were female. The age distribution was 0-88 years with a median of 45 years. The average age at infection was higher in females than males. The incidence rate per 100,000 persons was found to increase with age. The number of visits for confirmed cases reported from medical facilities and the lag between disease onset and report date did not change significantly over time (p-value>0.05). In addition, 19 cases of dengue hemorrhagic fever resulted in 4 deaths, with victims' ages in the range of 66-76 years. Multiple regression was conducted on vectors located in 118 areas that were within 5 kilometers of the Kaohsiung weather station and the average weekly temperature and rainfall. Results showed that the average temperature and rainfall in a given week were correlated with the following week's Breteau index (Adj. R^2=0.6985, p-value<0.01). From November 15-30, 2006, the Kaohsiung City Government's Environmental Protection Bureau implemented a plan to mobilize cleaning crews to reduce the amount of containers in 77 areas. Among them, only 5 areas had cases of dengue fever occur in 2007.

Keywords: Dengue Fever, Dengue Hemorrhagic Fever, Container Reduction, Weather Factors, Breteau Index, Examination Results

Introduction

The distribution of the dengue virus lies between 25 degrees North and 25 degrees South latitude. In the past, Taiwan experienced three major island-wide outbreaks of dengue fever, in 1915, 1931 and 1942. In recent years, the country has continued to experience other localized outbreaks, including one in 2002 that was the most severe. During that year, there were 5336 confirmed cases; and the amount of resources consumed was hard to estimate.

Virus gene sequencing analysis has shown that most cases of dengue fever in Taiwan were imported from other countries, and these viruses have not continued to spread. Most of the imported cases have come from the following countries: Indonesia, Vietnam, Philippines, Thailand, Malaysia, Singapore, and Myanmar. Taiwan has close relationships with these countries due to global travel. Thus, preparations must be made for possible outbreaks each year. In Taiwan, particularly the Kaohsiung City-Kaohsiung County-Pingtung County (K-K-P) and Tainan regions, mixed transmission of different virus serotypes have occurred on many occasions. This cross-infection could potentially result in dengue hemorrhagic fever, which is more dangerous than classic dengue fever.

The outbreak of dengue fever in 2006 was the first on a large scale after 2002. It tested the prevention experience gained over the past few years and at the same time established a new battle plan. Although the process was arduous, it was effective at controlling the outbreak in the end. Thus, we review the experience of controlling the 2006 dengue fever outbreak in the K-K-P region and conduct a thorough analysis of the relevant data.

Outbreak Investigation and Response Measures

1. Reporting Criteria

In Taiwan, dengue fever is classified as a Category 2 notifiable disease. When medical personnel discover that patients have a fever (approximately 38 degrees Celsius) and at least two of the following symptoms: headache, eye pain, muscle pain, joint pain, skin rash, and hemorrhage, they should suspect dengue fever and report the case within 24 hours to the health department.

In order to control outbreaks effectively, local health officials adopts the so-called 3-in-1 prevention measures when new cases of dengue fever occur: starting outbreak investigation (such as expanded serum collection), emergency spraying, and eliminating the breeding source. Expanded serum collection targets neighboring households and contacts within a 50-200 meter area of confirmed dengue fever cases, and serum samples are taken regardless of whether or not the people have symptoms. This step determines the community's outbreak status and allows earlier diagnosis of patients with latent infection. If other people suspect possible infection, they may go to the local health clinic for a serum test.

Aside from reporting suspect cases of dengue fever, medical personnel must also report separately patients who meet diagnostic criteria for dengue hemorrhagic fever or dengue shock syndrome. In reporting cases of dengue fever or dengue hemorrhagic fever, health officials must conduct a thorough investigation and provide the patient's basic information, including sex, age, location, onset date, report date, and number of medical visits.

2. Diagnostic Methods

(1) Laboratory methods: serum samples taken within 7 days of disease onset

(acute phase) undergo the following four examination methods. Serum samples taken at 8-13 days (early convalescent phase) and 14-30 days (late convalescent phase) after disease onset will be examined for antibodies.

1. Virus nucleic acid testing [Real-Time Reverse Transcription Polymerase Chain Reaction (Real-Time RT-PCR)]: can be used to detect the presence of dengue virus RNA in the early stages of disease (within 5 days) and identify the serotype. Due to the high sensitivity, false positives may be possible.
2. Virus isolation: if the dengue virus can be isolated from the patient's serum sample taken 1-7 days after disease onset, then diagnosis can be confirmed.
3. Detection of antibodies (Capture IgM and IgG ELISA): use the dengue virus and Japanese encephalitis virus (E/M)-specific capture IgM and IgG ELISAs.
4. Gene sequencing analysis: since there is only one strain of DENV-1, gene sequencing analysis is performed on DENV-2 and DENV-3.
   (1) DENV-3 gene sequencing analysis: sequence the entire structural gene (C-pM/M-E; 2319 nt).
   (2) DENV-2 gene sequencing analysis: sequence the partial NS5 gene (153 nt) and entire structural gene (2325 nt).

(2)Laboratory definition: laboratory results are positive, negative, or indeterminate. If any one of the following criteria is met, then the case is positive:

1. Dengue virus can be isolated from the serum sample;

2. Dengue virus nucleic acid can be detected in the serum sample;

3. Patients are positive for both IgM and IgG, or greater than four-fold rise of IgM or IgG in paired serum sample; in addition, patients are negative for Japanese encephalitis virus IgM.

(3) Repeat serum collection

1. If the test result from the first serum collection is positive, then the case is confirmed. When 14-30 days have passed since disease onset, a serum sample should be collected during late convalescent phase. By analyzing antibodies in the serum, we can determine if the patient is a primary infection or re-infection case, as well as the serotype of the dengue virus.
2. If the test result from the first serum collection (acute phase) is indeterminate (if only one IgM or IgG is positive) or negative, a second serum sample should be taken 14 days after disease onset.
3. If clinical symptoms or epidemiologic data suggest a high suspicion of dengue virus infection, a blood sample during the early convalescent phase (8-13 days after disease onset) can be taken in advance and sent in for examination.

3. Case Classification

(1) When the laboratory diagnosis is positive, the case is confirmed, whether or not the patient has symptoms.

(2) When the case meets the criteria for reporting but the final examination result cannot be determined, it is classified as a suspect case.

(3) When laboratory results are negative, diagnosis can be excluded.

4. Investigation of Vector Density

(1) Residential areas in every village and area (li) were randomly sampled, and 50-100 households were investigated each time (if the area had less than 50 households, then the entire area was chosen; in districts far from residential areas, investigating every 3 people for 3-4 hours was the standard procedure). The density of larvae was measured using the Breteau index, while the density of adult mosquitoes was measured with the adult mosquito index (details of each index and its computation methods are in the section "Mosquito index and computation methods").

(2) Besides residential areas, settings where people congregate and places suitable for vector breeding, such as institutions, schools, open fields, parks, gardens, and mountainous areas should be considered for investigation. The investigation area should be the entire district or determined based on places that are easily reached (with the standard of investigating every 3 people for 3-4 hours). The density of larvae and amount of containers should be measured.

(3) The number of areas investigated for vector density each month in Tainan County, Tainan City, Kaohsiung County, Kaohsiung City, and Pingtung County is at least 50% of the total number of areas in these regions. In other cities and counties, the number of investigated areas from June to November is roughly 15% of the total number of areas. From December to May, this percentage is about 10%.

(4) Mosquito index and computation methods

1. Breteau index: the number of containers that are positive for breeding larvae per 100 households investigated.
2. Container index: the percentage of containers that breed larvae per 100

containers sampled.

3. Larvae index: the average number of larvae in each household, multiplied by 100.
4. Adult mosquito index: the density of adult vectors, which represents the average number of vectors that come into contact with female mosquitoes.

5. Correlation Between Weather Data and Vector Density

(1) Weather data: the Kaohsiung Weather Observation Station was selected and daily raw data was used to calculate the average weekly temperature and weekly rainfall.

(2) Vector data: 118 areas in Kaohsiung City and County that lied within 5 kilometers of the weather station were selected and matched-pair analysis was performed.

(3) Matching the Breteau index and average weekly temperature and rainfall in the multiple regression model:

1. Since the egg stage is affected by temperature changes, we chose weather data from 0-2 weeks prior to the week of the Breteau index investigation to perform the matched-pair analysis. Without considering possible collinearity, variables (including weekly rainfall, average weekly temperature) were entered into the statistical model. By comparing matches of different weeks in the multiple linear regression model and the size of the R^2 value (adjusted coefficient of determination), we chose the match with the largest R^2 value for further analysis.
2. We used Microsoft Excel to produce tables and figures and NCSS

statistical software to conduct analyses.

6. Definitions for Districts with sporadic disease or disease concentration: in order to efficiently allocate resources and observe the outbreak, areas with dengue fever were categorized into the following:
   (1) Districts with sporadic disease: area with 1 confirmed case of dengue fever or 2 confirmed cases have occurred approximately 14 days apart in the same area.
   (2) Districts with disease concentration:
      1. When 2 confirmed cases have occurred, and the distance between their residences/places of activity is not more than 150 meters; the time between disease onset is less than or equal to 14 days.
      2. When the distract with disease concentration already has 2 confirmed cases, the third case can be confirmed if:
         (1) The distance between the third case and the residence/place of activity for another confirmed case in the same district is not more than 150 meters;
         (2) Its date of disease onset and the disease date for another confirmed case in the same district is less than or equal to 14 days.
      3. When the districts with disease concentration adds another confirmed case (fourth, fifth, and so on), the above guidelines should be followed analogously.
7. Container Reduction Plans: the prevention of dengue fever emphasizes eliminating the breeding source. In order to reverse the outbreak, a plan was implemented in Kaohsiung City's Cianjhen, Lingya and Sanmin districts. From November 15-30, 2006, the Environmental Protection Bureau

mobilized cleaning crews to reduce the amount of containers.

(1) In order to let citizens and cleaning crews quickly understand the targeted items, a mnemonic was created: one “ping” (bottles, containers and used storage batteries), two “tai” (used tires), three “gang” (water jars and tubs), four “si” (laundry baskets), five “lung” (styrofoam), six “he” (candy and cookie boxes), seven “ma” (toilets), eight “bu” (canvas), nine “ju” (aquariums), ten “chuan” (helmets), eleven “lang” (betel nut stand posts), twelve “ta” (cooling towers), thirteen “zi” (pails, buckets, plates, and ladles).

(2) Cleaning took place during November 15-30, 2006.

(3) Targeted areas: primarily included districts with disease concentration, including Minghsiao and 36 other areas in the Cianjhen district, Wanchung and 22 other areas in the Sanmin district, and Linjin and 19 other areas the Lingya district. Implementation of container reduction plans in areas not included depended on the capacity of their administrative regions.

(4) Evaluation of Results:

1. Evaluation criteria: the investigation included the Breteau index, larvae index, adult mosquito index, positive rate, and the positive drainage and basement score.
2. Results were classified into the following 3 categories:
   (1) Need immediate action: if the investigation results showed that the larvae index was greater or equal to Level 5 or the adult mosquito index was greater or equal to 0.2 or the Breteau index was greater or equal to Level 3.

(2) Satisfactory result: the larvae index was less than or equal to Level 1 and the adult mosquito index was 0 and the Breteau index was less than or equal to Level 1.

(3) Need to improve preventive measures: between the need immediate action and satisfactory result categories.

Results

(1) Scale of Outbreak: the K-K-P region reported 2066 cases of locally-acquired dengue fever in 2006. According to the disease date, the peak of the outbreak occurred in week 43 with 87 cases (Figure 1). In total, there were 952 confirmed cases, 861 negative cases and 253 indeterminate cases (including 16 deaths that occurred before a second sample could be taken; thus, 237 cases did not have a second sample).

(2) Case Distribution: of the 952 confirmed cases, 757 cases were located in Kaohsiung City (including 302 in the Cianjhen District, 135 in the Sanmin District, 157 in the Lingya District, and 50 in the Hsiaogang District), and 185 cases were in Kaohsiung County [including 164 in Fongshan City and 10 in Pingtung County (with 5 cases in Pingtung City)] (Figure 2). In Kaohisiung City, Kaohsiung County and Pingtung County, the highest rate of dengue fever per 100,000 persons was found in Kaohsiung City's Cianjhen District (150.4 persons), with Lingya District in second (82.1 persons), followed by Chienking District (55.5 persons), and Fongshan City (48.6 persons) as shown in Figure 3.

(3) Source of Reporting: 654 confirmed cases were reported from hospitals, 105 cases from clinics, and 193 cases came from expanded serum collection activities.

(4) Analysis of Dengue Virus (DENV) Serotype:

1. Serotype distribution: 371 cases belonged to the DENV-3 serotype, 34 to the DENV-2 serotype, 1 to the DENV-1 serotype, and 546 cases were not identified. The distribution of virus serotypes was as follows: 1 case of DENV-1 in Pingtung County, 97 cases of DENV-3 and 1 case of DENV-2 in Kaohsiung County, 274 cases of DENV-3 and 33 cases of DENV-2 in Kaohsiung City. Further analysis showed 129 cases of DENV-3 and 1 case of DENV-2 in the Cianjhen District, 16 cases of DENV-3 and 20 cases of DENV-2 in the Sanmin District, 81 cases of DENV-3 in the Lingya District, 30 cases of DENV-3 in the Hsiaogang District, and 7 cases of DENV-3 and 3 cases of DENV-2 in the Kushan District.
2. Results from gene sequencing analysis: 90 serotypes belonged to DENV-3, 30 to DENV-2 and 1 to DENV-1. Results showed that 6 strains were primarily responsible for transmission. The DENV-3 virus could be separated into 2 different strains (DENV-3-1 and DENV-3-2) that were most similar to the gene sequence of a virus from Cambodia. The DENV-2 virus could be separated into 3 different strains (DENV-2-1, DENV-2-2 and DENV-2-3) that were similar in sequence to a virus from Vietnam; the DENV-1 virus also closely resembled one from Vietnam.

(5) Case Population Demographics: there were 442 male confirmed cases and 510 female confirmed cases. The age distribution was 0-88 years (average 43.2, median 45 and mode 51 years). Males had an average age of 40.7 years, while females had an average age of 45.4 years. The average ages for males and females were statistically different (p-value=0.0002). The

highest incidence rate per 100,000 persons was found in the age group 65 and above with 35.53 persons, followed by age group 25-64 with 30.21 persons, age group 5-24 with 17.25 persons, and age group 0-4 with 6.58 persons. When comparing the incidence rates in different age groups when stratified by sex, the rate was higher in males for the 24 years and under group, while the rate was higher in females for the 25 years and above group. The rate of dengue fever in females was 1.2 times higher than the rate in males (Figure 4).

(6) Number of Visits for Cases Reported by Medical Facilities (excluding transferred cases from expanded serum collection activities)

1. Descriptive analysis: according to the outbreak investigation report, among the 759 confirmed cases reported by medical facilities, the average number of visits was 1.89 (SD=1.11). Stratified by week, in weeks 26-35, the average visits for the 137 confirmed cases was 1.52 (SD=0.92). In weeks 36-44, the average visits for the 395 cases was 1.99 (SD=1.14), and the 227 cases from weeks 45-53 visited their medical facilities an average of 1.94 times (SD=1.12).
2. Simple regression analysis: the correlation between the number of medical visits and week of disease was not statistically significant (p-value=0.0837). The number of visits did not change as the number of weeks increased.

(7) Time from Disease to Report Date for Cases Reported by Medical Facilities (excluding transfer cases from expanding serum collection activities)

1. Descriptive analysis: among the 759 confirmed cases reported by medical facilities, the average time from disease onset date to report

date was 4.42 days (SD=2.46). Stratified by week, in weeks 26-35 the average time from disease onset to report date for the 137 confirmed cases was 4.64 days (SD=2.15). In weeks 36-44, the average time from disease onset to report date for the 359 cases was 4.33 days (SD=2.51), and the 227 cases in weeks 45-53 had an average lag time of 4.43 days (SD=2.55).

2. Simple regression analysis: The correlation between time from disease to report date and the week of disease was not statistically significant (p-value=0.235), showing that the lag time did not change as the number of weeks increased.

(8) This outbreak resulted in 19 cases of dengue hemorrhagic fever: 2 cases aged 0-4, 4 cases aged 5-24, 7 cases aged 25-64, and 6 cases aged 65 and above. Twelve cases were male (11 stayed in the hospital) with a corresponding incidence rate of 6.4 per 1,000,000 persons. Seven cases were female (all 7 stayed in the hospital) with a corresponding incidence rate of 3.9 per 1,000,000 persons. There were 4 deaths (3 male and 1 female) with the victims' ages in the range 66-76 year. The mortality rate was 21.1%.

(9) Analysis of First Sample and Combined Results

1. Examined by PCR: 1689 reported cases were examined for antibodies and underwent PCR testing. Among them, 733 cases were confirmed for dengue fever, with 456 cases testing PCR positive (456/457, 99.9% positive rate). A total of 115 cases (100% positive rate) were PCR negative and both IgG and IgM positive, while 95 cases (70.9% positive rate) were only IgM positive and 12 cases (60% positive rate) were only IgG positive. Results showed that 55 cases (5.7% positive rate) were

negative for PCR, IgG and IgM (Table 1).

2. Not examined by PCR: 377 reported cases were tested for antibodies but did not undergo PCR testing. Among them, 219 cases were confirmed for dengue fever. Results showed that 147 cases (100% positive rate) were both IgG and IgM positive, while 55 cases (83.3% positive rate) were positive only for IgM and 5 cases (83.3% positive rate) were positive only for IgG. There were 12 cases (7.5% positive rate) that were negative for both IgG and IgM (Table 2).

(10) Analysis of Weather Data and Breteau Index:

1. Simple regression of weather factors: simple regression was performed on average weekly temperature and the following week's Breteau index. The R^2 value was 0.4462 (p-value<0.01) (Figure 5). The largest R^2 value was found in the simple regression model with weekly rainfall and the following week's Breteau index (R^2 value=0.4939, p-value<0.01) (Figure 6). Thus, the only weather factors found to be significantly correlated with the Breteau index were average weekly temperature and weekly rainfall.
2. Multiple regression of weather factors:
   (1) Analysis of collinearity among variables: the tolerance of the average weekly temperature and rainfall was 0.8951 (>0.1), and the variables were not collinear.
   (2) The largest R^2 value was found in the multiple regression model containing the average weekly temperature and rainfall and the following week's Breteau index (Adjusted R^2=0.6985, p-value<0.01). Thus, the only weather factors found to be significantly correlated with the Breteau index were average

weekly temperature and weekly rainfall.

(11) Results from Container Reduction Activities: the results for the period November 15-30, 2006, are shown in Table 3.

(12) Evaluation of Results: the evaluation took place until December 26, 2006. Among the 77 targeted areas in Kaohsiung City's Cianjhen, Lingya and Sanmin districts, 2 areas needed immediate action, 57 areas needed to improve preventive measures and 18 areas maintained satisfactory results (Table 4). However, after implementing clean-up activities in these 77 areas, 5 areas (Dintai, Dinsi and Chengshuen Areas in the Sanmin District plus Chengyang and Chenghai Areas in the Cianjhen District) still had cases of dengue fever occur in 2007.

Discussion and Suggestions

Dengue fever is currently the most widespread vector-borne viral disease worldwide and is responsible for 50 million infections annually [1]. Infection by any serotype of dengue virus may present no symptoms, result in slight fever, or progress to dengue hemorrhagic fever or dengue shock syndrome.

In 2006, confirmed cases of dengue fever within Kaohsiung City originated in the Cianjhen District's Rueihe Area. Transmission began at the end of June 2006 and spread primarily to Kaohsiung City and Kaohsiung County (Figure 2). We suggest establishing ties within these areas in order to prevent further transmission in case of a dengue fever outbreak. For instance, each city and county can designate liaisons and establish means of communication so that preventive measures can be developed together.

Among the confirmed cases of dengue fever, 46.4% (442/952) were male, while 53.6% (510/952) were female. The age distribution of dengue fever and

dengue hemorrhagic fever in Taiwan is similar to countries such as Singapore and Cuba, where patients are mostly adults. This pattern is different from high-incidence countries, such as Thailand, Philippines and Vietnam (where over 70% of patients with dengue hemorrhagic fever are children under the age of 15 [2]). The question of why dengue fever occurs primarily in adults in Taiwan, whether it is related to factors such as area of infection or occupation, awaits further analysis.

Although the relevant organizations made great efforts to reach out to citizens and medical personnel immediately after the outbreak occurred, both the number of medical visits and the time between disease onset and report date did not decrease with time. Patients made an average of 2 or more visits before the case was reported by the medical facility. However, the fact that the average time between the first visit to the report date was less than 4 days may indicate that medical facilities and the general population already have a good understanding of infectious diseases, and there is less room for improvement. Since atypical cases or those with mild disease presentations were also reported quickly, whether this was related to the particular virus strain in addition to the doctor's vigilance requires further clarification. Since viremia of the dengue virus infection lasts from 1 day before disease onset to 5 days afterwards, health authorities can begin preventive measures earlier to reduce further spread of the virus if cases are reported sooner. According to the way in which citizens access care, patients would have visited 2 or 3 hospitals or clinics in the 3 or more days required for case reporting. Since the early stages of dengue fever infection do not present with classical symptoms, factors such as the doctor's lack of vigilance or a desire to maintain the current doctor-patient relationship prevent timely case reporting to health

authorities, which in turn results in missed opportunity for prevention.

In terms of laboratory throughput, samples received before 10am will have results by the end of the day, allowing immediate consideration by health authorities when planning prevention strategies. Guidelines for spraying pesticides were based on a previous outbreak in 2004 and are as follows: (1) If IgM, IgG and PCR are all negative, spraying is not necessary; (2) If either IgM or IgG or PCR is positive, spraying should begin according to the originally scheduled intervals; (3) If the second sample is negative, spraying should stop. If the result has not been determined, spraying should be implemented according to the originally scheduled intervals [3]. The 2007 guidelines for using pesticides to prevent dengue fever are as follows: health authorities can use epidemiologic data, vector investigation data and clinical evidence to make a combined diagnosis, evaluate risk and make necessary adjustments (finish spraying within 36 hours) [4]. Among the 952 confirmed cases of dengue fever in 2006, 67 cases had negative first samples and positive second samples. Thus, when the test for IgM antibodies is negative, spraying should not be ruled out immediately. We suggest that if the combined vector investigation results, clinical evidence and laboratory results present a high suspicion of dengue fever, spraying should start as soon as possible in order to reduce spread of the outbreak. This way, local authorities are given the opportunity to make a diagnosis, for it is not necessary to begin spraying indiscriminately given a limited amount of time.

The vector that carries yellow fever and dengue fever is the *Aedis* mosquito, and the risk of transmission for both diseases is similar. In the early days when yellow fever data was not readily available, the hazard standards for vector density were determined based on the risk of transmission for dengue

fever. Areas with Breteau index above 50% (≥Level 6), residential index above 35% (>Level 5) and container index of 20% (>Level 5) were considered high-risk for disease transmission. Areas with Breteau index below 5% (<Level 2), residential index below 4% (<Level 2) and container index below 3% (Level 2) were considered not likely to transmit disease. These criteria will vary among areas. Although large outbreaks are not likely when the Breteau index is Level 2 or lower, case transmission or small localized outbreaks can still occur. Above Level 2, a higher index will result in a higher possibility of transmission. Thus, the magnitude of the vector density is closely related to whether or not transmission of dengue fever will occur. In order to prevent transmission, efforts must be made to control vectors by thoroughly eliminating the breeding source. In 2007, a container reduction policy to eliminate vectors was implemented. The Central Outbreak Coordination Center created the following mnemonic to target specific items and encourage environmental organizations to meet the goals for number of items collected and tonnage: one “ping” (bottles, containers and used storage batteries), two “tai” (used tires), three “gang” (water jars and tubs), four “si” (laundry baskets), five “lung” (styrofoam), six “he” (candy and cookie boxes), seven “ma” (toilets), eight “bu” (canvas), nine “ju” (aquariums), ten “chuan” (helmets), eleven “lang” (betelnut stand posts), twelve “ta” (cooling towers), thirteen “zi” (pails, buckets, plates, and ladles). The goal for number of items was determined by Section Chief Huang Chi-Chuan, a dengue fever expert who used past prevention experiences to calculate the number. Although there was no good scientific evidence to confirm its plausibility, the desired goal was accomplished. After the evaluation of results, only 5 areas (Dintai, Dinsi and Chengshuen Areas in the Sanmin District plus Chengyang and Chenghai Areas

in the Cianjhen District) out of the 77 areas in which work was completed had cases of dengue fever occur in 2007, confirming our campaign's effectiveness.

Since atmospheric pressure, temperature, humidity, and rainfall and the larvae density index are statistically associated [5], the vector index was also correlated with temperature and rainfall in 2006. Due to the El Niño effect, the winter was warmer than usual. Depending on weather changes alone to lower the Breteau index is hopeless. Thus, implementing container reduction activities to get rid of the breeding source and actively cut the chain of transmission will allow us to be one step ahead of the outbreak. Furthermore, mobilizing prevention units and vector experts to evaluate results may prevent the outbreak from proceeding past the winter.

Complete elimination of the vector breeding source is the most fundamental way to prevent dengue fever. This measure needs to be a priority for local officials; and cooperation from governmental departments needs to be fostered. Thus, city, county or local governments should gather the participation of relevant officials to establish inter-departmental dengue fever prevention centers in order to mobilize each office's capabilities. The mayor of each city, county or area should serve as convener of the prevention center so that they can lead the cooperation. For the fight against dengue fever, the heads of the Cianjhen, Sanmin, Lingya, and Kushan Districts served as coordinators for all the prevention activities at the district-level. The collaboration between health and environmental authorities was largely beneficial to the campaign. Mutual support between districts will be necessary to develop a collaborative spirit in order to put an early end to dengue fever outbreaks.

Acknowledgments

The authors would like to give special thanks to the Ministry of Transportation's Weather Bureau, the Kaohsiung City Government's Environmental Protection Bureau, the Kaohsiung City and County Governments' Health Bureaus, and the Centers for Disease Control Research and Diagnostic Center's Southern Regional Laboratory for providing data and enabling the completion of this report.

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Table 1. Relations between Examination results of Acute phase serum sample and final diagnosis for Reported Cases of Dengue Fever in the Kaohsiung- City- Kaohsiung County- Pingtung County - Penghu Region During 2006 (Tested by PCR)

	Examination Results							
Case Results	PCR(+) IgM(+) IgG(+)	PCR(+) IgM(+) IgG(-)	PCR(+) IgM(- IgG(+)	PCR(+) IgM(-) IgG(-)	PCR(-) IgM(+) IgG(+)	PCR(-) IgM(+) IgG(-)	PCR(-) IgM(-) IgG(+)	PCR(-) IgM(-) IgG(-)
Positive	25	101	4	326	115	95	12	55
Negative	0	0	0	1	0	8	4	715
Unclear	0	0	0	0	0	31	4	193
Total	25	101	4	327	115	134	20	963
Pos. Rate	100%	100%	100%	99.7%	100%	70.9%	60%	5.7%

Table 2. Relations between Examination results of Acute phase serum sample and final diagnosis for Reported Cases of Dengue Fever in the Kaohsiung- City- Kaohsiung County- Pingtung County - Penghu Region During 2006 (Not Tested by PCR)

	Examination Results			
Case Results	IgM(+)/IgG(+)	IgM(+)/IgG(-)IgM(-)/IgG(+)IgM(-)/IgG(-)		
Positive	147	55	5	12
Negative	0	3	0	130
Indeterminate	0	8	1	16
Total	147	66	6	158
Positive Rate	100%	83.3%	83.3%	7.6%

Table 3. Container Reduction Strategy in Kaohsiung City During 2006：Estimated target weight and number of waste items for reduction

District	# Areas	# Houses	Population	Target Wt*	Actual Wt	Target No.#	Actual No.
Cianjhen	36	40903	111473	11.1	9.5	28632	25105
Sanmin	22	41995	118756	11.9	11.5	20998	27052
Lingya	19	16868	48586	4.9	12.3	8434	25178

*：Population × 0.1 Kg

Notes #：Adjusted according to factors such as number of houses, environmental ecology, culture, and outbreak status.

Table 4. Results of Container Reduction Strategy in Kaohsiung City During 2006

	Cianjhen District	Sanmin District	Lingya District	Prevention Status	Notes
Number of Areas	1 (2.8%)	1 (4.5%)	0 (0%)	Need immediate action	2 (2.6%)
	23 (63.9%)	19 (86.4%)	15 (78.9%)	Need improvement	57 (74%)
	12 (33.3%)	2 (9.1%)	4 (21.1%)	Satisfactory result	18(23.4%)

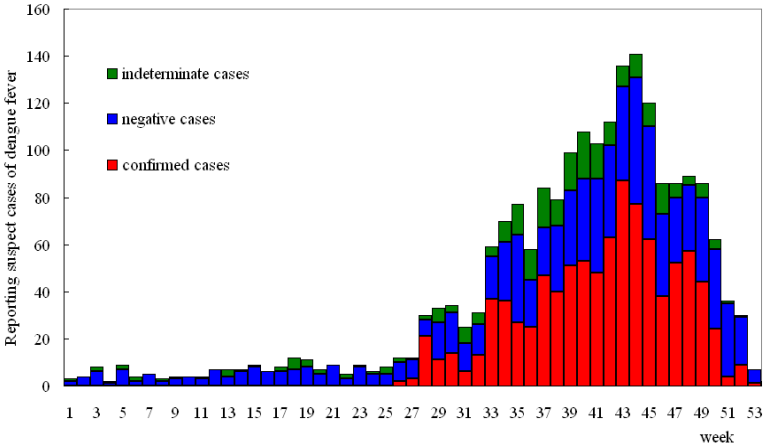


Figure 1. Epidemic Curve of Dengue Fever in Kaohsiung City- Kaohsiung County- Pingtung County During 2006

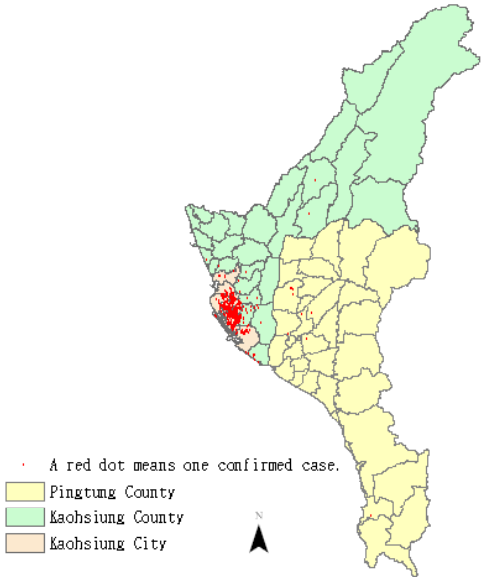


Figure 2. Distribution of Locally-acquired Dengue Fever Cases in Kaohsiung City- Kaohsiung County-Pingtung County During 2006

Figure 3. Incidence Rate of Dengue Fever (No. of cases per 100,000) in Figure 3. Kaohsiung City- Kaohsiung County-Pingtung County During 2006

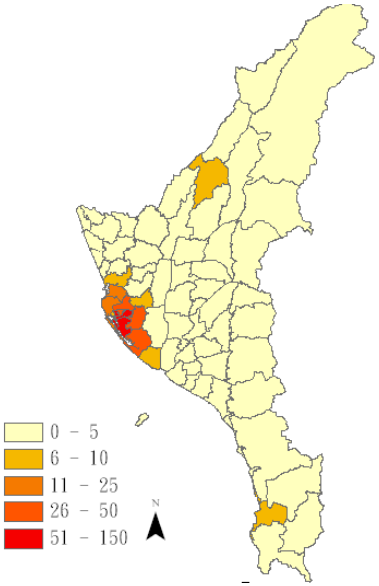
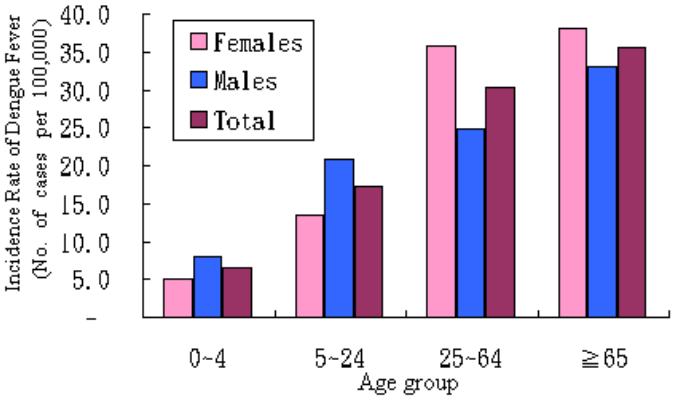


Figure 4. Incidence Rate of Dengue Fever by Age and Sex in Kaohsiung City- Kaohsiung County-Pingtung County During 2006



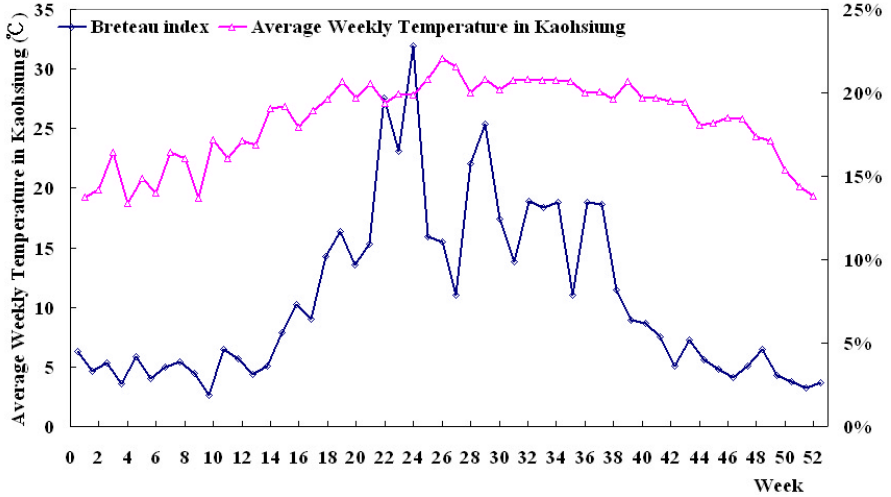


Figure 5. Association Between Vector Index and Average Weekly Temperature in Kaohsiung During 2006

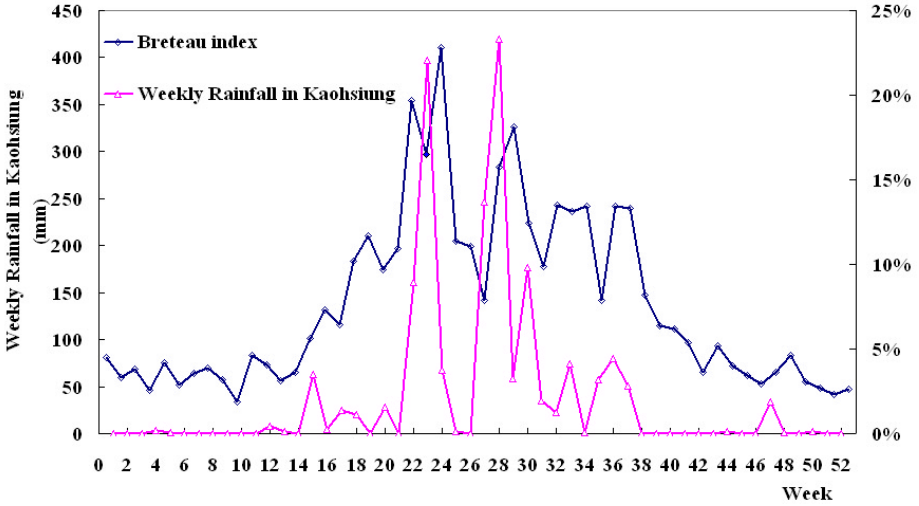


Figure 6. Association Between Vector Index and Weekly Rainfall in Kaohsiung During 2006