Surveillance and Control of Dengue Hemorrhagic Fever (DHF) in Southern Areas of North-Eastern, Thailand

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Abstract
Dengue fever (DF) and Dengue Hemorrhagic Fever (DHF) are important public health diseases mainly transmitted by Aedes aegypti especially in southern areas of North-Eastern Thailand. The ArcGIS database was developed via software called "ArcView ver 3.2". Fifteen villages from three provinces, Ubon Ratchathani, Sri-Sa-Ket, and Amnart Charoen, were selected for the study based on the high number of cases and morbidity rates, especially during the pre-outbreak period. Larval vector surveys showed all dengue indices in the villages were normally higher during the pre-outbreak period compared to the outbreak and post-outbreak periods. Comparisons between provinces revealed that Sri-Sa-Ket had the highest dengue indices during the outbreak period. All dengue indices during and in the post-outbreak periods decreased. In all provinces, results showed the overall post-scores were higher than the pre-scores for DHF perception and prevention behaviors.

1. Background

Vector borne diseases are the world's most common health hazard and represent a constant and serious risk to a large part of its population. Dengue fever (DF) and dengue hemorrhagic fever (DHF), mainly transmitted by *Aedes aegypti*, are responsible for millions of cases annually, occurring in over 100 countries throughout the Americas, Southern Europe and Mediterranean countries, Asia, and the Pacific region (World Health Organization, 2002). DF and DHF epidemics are the leading cause of children's hospitalization in South-East Asia and are responsible for high expenditure, 15 to 20 million US$ per year in Thailand) (Sommani et al., 2000). Fatalities due to DHF have decreased nationally but Thailand still reports between 20,000 and 100,000 cases annually (Nimmannitya, 2002) if that. Recently, the incidence of DHF has increased in many southern areas of North-Eastern Thailand, especially Ubon Ratchathani, Sri-Sa-Ket, and Amnart Charoen (Srijakrawanwong et al. 1993 and Sathimai et al., 1998). These areas with a tropical climate and are close to the borders with Cambodia and Laos. A high number of DHF cases normally occur during the rainy season due to the increased breeding of the dengue mosquito (Medical Science Committee, Thailand, 1998 and Focks and Chadee, 1997). Despite national strategies regarding the *aedes* mosquito and DHF control, outbreaks of the disease occur each year. There are four different serotypes of dengue virus, DEN-1, DEN-2, DEN-3, and DEN-4. The viruses are transmitted by mosquitoes to humans through bites during probing and blood feeding (Kuno, 1995). Most of the infections by dengue viruses are not severe and present asymptomatically, allowing infected patients to maintain normal activities. Female mosquitoes lay eggs in containers, such as water jars, cans, and used tyres, and bite humans. Rapid industrial and economic development over the last two decades have brought about massive infrastructure changes and have created conducive environments for the breeding of the *aedes* mosquito (Goh et al., 1987). The flight range of the mosquito is less than a kilometer, limiting the spread of the disease, and environmental changes have had a major effect on the pattern of dengue incidence distribution. Vector control strategies are mainly based on mosquito population control, there being no vaccination available to treat the viruses. Control methods include spraying campaigns to quickly stop transmission during epidemics but the efficiency of prevention and control activities is often too slow as it takes quite a long time to set up the activities in epidemics and to maintain them during non-epidemic periods. Variety in epidemiological patterns of DHF makes it difficult to predict epidemics normally reported via dengue vector indices, house index (HI), container index (CI), and Breteau index (BI). Geographic information system (GIS) technologies have previously been used in

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public health to help health authorities establish surveillance and mitigation strategies (Curran et al., 2000). GIS technologies are able to integrate, analyze, and display spatial and temporal data from various sources in one central location. From the public health perspective, GIS is essentially used to determine the health situation of an area, generating and analyzing disease hypotheses, identifying high risk disease-affected areas, prioritizing areas for mitigation and surveillance plans, and programming and monitoring the incidence record (Barbazan et al., 2000). In the cases of DF and DHF, GIS is being used to evaluate and model the relationships between climatic and environmental factors with the incidences of viral diseases. GIS applications have the potential to revolutionize epidemiology and its applications in human health (Hay, 2000). Recent studies have demonstrated the use of GIS satellite imagery and digitized land-use maps, and global positioning data promises improvements in predicting changes in habitats of mosquito vectors as they affect disease transmission (Linthicum et al., 1994 and Chaikoolvatana et al., 2008). The researchers aimed to develop an ArcGIS database containing dengue vector data and DHF surveillance and control in targeted areas of southern North-Eastern Thailand and to evaluate villagers' behaviors and attitudes towards DHF prevention.

2. Methods

2.1 Study Areas

The study areas were fifteen selected villages in three different provinces, Ubon Ratchathani (total area 16,112.65 km^2), Amnart Charoen (total area 3,161.24 km^2), and Sri-Sa-Ket (total area 8,839.97 km^2). Five villages in each province were selected because of their high incidence of DHF cases and high morbidity/mortality rates during the five year period 2004 to 2008.

2.2 Data Collection

2.2.1Dengue indices survey

All fifteen villages of the three provinces were purposively surveyed. The collection of data was divided into three different periods: 1) *Pre-outbreak* (February to May 2009), 2) *Outbreak* (June to October 2009), and 3) *Post-outbreak* (November to January 2009). All residential houses (100 percent) were surveyed using a standard tool of the World Health Organization (WHO), the Visual Larval Survey (Goh, 1993). Dengue vector indices, house index (HI), container index (CI), and Breteau index (BI), were collected from indoor, outdoor natural, and outdoor artificial water containers at each household to determine the presence of *Aedes aegypti* mosquitoes. The location of each individual household was geographically mapped by a Global Positioning System (GPS). Comparisons of the dengue indices surveys of the three provinces were made.

2.2.2 Analysis of DHF perceptions and prevention behaviors

Three districts with high incidences of DHF cases in the three provinces participated in the study by completing a DHF perceptions and prevention behaviors survey. These districts were (Figure 1):

1. Ubon Ratchathani districts - Khueng-Nai (18), Warinchumrab (37), Boontharik (41) (n= 96)
2. Sri-Sa-Ket districts - Munag-Chan (20), Khu-Khan (28), Wang-Hin (22) (n=70)
3. Amnart Charoen districts - Leu-Amnart (17), Muang (19), Trakan-Phutphol (16) (n=52)

Note: (number of volunteers)

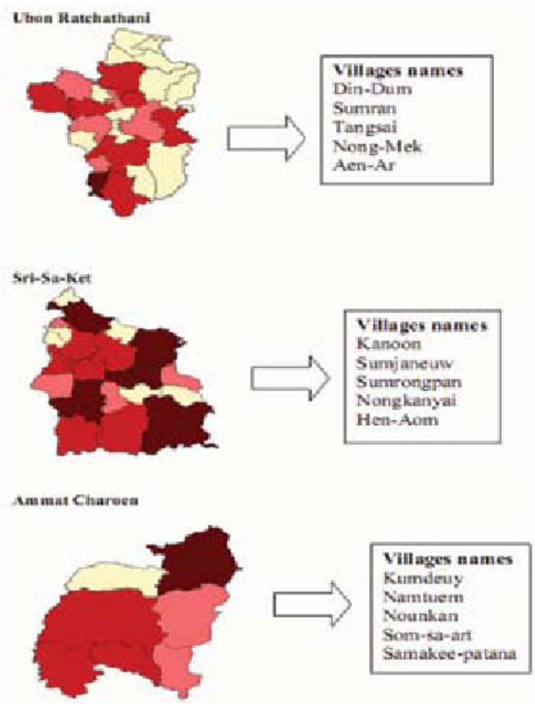


Figure 1: Village Names

Volunteers from each district were purposively sampled for the survey (Daniel, 1987) and a total of two hundred and eighteen were interviewed. A questionnaire was developed and tested for both content validation and reliability. The average of Cronbach's alpha coefficient was found to be 0.784. Each questionnaire item was scored at a value of either one (1) or zero (0) point, giving a maximum score of 16 points. It was decided that a score between 11 and 16 was considered as a high level of perception, a score between 6 and 10 was considered an average level of perception, and a score of 0 and 5 was considered a low level of perception (Wongbutdee et al., 2010). A family member of each household was interviewed and filled out the questionnaire (this was regarded as the pre-test). Public health staff then provided basic information and self-care behaviors for volunteers in relation to dengue mosquitoes and DHF prevention. Immediately after the completion of this, all volunteers completed a questionnaire (this was regarded as the post-test). Comparisons of scores between the three provinces were made.

2.3 Statistical Analysis

All data were evaluated statistically.

- Firstly, the number of DHF cases and mortality and morbidity rates were descriptively analyzed. House index (HI) was defined as the percentage of houses found to be positive for larvae;
  - A score above 10 was considered → a *High Risk of DHF*
  - A score between 1 and 10 was considered → an *Average Risk of DHF*
  - A score below 1 was considered → *a Low Risk of DHF*
- Secondly, container index (CI) was defined as the percentage of water-filled containers found to be positive for larvae and the same classification of values as for HI values were adopted.
- Finally, Breteau index (BI) was defined as the percentage of the number of larvae-positive containers per 100 houses;
  - A score of above 50 was considered → *a High Risk of DHF*
  - A score between 5 and 50 was considered → *an Average Risk of DHF*
  - A score below 5 was considered → *a Low Risk of DHF* (Thavara, 2004)
- Additionally, comparisons of dengue indices between the three provinces were made through the use of descriptive (e.g., Mean, SD, Percentage) and analytical statistics (e.g., Correlation coefficient, ANOVA).
- DHF perception and prevention behaviors of each province were assessed via the descriptive statistics of means, standard deviations (SD), and percentages.

2.4 ArcGIS Database Developments

The ArcGIS database was developed via software called 'ArcGIS® ver.3.2' and was programmed in *Avenue* language with *Dialogue Design* function. The steps of the development included:

Input dengue vector indices and DHF perception and prevention behaviors into ArcGIS database

↓

Input attribute and spatial data into ArcGIS (Figure 2)

↓

Develop the boundaries of the villages and residential houses via remote sensing tool and GPS (Figure 3)

↓

Develop a data dictionary via binding data field of both attribute and spatial data into ArcGIS database

↓

Analyze high risk DHF areas via specifying weight score of DHF risk factors including dengue vector indices (HI, CI, BI), prevention behaviors, land uses, altitude of target areas, and hospital distance

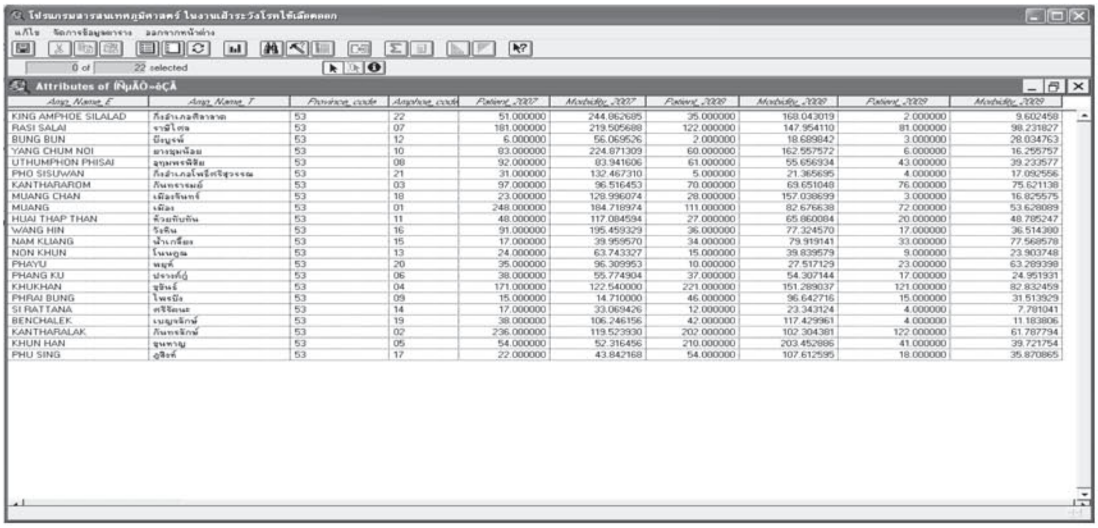
↓

Above data was mapped and imported into ArcGIS database for further evaluation. This program potentially functions to edit, search, save, and represent the data (Figure 4)

3. Results

3.1 Dengue Hemorrhagic Fever (DHF) Population Density and Morbidity Rate

The population density of DHF for each district in Ubon Ratchathani, Sri-Sa-Ket, and Ammart Charoen was calculated by consideration of the number of cases. The five districts with the highest density of DHF cases and morbidity rates in Ubon Ratchathani were Det Udom (126 cases, 74.40%), Muang (113 cases, 49.83%), Trakan Phuetphon (84 cases, 70.02%), Khueng Nai (65 cases, 58.80%), and Phibun Mangsahan (46 cases, 34.40%). In Sri-Sa-Ket, the districts with the highest density and rates were Kan Ta Ra Rak (122 cases, 61.78%), Khu Kan (121 cases, 82.83%), Ra Sri Salai (81 cases, 98.23), Kun Ta Ra Rom (76 cases, 75.62), and Muang (72 cases, 75.62%). In Amnart Charoen, the districts with the highest density and rates were Muang (71 cases, 54.15%), Cha Nu Marn (28 cases, 75.86%), Hao Ta Pan (26 cases, 51.20%), Leu Amnart (23 cases, 61.05%), and Pa Thum Raj (14 cases, 30.91%).



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Attributes of ÎÑµÃÒ-éÇÅ

Amp_Name_E	Amp_Name_T	Province_code	Amphoe_code	Patient_2007	Morbidity_2007	Patient_2008	Morbidity_2008	Patient_2009	Morbidity_2009
KING AMPHOE SILALAD	กิ่งอำเภอศิลาลาด	53	22	51.000000	244.862685	35.000000	168.043019	2.000000	9.602458
RASI SALAI	ราษีไศล	53	07	181.000000	219.505688	122.000000	147.954110	81.000000	98.231827
BUNG BUN	บึงบูรพ์	53	12	6.000000	56.069526	2.000000	18.689842	3.000000	28.034763
YANG CHUM NOI	ยางชุมน้อย	53	10	83.000000	224.871309	60.000000	162.557572	6.000000	16.255757
UTHUMPHON PHISAI	อุทุมพรพิสัย	53	08	92.000000	83.941606	61.000000	55.656934	43.000000	39.233577
PHO SISUWAN	กิ่งอำเภอโพธิ์ศรีสุวรรณ	53	21	31.000000	132.467310	5.000000	21.365695	4.000000	17.092556
KANTHARAROM	กันทรารมย์	53	03	97.000000	96.516453	70.000000	69.651048	76.000000	75.621138
MUANG CHAN	เมืองจันทร์	53	18	23.000000	128.996074	28.000000	157.038699	3.000000	16.825575
MUANG	เมือง	53	01	248.000000	184.718974	111.000000	82.676638	72.000000	53.628089
HUAI THAP THAN	ห้วยทับทัน	53	11	48.000000	117.084594	27.000000	65.860084	20.000000	48.785247
WANG HIN	วังหิน	53	16	91.000000	195.459329	36.000000	77.324570	17.000000	36.514380
NAM KLIANG	น้ำเกลี้ยง	53	15	17.000000	39.959570	34.000000	79.919141	33.000000	77.568578
NON KHUN	โนนคูณ	53	13	24.000000	63.743327	15.000000	39.839579	9.000000	23.903748
PHAYU	พยุห์	53	20	35.000000	96.309953	10.000000	27.517129	23.000000	63.289398
PHANG KU	ปรางค์กู่	53	06	38.000000	55.774904	37.000000	54.307144	17.000000	24.951931
KHUKHAN	ขุขันธ์	53	04	171.000000	122.540000	221.000000	151.289037	121.000000	82.832459
PHRAI BUNG	ไพรบึง	53	09	15.000000	14.710000	46.000000	96.642716	15.000000	31.513929
SI RATTANA	ศรีรัตนะ	53	14	17.000000	33.069426	12.000000	23.343124	4.000000	7.781041
BENCHALEK	เบญจลักษ์	53	19	38.000000	106.246156	42.000000	117.429961	4.000000	11.183806
KANTHARALAK	กันทรลักษ์	53	02	236.000000	119.523930	202.000000	102.304381	122.000000	61.787794
KHUN HAN	ขุนหาญ	53	05	54.000000	52.316456	210.000000	203.452886	41.000000	39.721754
PHU SING	ภูสิงห์	53	17	22.000000	43.842168	54.000000	107.612595	18.000000	35.870865

Figure 2: Example of attribute and spatial data

Figure 3: The boundaries of the villages and houses via remote sensing

3.2 Larval Vector Survey

3.2.1 Overall dengue indices in three provinces

The overall dengue indices (HI, CI, BI) in Ubon Ratchathani during the pre-outbreak period were mainly high in some villages such as Sumran (HI 26%, CI 15%, BI 39%), Tangsai (HI 22%, CI 18%, BI 13%), and Nong-Mek (HI 21%, CI 11%, BI 22%). However, the indices decreased during the outbreak season in most areas (for example, Sumaran [HI 11.4%, CI 3.14%, BI 11.41%]). The indices values fluctuated during the post-outbreak period, for example, Tangsai and Nong-Mek had high indices. Sri-Sa-Ket had the similar situation of dengue indices as Ubon Ratchathani. However, the indices in this province were higher than those in the other two provinces. During the pre-outbreak period, the indices tended to increase in some particular villages, such as Sumjaneuw (HI 55%, CI 20%, BI 120%) and Nongkanyai (HI 58%, CI 32%, BI 25%). All index values declined during the outbreak period. For Amnart Charoen, the overall vector index values increased during the pre-outbreak period, for example Kumdeuy (HI 42%, CI 21%, BI 44%) and Nounkan (HI 40%, CI 22%, BI 45%), and gradually decreased during the outbreak period, (except in Som-sa-art [BI: 9 → 38%]) and in the post-outbreak period (except in Som-sa-art [HI: 3.81 → 11.32%]).

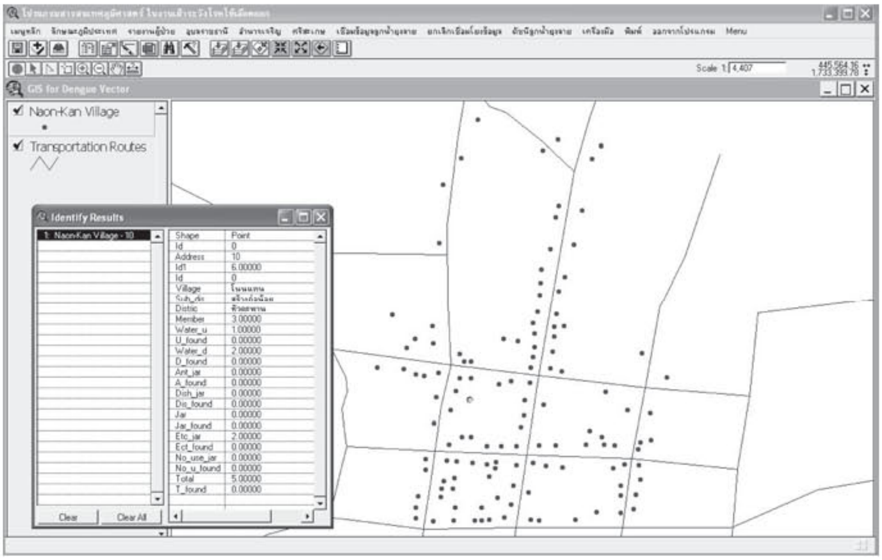

Figure 4: Mapping data

Table 1 : Dengue vector indices (HI, CI, BI)

Province(s) / Village name(s)	Pre-outbreak			Outbreak			Post-outbreak		
Ubon Ratchathani	HI	CI	BI	HI	CI	BI	HI	CI	BI
1.Din-Dum	6.40	3.63	6.98	12.92	4.03	19.66	4.97	0.97	4.97
2.Sumran	25.49	16.33	39.22	11.41	3.14	11.41	4.40	0.87	4.40
3.Tangsai	21.51	18.57	13.98	10.58	3.44	10.58	21.00	7.69	24.00
4.Nong-Mek	20.81	10.70	20.81	10.17	2.92	11.86	28.67	8.30	30.00
5.Aen-Ar	13.79	7.44	13.79	11.27	2.24	14.08	3.80	0.66	3.80
Sri-Sa-Ket									
1.Kanoon	44.17	16.86	12.08	3.70	0.70	3.70	4.65	1.59	5.81
2.Sumjaneuw	66.33	20.32	118.37	46.56	12.41	65.99	24.68	9.00	39.15
3.Sumrongpan	39.86	28.90	126.35	55.17	16.37	78.62	34.35	12.27	45.24
4.Nongkanyai	58.61	32.86	25.27	45.26	13.04	63.16	40.22	17.11	84.78
5.Hen-Aom	34.62	17.46	79.49	44.08	14.07	61.18	22.97	6.27	26.35
Amnart Charoen									
1.Kumdeuy	42.40	21.32	44.00	4.17	0.95	7.29	3.20	0.45	3.20
2.Namtuem	8.94	4.26	8.94	11.38	1.95	11.38	4.07	0.72	4.07
3.Nounkan	40.48	22.80	45.24	12.70	3.11	18.25	2.36	0.52	3.15
4.Som-sa-art	20.95	8.24	21.43	3.81	0.89	5.24	11.32	2.25	13.21
5.SDamakee-patana	8.60	3.60	9.68	29.03	7.35	38.71	12.63	2.65	14.74

3.2.1 Overall dengue indices in three provinces

The overall dengue indices (HI, CI, BI) in Ubon Ratchathani during the pre-outbreak period were mainly high in some villages such as Sumran (HI 26%, CI 15%, BI 39%), Tangsai (HI 22%, CI 18%, BI 13%), and Nong-Mek (HI 21%, CI 11%, BI 22%). However, the indices decreased during the outbreak season in most areas (for example, Sumaran [HI 11.4%, CI 3.14%, BI 11.41%]). The indices values fluctuated during the post-outbreak period, for example, Tangsai and Nong-Mek had high indices. Sri-Sa-Ket had the similar situation of dengue indices as Ubon Ratchathani. However, the indices in this province were higher than those in the other two provinces. During the pre-outbreak period, the indices tended to increase in some particular villages, such as Sumjaneuw (HI 55%, CI 20%, BI 120%) and Nongkanyai (HI 58%, CI 32%, BI 25%). All index values declined during the outbreak period. For Amnart Charoen, the overall vector index values increased during the pre-outbreak period, for example Kumdeuy (HI 42%, CI 21%, BI 44%) and Nounkan (HI 40%, CI 22%, BI 45%), and gradually decreased during the outbreak period, (except in Som-sa-art [BI: 9 → 38%]) and in the post-outbreak period (except in Som-sa-art [HI: 3.81 → 11.32%]).

3.2.2 HI, CI, BI Comparison between Provinces

Pre-outbreak: Comparisons of HI values of the three provinces revealed that Sri-Sa-Ket had the highest (Sumjaneuw [66.33%], Nongkanyai [58.61%], and Kanoon [44.17%]), followed by Amnart Charoen (Kumdeuy [42.40%] and Nounkan [40.48%]), and Ubon Ratchathani (Sumran [25.49%], Tangsai [21.51%], and Nong-Mek [20.81%]). CI values increased during and after the DHF outbreak, especially in Sri-Sa-Ket (between 16-32%) compared to Ubon Ratchathani (between 6-25%) and Amnart Charoen (between 3-22%). There also tended to be an increase in BI values, especially in Sri-Sa-Ket (Sumajaneuw [118%], Sumrongpan [126%], and Hen-aom [79%]) compared to Ubon Ratchathani and Amnart Charoen.

Outbreak: Overall, the HI values in the three provinces decreased during the outbreak, except Samakee-patana (Amnart Charoen). All high risk areas decreased in terms of CI indices, Ubon Ratchathani from 2 to 4%, Sri-Sa-Ket from 1 to 15%, and Amnart Charoen from 0.8 to 7%). As a result, BI values declined due to the decreases in both HI and CI values. Samakee-patana (Amnart Charoen) was the only village that had a higher BI value during the outbreak period (39%) compared to the pre-outbreak period (10%).

Post-outbreak: Dengue vector indices decreased after the outbreak in all provinces except for the Sri-Sa-Ket village of Nongkanyai where HI values increased (87%).

Table 2: Demographic Data of DHF perception and prevention behavior volunteers

Demographic Data	Frequency (%)			Total (%) (n=218)
	Ubon Ratchathani (96)	Sri-Sa-Ket (70)	Amnart Charoen (52)	
1. Gender				
- Male	50 (52.08)	34 (48.57)	27 (51.92)	111 (50.92)
- Female	46 (47.92)	36 (51.43)	25 (48.08)	107 (40.08)
2. Age (years)				
- <20	2 (2.08)	12 (17.14)	11 (21.15)	25 (11.46)
- 21-30	7 (7.29)	17 (24.29)	13 (25)	37 (16.97)
- 31-40	31 (32.29)	21 (30)	14 (26.92)	66 (30.27)
- 41-50	21 (21.87)	11 (15.71)	6 (11.54)	38 (17.43)
- >50	35 (36.46)	10 (14.29)	8 (15.39)	53 (24.31)
3. Family member (including yourself) (persons)				
- 1	14 (14.58)	8 (11.43)	10 (19.23)	32 (14.67)
- 3	39 (40.63)	18 (25.71)	13 (25)	70 (32.11)
- 5	32 (33.33)	32 (45.71)	18 (34.62)	82 (37.61)
- 7	10 (10.42)	7 (10)	8 (15.38)	25 (11.47)
- > 7	1 (1.04)	5 (7.14)	3 (5.77)	9 (4.12)
4. Marital status				
- Single	46 (47.92)	11 (15.71)	8 (15.38)	65 (29.81)
- Married	46 (47.92)	57 (81.43)	42 (80.77)	145 (66.51)
- Divorced/ widow	-	2 (2.86)	2 (3.84)	4 (1.83)
5. Education level (degrees)				
- No education	8 (8.33)	36 (51.43)	8 (15.38)	52 (23.85)
- Elementary school	65 (67.741)	18 (25.71)	34 (65.38)	117 (53.67)
- Junior high school	13 (13.54)	10 (14.29)	5 (9.62)	28 (12.84)
- Senior high school	6 (6.25)	-	5 (9.62)	11 (5.05)
- Diploma	3 (3.13)	-	-	3 (1.38)
- Bachelor	1 (1.04)	2 (2.86)	1 (0.19)	4 (1.83)
- Higher than bachelor	0	4 95.71)	-	4 (1.83)
6. Income (baht/ month)				
- Less than 5,000	52 (54.17)	50 (74.43)	44 (84.62)	146 (66.97)
- 5,001 – 10,000	40 (41.67)	20 (28.57)	8 (15.38)	68 (31.19)
- 10,001 – 20,000	4 (4.17)	-	-	4 (1.83)
- > 20,001	-	-	-	-
7. Occupation (s)				
- Farmer	40 (41.67)	30 (42.86)	29 (55.77)	99 (45.41)
- Merchant	10 (10.42)	7 (10)	4 (7.69)	21 (9.63)
- Worker	29 (30.21)	16 (22.86)	10 (19.23)	55 (25.23)
- Governmental officer	8 (8.33)	4 (5.71)	5 (9.62)	17 (7.80)
- Housewife	7 (7.29)	4 (5.71)	-	11 (5.05)
- Student	5 (5.21)	1 (1.43)	-	6 (2.75)
- No job	7 (7.29)	8 (11.43)	6 (11.54)	21 (9.63)
- Miscellaneous (specified)……..	-	-	-	-
8. Within 3 years, do you have any family members infected with DHF?				
- Yes	51 (53.13)	12 (17.14)	10 (19.23)	73 (33.48)
- No	45 (46.87)	58 (82.86)	42 (80.77)	145 (66.52)
9. Did you receive DHF information?				
- Yes	91 (94.79)	60 (85.71)	52 (100)	203 (93.12)
- No	5 (5.21)	10 (14.29)	-	15 (6.88)
9.1 If "yes" Where did you receive it? (can specified more than "one" answer)				
- Television	38 (39.58)	60 (85.71)	36 (69.23)	134 (61.46)
- Radio	18 (18.75)	58 (82.86)	34 (65.38)	110 (50.45)
- Poster/ brochure	17 (17.71)	38 (54.29)	10 (19.23)	65 (29.81)
- Newspaper	17 (17.71)	5 (7.14)	10 (19.23)	32 (14.68)
- Watchtower	31 (32.29)	30 (42.86)	45 (86.54)	106 (48.62)
- Short course training	4 (4.17)	30 (42.86)	2 (3.86)	36 (16.51)
- Public health provider	81 (84.39)	2 (2.86)	49 (94.23)	132 (60.55)
- Family member	1 (1.04)	-	21 (40.38)	22 (10.09)

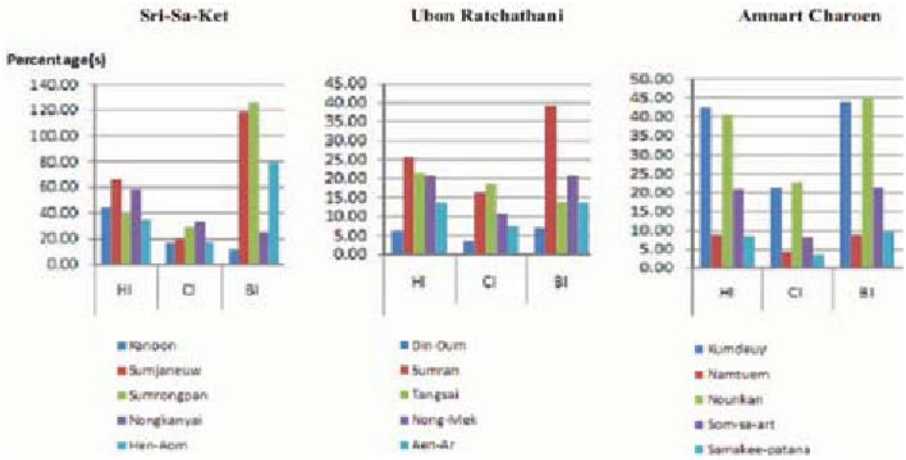

Chart 1: Dengue indices during Pre-Outbreak

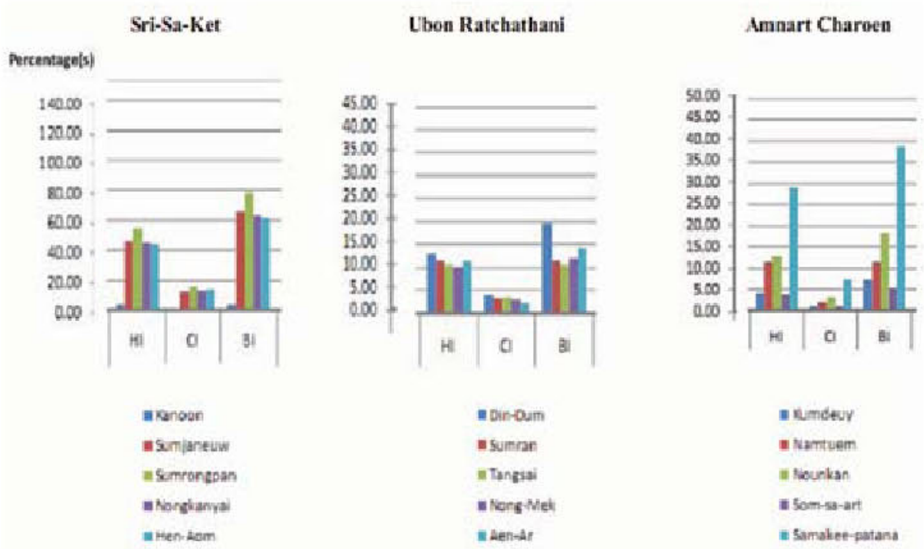

Chart 2: Dengue indices during Outbreak

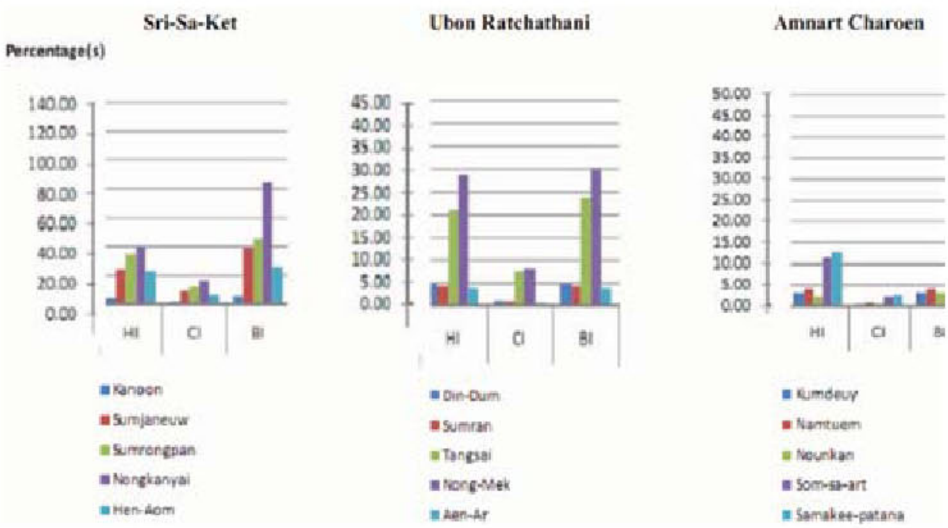

Chart 3: Dengue indices during Post-Outbreak

Table 3: DHF perception and prevention behavior (n = 218) (Pre-Posttest)

Score level(s)	Score(s)					
	Ubon Ratchathani (96)		Sri-Sa-Ket (70)		Amnart Charoen (52)	
	Pre	Post	Pre	Post	Pre	Post
	Number (%)	Number (%)	Number (%)	Number (%)	Number (%)	Number (%)
High level (score: 11-16)	42	60	30	49	27	34
Middle level (score: 6-10)	24	19	24	10	18	10
Low level (score: 0-5)	30	17	16	11	7	8
Mean ±SD	9.87 ± 2.514	13.56 ± 2.879	7.48 ± 2.569	11.02 ± 1.475	8.91 ± 3.128	12.14 ± 2.041

3.3 DHF Perception and Prevention Behaviors

3.3.1 Demographic data

The overall survey within the three provinces found most of volunteers were males (50.92%). The respondents were from middle class families (66.97%) aged between 31 and 40 (30.27%). The majority were farmers (45.41%) followed by workers (25.23%), just over half (53.67%) of whom had completed elementary school education level. The majority (66.52%) had not had DHF in the past 3 years. They also received information regarding DHF prevention and control via television (61.46%), from a public health provider (60.55%), and radio (50.45%).

3.3.2 Pre-/post-tests of DHF perception and prevention behaviors

Results revealed that the post-scores were higher than the pre-scores in DHF perception and prevention behaviors in all provinces. Some misunderstandings relating to DHF were found after instruction from public health providers. For example, volunteers in Sri-Sa-Ket did not think that DHF was a life-threatening disease. Also, most volunteers from Amnart Charoen disagreed that DHF was a contagious disease carried by mosquitoes.

4. Discussion and Conclusions

Larval vector indices of the three provinces were significantly higher in the pre-outbreak period than the outbreak and post-outbreak periods. Therefore, preventive measures must be focused on the pre-outbreak period, being proactive instead of waiting for the outbreak and then reacting. Campaigns of DHF prevention and control by the Department of Prevention and Control Region 7 were implemented in communities, including health education, larval elimination by pyrethoid space fogging, 1% temophos sand granules, and the combination method, and self-surveillance to avoid being bitten by *aedes* mosquitoes. As a result, dengue indices generally decreased over a period of time. However, there were some exceptions to this, as shown by the villages of Tangsai and Nong-Mek having increased dengue indices in the post-outbreak period. These exceptions may be due to the remoteness of the villages from the basic public health system and the regular movement of people increasing the chances of the spread of dengue vectors. The high incidence in Sri-Sa-ket may be explained by geographic and demographic factors. Sri-Sa-Ket has a large area of forests, especially in the border regions between Thailand and Cambodia. This provides many breeding sites for mosquitoes. The local population in these areas is generally poorly educated, has low levels of sanitation, and is highly mobile, regularly moving from site to site. These factors must be considered in the increase of DHF cases in this province. It is difficult to link increases in morbidity rates with those in dengue indices. Effective self-care management may be a factor in controlling morbidity rates and dengue indices, in terms of maintaining a clean environment. However, other health behaviors may be also responsible for changes in morbidity rates, and indices may be due to climate change and poor sanitation. Morbidity rates and dengue indices need to be considered separately and then integrated for use in strategies for DHF control. The number of DHF cases and disease prevalence in South-East Asian countries, including Thailand, changes every year. It appears that there are some limiting factors regarding the spread of DHF disease, including national policy, local sanitation, health education, self-management, enforcement, and community participation (Barbazan et al., 2000, Wongbutdee et al., 2010, Teng, 1997, Boo, 2001, Madon et al., 2001 and Umor et al., 2007). These factors suggest some possible solutions to minimize dengue vector and DHF incidence. *Dengue vector and breeding habitats reduction*: Current methods of source reduction of *aedes* mosquitoes in Thailand include fogging spray, 1% themophos sand granules, mosquito nets, and effective drainage systems (Chanruang et al., 2008).

Local populations lack responsibility and realization of DHF prevention and the Ministry of Environment needs to be more proactive in its efforts to provide access to public health services for remote areas so that information about DHF prevention strategies is distributed to people in high risk areas and treatment is readily available. *But Community participation*: It is important to collaborate with target groups to implement a system or re-design structures to prevent mosquito breeding. For example, the participation of ordinary people in schools, universities, markets, and shopping malls is required to address common mosquito breeding habitats. People need to understand standard protocols for mosquito control in their workplaces. The Ministry of Environment is responsible for the specifications for mosquito control measures and the education of people in identifying the habitats. Also, public places and amenities such as bus shelters and road gutters are required to be re-structured to avoid mosquito breeding. The formation of volunteer dengue prevention groups among residents is encouraged to assist current public health providers in prevention activities, inspection of households, and education of peers. *Public education*: Table 3 shows that people in high risk areas generally have high perception and knowledge of dengue fever and the *aedes* mosquito, but the authors recognized that this knowledge is not translated into action in the checking and removal of stagnant water from their premises, especially when the public generally sees the control of DHF as a government responsibility. Public education needs to be an active and ongoing process through the media, pamphlets and posters, house-to-house visits, talks, seminars, and exhibitions, with education programs tailored for different target groups. *Impact of globalization*: The rapid explosion in global trade and international travel utilizing various modes of transport enhances the potential for the introduction and spread of exotic vectors and exotic pathogens via local residents and/or international travelers infected while visiting disease endemic areas. Minimizing the introduction and spread of pets and vectors as well as exotic pathogenic organisms requires well-coordinated, systematic detection, surveillance, and control programs at local, regional, and national levels. *Environmental changes* (Chua et al., 2005): DHF incidence is higher in areas of rapid development and dense population. Other environmental factors that influence dengue outbreak distribution include population growth, inadequacies in urban infrastructure such as solid waste disposal, and rises in domestic and international travel.

Rapid industrial and economic development over the past two decades have brought about massive infrastructure changes and have created conducive, artificial environments for the breeding of the *aedes* mosquito. Table 3 shows that most participants in high risk areas had adequate knowledge of DHF prevention. Nevertheless, these revelations may not represent the real situation in DHF prevention as the number of cases and dengue indices are still high at some periods of the year. Also, there were some noticeable misunderstandings regarding DHF prevention behaviors including lack of public health providers, shortage of national budget, changes in health policies, limited access to public health services in remote areas, and poor lifestyle habits including house cleaning, use of mosquito nets, and elimination of mosquito breeding habitats. This may be explained by the focus of most prevention programs being on 'knowledge' rather than 'practice' or behavior change itself. Also, regular evaluation of prevention behaviors within high risk areas should be focused so that target populations understand and behave properly to avoid DHF infection and campaigns of DHF surveillance and control need to be done continuously. This also suggests the need for a re-focus of programs to concentrate more on behavior change interventions as DHF epidemics in different countries, including Thailand, may occur in the post-outbreak period, the traditionally low vector density season. Behavior change is required at five levels, individual, household, community, institution, and policy-making and regulation. These levels, while distinct in some respects, are related and programs must explore this relationship, stress practice in addition to the accumulation of knowledge, and emphasize benefits of healthy behaviors. Finally, all these issues urgently need to be addressed by the adaptation of national health policies and sufficient budget should be made available in remote and/or high risk areas for DHF surveillance and control activities throughout the year. In summary, use of the ArcGIS database results in faster and better health mapping and analysis than conventional methods, giving health professionals quick and easy access to a large volume of data, and dengue vector indices can also be collected and interpreted for incidence of DHF transmission. The ArcGIS database also provides a variety of dynamic analysis tools and display techniques for dengue vector indices and epidemiology of DHF via maps, graphs, charts, and tables. Further evaluation of the effectiveness of the ArcGIS database is necessary and efforts need to be made to implement it into the routine work of public health providers.

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