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Multiple Linear Regression Model to Predict Dengue Haemorrhagic Fever (DHF) Patients in Kreang Sub-District, Cha-Uat District, Nakhon Si Thammarat, Thailand

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ABSTRACT

To estimate the risk of dengue haemorrhagic fever (DHF) transmission, the larval indices were executed and the regression model was fitted to explain and predict the relationship between household's activities and DHF patients. Stratified random sampling was used to select the sample, 11 villages of Kreang sub-district were assigned to stratum. Three hundred households were assigned to sample units. Descriptive statistics were used to analyze the data and stepwise regression was used to form the model. The results showed that 9 out of 11 villages were high DHF risk transmission while 2 villages were medium risk. 26.9 % of the variation of DHF patients was explained by number of water storage container, *Aedes aegypti* in drainage of refrigerators, pH and temperature of water in containers, namely X's. This model: DHF patients = 0.167(X1) + 0.120(X3) + 0.362(X5) + 0.116(X8) +0.128(X13) + 0.195(X14) was sufficient to promote the appropriate DHF prevention and control campaigns' in this area and nearby localities.

Key words: DHF transmission, stratified sampling, larval indices, household's activities, stepwise regression

INTRODUCTION

Dengue hemorrhagic fever (DHF), is an infectious disease caused by the dengue virus and is a serious cause of morbidity and mortality in the most countries in the tropical and subtropical areas of the world. It is the most important mosquito-borne viral disease of public health significance. DHF has been reported in Thailand since late 1950 and the incidences of DHF, an acute and severe form of dengue virus infection have increased. Since the first DHF epidemic outbreak in Bangkok in 1958, epidemics have been reported from almost all parts of the country. The disease has occurred continuously and spread throughout the country from large urban areas to small towns. Khuan Kreang Peat Lands, Kreang sub district is located in Cha-uat district, Nakhon Si Thammarat. The study of Sujariyakul and Wonghiranrachata in Kreng sub district found that the Breteau index (BI: the number of positive containers for *Aedes* lavae per 100 houses) was higher than 240 [10]. This area was shown that a high DHF risk for the spread of the mosquito vector. This will affect the number of cases of dengue fever in the household. Household's members will help to prevent or avoid such behaviors. Multiple linear regression models are model that used to show the relationship between response and independent variables. This study aims to determine the multiple linear regression model to explain the relationship between household's activities and DHF patients in Khuan Kreang Peat Lands, Kreang sub district, Cha-uat district, Nakhon Si Thammarat.

Research Methodology:

A questionnaire survey was conducted in Khuan Kreang Peat Lands, Kreang sub district, Cha-uat district Nakhon Si Thammarat province (located 8° 32' 16.5" N latitude and 99° 56' 50.7" E longitude) in May-June 2011, covering 11 villages of Kreang sub district (Figure 1). Three hundred households in these 11 villages were sampled by a systematic stratified random sampling technique. By a proportional allocation method, these 300 sample units were assigned to 11 villages that assigned as stratums. One person in the collected household was identified as a sample unit. Breeding places [5] were sampled both indoors and outdoors within 15 m of the houses. Temperature and pH of water in all breeding places were measured. Larval surveys were conducted in the study area using fishnets. All live mosquito larvae were collected in plastic bags, taken

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to the biological laboratory, preserved in 70% ethyl alcohol and identified up to species level. In this study, the 1^{st}, 2^{nd} instars and pupae were discarded because mosquitoes at these stages could not be identified. Types and numbers of mosquito larvae in water containers at each household were classified. Mosquito's larvae were identified as *Aedes aegypti, Aedes albopictus* or others from the biological laboratory [4] The data were computerized and validated using SPSS for Windows. Percentage, mean, standard deviation and Pearson's correlation coefficient were used to analyze the data. Entomological indices, such as house index (HI; percentage of number of *Aedes* positive households), container index (CI; percentage of number of *Aedes* positive containers), and Breteau index (BI; number of positive containers in 100 households), were executed [3,11]. The multiple regression was based on the formula: $Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_k X_k + \varepsilon$, where Y was the DHF patients in household, $\beta_{1 \text{ to } k}$ were the regression coefficient of household's activities variables of $X_{1 \text{ to } k}$ and ε was the error term. In the multiple regression analysis, the fifteen variables that were significantly correlated to DHF patients (see Table 1 for more details) were included in the tentative model. Stepwise regression technique was algorithm for including and excluding independent variables, used to select adequate model with the highest coefficient of determination (R^2). The selected model identified the multicollinearity by examining the variance inflation factor (VIF), i.e. a VIF value less than 5 indicated absence of multicollinearity. Durbin–Watson Test was used to explore the independent of error term.

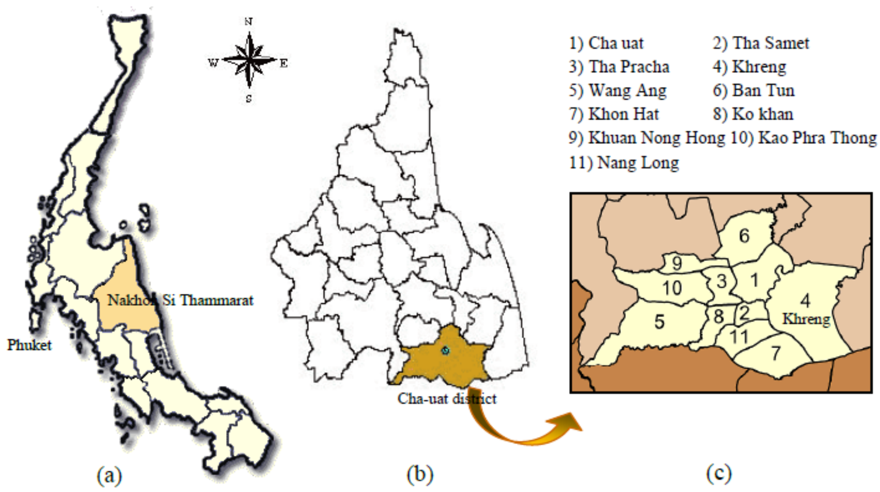

Fig. 1: a) Map of Southern Thailand b) Map of Nakhon Si Thammarat province c) Map of Cha-uat District

Results and Discussion

Containers found in this study**,** displayed some household's activities**.** Two thousand four hundred and seventy four containers were found in this study. 33.10 % was of number of earthen jars, 20.57 % was of plastic bucket and followed by container in bath room, cement tank, water jar, with 18.23%, 8.57%, 5.21%, respectively. In addition, old car or boat and ceramic container were found only 1 piece in 300 households in this study (Figure 2 and Table 2).

Table 1: Abbreviations for household's activity variables and correlation coefficient with dependent variable (DHF Patients)

variables	definition	correlation coefficient (r)	p value
Y	Number of DHF cases in the past year	1.000	
X1	Animal pan	0.230	0.000
X2	Drainage of refrigerator	0.195	0.001
X3	Earthen jar	0.137	0.018
X4	Metal container	0.113	0.051
X5	Number of *Aedes aegypti* in drainage of refrigerator	0.421	0.000
X6	pH of water in animal pan	0.235	0.000
X7	pH of water in drainage of refrigerator	0.223	0.000
X8	pH of water in plant pot saucer	0.122	0.034
X9	pH of water in water jar	0.193	0.001
X10	Temperature of water in animal pan	0.258	0.000
X11	Temperature of water in drainage of refrigerator	0.201	0.000
X12	Temperature of water in earthen jar	0.120	0.039
X13	Temperature of water in metal container	0.114	0.048
X14	Temperature of water in water jar	0.216	0.000
X15	Water jar	0.156	0.007

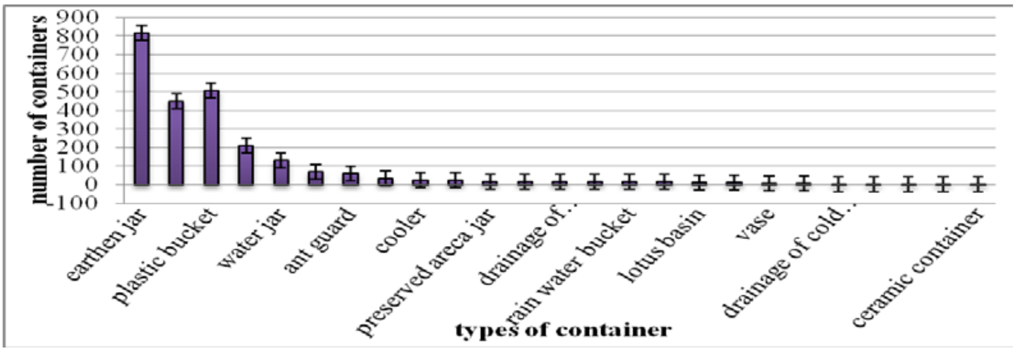

Fig. 2: Number of containers in households classified by types of containers

Table 2: Number, percentage and $\bar{X} \pm SD$ of water storage containers in households

types of container	number of containers (pieces)	percentage	$\bar{X} \pm SD$
earthen jar	819	33.10	2.49±2.92
container in bath room	451	18.23	1.50±0.84
plastic bucket	509	20.57	1.44±1.54
cement tank	212	8.57	0.57±0.76
water jar	129	5.21	0.43±0.76
plastic container	70	2.83	0.23±0.69
ant guard	59	2.38	0.20±0.86
water plant container	32	1.29	0.11±0.31
cooler	24	0.97	0.08±0.28
used tire	23	0.93	0.08±0.30
preserved areca jar	15	0.61	0.07±0.42
animal pan	17	0.69	0.06±0.35
drainage of refrigerator	17	0.69	0.06±0.23
metal container	16	0.65	0.05±0.23
rain water bucket	16	0.65	0.05±0.34
earthenware	15	0.61	0.05±0.23
lotus basin	12	0.49	0.04±0.29
outdoor basin	11	0.44	0.04±0.21
vase	8	0.32	0.03±0.16
plant pot saucer	8	0.32	0.02±0.15
drainage of cold water	4	0.16	0.01±0.12
indoor basin	3	0.12	0.01±0.10
container for spot betel	2	0.08	0.01±0.08
old car or boat	1	0.04	0.00±0.07
ceramic container	1	0.04	0.00±0.58
total	**2,474**	**100.00**	

Entomological Indices: House Index (HI) and Breteau Index (BI) indicated the DHF risk levels. Mean of HI in Kreang District was 36.80 and BI was 70.36. These value were higher than standard criterion (HI<1, BI<50). They illustrated that Kreang District was high DHF risk area.

Correlation and regression analysis were the major statistical tools used in this study for investing and selecting the statistical significance in the relationship between household's activities and DHF patients. The results revealed that out of 167 variables, 15 variables that were correlated with the number of cases of DHF patients. Pearson's correlation coefficient of 15 variables showed positive significantly correlation between household's activities and DHF patients. It found that 6 out of 15 variables in this study showed significant correlated with DHF patients. The residuals correspond with the assumptions of regression analysis ($E[e_i] = 0$, Var $[e_i]$ approximate 1, independent of e_i and e_j; Durbin-Watson = 1.819>1.5). Interval of VIF of all significant variables were 1.003-1.038 which less than 5. Results of residual analysis were then used for the verification of the applicability of assembled regression model. The existences of influential and outlier observations were checked but not found in the model (maximum of standard error was not more than 3) (Table 3).

Table 3: Residual statistics

	mean	standard deviation	minimum	maximum
predicted value	0.15	0.25	0.04	2.98
residual	0.00	0.41	-13.8	2.37
standard error of predicted value	0.00	0.99	-3.14	5.70

An analysis of variance (ANOVA) indicated that data fit the model well ($F_{6,\ 293,\ 0.01}$ = 18.009, p=0.000). 26.9% of the variation of DHF patients were explained by 6 independent variables (Adjusted R^2 = 0.25) with constant in model. Six predictor variables were the set of independent variables to predict DHF patients, namely, animal pan (X1); (t=3.322, p=0.001), earthen jar (X3); (t=2.114, p=0.035), number of *Aedes aegypti* in drainage of refrigerators (X5); (t=7.422, p=0.000), pH of water in plant pot saucer (X8); (t=2.327, p=0.021), temperature of water in metal container (X13); (t=2.376, p=0.018) and temperature of water in water jar (X14); (t=2.671, p=0.008) but the constant term was not significant parameter; (t=1.249, p=0.213). The regression model was predicted model of DHF patients using general multiple linear regression model were obtained from the following:

Y = 0.038 + 0.168(X1) + 0.107(X3) + 0.378(X5) + 0.117(X8) + 0.119(X13) + 0.136(X14).

Since, it was not significant of constant term in this study. The updated regression model without constant term or the multiple linear regression through the origin, composed of six predictors to predict DHF patients, still be; animal pan (X1); (t=3.411, p=0.001), earthen jar (X3); (t=2.445, p=0.015), number of *Aedes aegypti* in drainage of refrigerators (X5); (t=7.391, p=0.000), pH of water in plant pot saucer (X8); (t=2.390, p=0.017), temperature of water in metal container (X13); (t=2.646, p=0.009) and temperature of water in water jar (X14); (t=3.871, p=0.000), with R^2=26.9% (adjust R^2 =25.4%, Durbin-Watson = 1.819). Thus, the appropriate regression model was based on the following:

Y = 0.167 (X1) + 0.120 (X3) + 0.362 (X5) + 0.116 (X8) + 0.128 (X13) + 0.195 (X14).

The regression coefficients represented the independent contribution of each independent variable for the prediction of dependent variables. In present study, household's activities such as number of water storage containers (animal pan, earthen jar), number of *Ae. aegypti* mosquito larvae, pH and temperature of water in water storage containers were related to the DHF patients in Kreang sub district, Cha-uat district Nakhon Si Thammarat.

Household's activities about *Aedes* mosquitoes contribute to breeding place. All of predictors had positive impact on DHF patients. In the other words, DHF patients would be expected to increase as all of them increase. The possible of DHF patients prediction occurred, when you can estimate the number of positive containers, the number of *Aedes* larvae in the positive containers, temperature and pH of water in positive containers.

Opened water-filled containers (animal pans, earthen jars, drainage of refrigerators) provided breeding sites for *Aedes aegypti* mosquitoes. All of them were found around the houses during the survey. This result was corresponded with the studies of Koopam et al. [7], Khera and Sharma [6] and Bhandari et al. [2], indicated that uncovered water containers and pitchers were significantly associated with dengue infection.

The number of *Aedes* larvae in drainage of refrigerators displayed the association with DHF patients in Kreang sub district, Cha-uat district, Nakhon Si Thammarat. It reflected some cultural practices of the people in this area. Our results from this work seemed to support with the study of Barrera et al. [1] which reported that mosquito productivity was associated with ornamental containers, miscellaneous containers, metal drums, tires and animal pans. The number of *Aedes* larvae showed the entomological risk because adult *Aedes* larvae abundance was correlated with diagnosed dengue cases [9].

Temperature of water in water jars and metal containers associated with DHF patients in this study. The result corresponded with a research of Wongkoon et al. [12] and Lester et al. [8]. They founded that the mean temperatures, container surface area and water depth influenced the population dynamics of the mosquito and the transmission of dengue disease. As the mean temperature increased, the DHF case also increased. It was possible that most of the physiological functions of vectors in this area were subject to optimal mean temperature. Opened water-filled containers and number of *Aedes* larvae, temperature of water in water jar and metal container displayed the association with DHF patients in Kreang sub district, Cha-uat district Nakhon Si Thammarat. If we can estimate the number of *Aedes* positive containers or *Aedes* larvae, we can predict the DHF patients each household. Provincial Health Office may have to design a campaign for DHF prevention more specifically in each locality.

Conclusion:

This study has demonstrated that six household activities (animal pans, earthen jars, number of *Aedes aegypti* in drainage of refrigerators, pH of water in plant pot saucers, temperature of water in metal containers and temperature of water in water jars) were suitable predictors for explaining the number of DHF patients in Kreang sub-District. In conclusion, household's activities and abiotic of containers characteristics of exert a significant influence on mosquito breeding site selection among *Ae. Aegypti* and *Ae. albopictus*. Earthen jars were the preferred breeding site for this mosquito in this study, followed by plastic bucket, container in bath room, cement tank and water jars. These preferences could be exploited to develop novel techniques to deter oviposition.

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