Transmission of dengue hemorrhagic fever and climate variability in Jakarta

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Abstract. Dengue hemorrhagic fever (DHF) has become an endemic in major cities in Indonesia. The climate change and poor level of awareness and knowledge of the community in Indonesia have caused an increase in the DHF cases. Outbreaks on January until April 2015, the morbidity rate reached 50.75. In 1996, the Intergovernmental Panel on Climate Change (IPCC) predicted threefold increase in the dengue hemorrhagic fever incidents in Indonesia by 2070, if the environment and community conditions do not improve. This study aims to provide a dynamic model to predict the dynamics of the DHF incidents based on climate variability in the Special Capital Region of Jakarta. The design of this study was ecologic study with hypothesis test, modelling, simulation, and intervention. In collecting the data, interview with respondents and measurement of climate variables were conducted. Interviews with respondents include the level of knowledge, attitudes, and behaviour (PSP) of the community. Measurements of climate factors include rainfall, temperature, humidity and CO2 level in the ambient environment. The DHF system dynamics model simulation shows that the significant effect on the decline of Breeding Places and the decrease of DHF cases were achieved by increasing the participation of the community to actively control water places that are potential for mosquito breeding places.

1. Introduction
The increasing population has caused higher cases of communal disease. The DHF cases in Indonesia first appeared in Surabaya in 1968. Based on the number of cases, Indonesia ranked second after Thailand. The Ministry of Health reported that the number of DHF continued to increase from 0.05 in 1968 to 35.19 in 1998 when it was recognized, there was a relationship between environmental changes and an increase in cases of disease. This morbidity rate continues to increase every year. It became 43.31 in 2015; 39.80 in 2014 with a total of 100,347 cases and it reached 50.75 in 2015. In 2014, 71,668 cases with 641 of them died were recorded in 34 provinces in Indonesia.

The number of environmental factors that are related to incidence of DHF which tend to recurred encourage researchers to investigate environmental factors can be used as indicators in predicting the
occurrence of DHF cases and DHF transmission system in Jakarta, as well as predicting the incidence of DHF through intervention models on system dynamics.

This study provides a dynamics model of DHF transmission in relation to climate variability that will contribute to improvements in development on a local and even national scale. The dynamics model of DHF transmission is expected to be an innovation to reduce the incidence of DHF, especially in Jakarta.

2. Methods
The study design was an ecological study with a hypothesis test. The modeling and simulation were carried out to identify factors that are relevant to future DHF cases. The added value of the study is the association between environmental factors in ecology such as rainfall, temperature and humidity as well as basic indicators of air quality, namely CO2, with vectors of DHF.

The study related to the dynamics model in providing the early warning for the emergence of DHF cases has been started since 2006. The patterns which were found in this study are suggested to be applied in a broader area, namely in Jakarta, Bogor, Depok, Tangerang and Bekasi (Jabodetabek).

2.1. Samples
The samples in this study were air quality sample, vector sample, case sample, house sample, and respondent sample. Air quality sample was taken from the research location. Vector sample was adult Aedes mosquitoes caught from the respondents’ house. Case samples were DHF experienced by respondents in the last two years. House sample was determined based on WHO standards for larvae and mosquito surveys according to the area and population: “Cluster Design Sampling” [1]. The sample size for PSP study was calculated based on hypothesis test for two proportions by using following equation:

\[
\text{n} = \left[ \frac{Z_{1-\alpha/2} \sqrt{2P(1-P)} + Z_{1-\beta} \sqrt{P_1(1-P_1) + P_2(1-P_2)}}{(P_1 - P_2)^2} \right]^2
\]

The minimum number of samples calculated based on the prevalence of DHF in the preliminary study was 14%, while the expected prevalence of control variables that had been found was 4%. The calculation used 5% confidence level and 90% test strength. The distribution of household sample was carried out by dividing the sample proportionally according to the number of cities in the Special Capital Region of Jakarta, namely Central Jakarta, East Jakarta, South Jakarta, West Jakarta, and North Jakarta. In each region, a total of 40 houses were taken with individual analysis units.

2.2. Data Collection
The study was conducted within three years starting in 2018. The following data were collected from the Special Capital Region of Jakarta:

- The environmental data: rainfall, temperature, humidity, vector, and CO2 level in the ambient air through direct measurements at the sampling point
- The community data to find out the knowledge, attitudes and behavior of the community about DHF

Rainfall measurements were carried out every rainy-day using rain gauge. Temperature and humidity were measured using thermo hygrometer, and CO2 level was measured using RAC sampler. The vector data collection of adult Aedes mosquitoes was carried out by purposive sampling in several households in each region.

Community data collection was carried out through interviews using a questionnaire to determine social, economic and education status of the community, as well as knowledge, attitudes and behavior of the community about DHF, prevention and eradication of Aedes vectors.
2.3. Data Analysis
To obtain the concept of DHF control in the future, a system dynamics model was used. The following stages were conducted to obtain the research outcome: (1) validating the environmental components (2) demonstrate the model in the relevant environment, (3) reporting the activity comprehensive. In this study, the case of DHF is considered as one of the components of the causal system in a scenario simulated through intervention.

2.4. System Modeling
The simulation was carried out through model construction, model development, and validation of the simulation results to determine the compatibility between the simulation results and established simulation mechanism. The simulation results were used to understand the process behavior and predict the future trends [2]. Based on the understanding of the systemic events, the following steps were carried out to build the modeling concept in Figure 2:
- Identifying the process that produces the actual event.
- Identifying the desired event.
- Identifying the gap between the actual state and the desired situation
- Analyzing the policies.

![Figure 1. The Modelling Concept](image)

3. Results and Discussion
The first year of the study has been conducted in the Special Capital Region of Jakarta, namely in the Central Jakarta (Harapan Mulya Urban Village, Kemayoran Sub-district), East Jakarta (Malaka Jaya Urban Village, Duren Sawit Sub-district), South Jakarta (Lenteng Agung Urban Village, Jagakarsa Sub-district), West Jakarta (Tomang Urban Village, Grogol Petamburan Sub-district), and North Jakarta (East Kelapa Gading Urban Village, Kelapa Gading Sub-district). The collection of environmental data and community data about DHF were carried out in the five regions from July to September 2018.

3.1. System Dynamics Model
3.1.1. DHF Case Prediction based on Model Simulation. Based on Figure 3, it is known that climate variability patterns affect the incidence of DHF because the life of the disease vectors and the dengue
virus as an agent is very dependent on the environmental conditions. The temperature, the humidity, the chemical composition in the air and of mosquitoes breeding places, the rainfall, the wind speed and other environmental factors are the limiting factors of its life. Therefore, the environmental system associated with the incidence of DHF has 4 subsystems, namely: climate subsystem, Aedes mosquito, human and DHF cases. These four subsystems are interconnected and they influence each other.

The climate subsystem (blue) is a series of climate factors related to global climate change that triggers an increase in global earth temperature. As a result, this global warming phenomenon can affect living things. The most dominant insect causing DHF is Aedes aegypti.

CH₄, N₂O, CO₂ and CFC-11 are gases that cause the global climate change or the so-called greenhouse effect if it is at a concentration exceeding normal concentration. The increase in global temperatures will increase sea surface temperatures. It will later trigger the El Nino phenomenon. According to the World Meteorological Organization (WMO), there is a relationship between the occurrence of El Nino and the incidence of DHF in Indonesia [3,4]. This cycle forms the climate subsystem in the model.

The second subsystem is the Aedes mosquitoes, from eggs to adult mosquitoes, which is indicated by a positive arrow. The connecting factor of the climate subsystem and mosquito subsystem is the breeding places for mosquitoes. The breeding places are highly affected by rainfall. When rainfall is high, the containers are easily filled with water and this relationship is indicated by a positive arrow.

Another connecting factor of the climate subsystem is the ambient temperature which then affects the Extrinsic Incubation Period (EIP). The EIP is influenced by environmental temperature, humidity, level of viremia in humans, and viral strains [5]. The increase in temperature will shorten the EIP and increase the transmission. The temperatures that increase to 34°C will affect the temperature of the water in breeding places which also accelerates the hatching of eggs into larvae [6,7].

The vector subsystem and the disease subsystem are connected by the Landing Rate and the role of dengue virus factors. The presence of DHF is determined by the contact between mosquitoes and humans. It is assumed that the larger the mosquito population the higher the Landing Rate, so the connecting arrow becomes positive. The larger the Aedes mosquito population the larger the infective Aedes population that carries the Dengue virus. This relationship is also indicated by a positive arrow.

After the Aedes mosquito bites a human, the virus replicates in the human body. The more viruses incubated into humans the more humans become infectious so that the number of DHF cases in the community increases. This link is indicated by a positive arrow.

Human activity is indicated by the intensity of petroleum fuels usage. The impact of fuel utilization is the increase of CO₂ emissions; the relationship is indicated by a positive arrow. The Landing Rate factor is also related to the human subsystem through the individual activeness factor. The more inactive a person is, the easier for mosquitoes to approach, especially during peak hours.

In this case, intervention in increasing the knowledge, attitudes and behaviour (PSP) of the community is required. From the analysis, it is known that the factors that are significantly related to the occurrence of DHF in the community are knowledge, attitudes and behaviour factors. This program provides community awareness education. This relationship is indicated by a positive arrow for PSP. Figure 3 shows the diagram stock flow scheme which is the model development stage, where all variables are included as factors that influence the incidence of DHF.

### 3.2. Knowledge Attitude and Behaviour

The research on the first year had been conducted in the Special Capital Region of Jakarta (DKI Jakarta) area, in the Central Jakarta (Harapan Mulya Urban Village, Kemayoran Subdistrict), East Jakarta (Malaka Jaya Urban Village, Duren Sawit Subdistrict), South Jakarta (Lenteng Agung Urban Village, Jagakarsa Subdistrict), West Jakarta (Tomang Urban Village, Grogol Petamburan District), and North Jakarta (East Kelapa Gading Urban Village, Kelapa Gading Subdistrict). Environmental and community data collection about dengue fever was performed in those five areas starting in July and continued until September 2018. The data on resident knowledge about Dengue Fever in DKI Jakarta is as follows.
Table 1. Distribution of Resident Knowledge in DKI Jakarta about Dengue Fever in Higher Education Applied Research (PTUPT) in 2018

| Variable                              | Frequency | Percentage (%) |
|---------------------------------------|-----------|----------------|
| **Knowledge about Dengue Disease**    |           |                |
| Know                                  | 199       | 99.5           |
| Does not Know                         | 1         | 0.5            |
| **Dengue Fever (DBD) Cause**          |           |                |
| Virus/Germ                            | 2         | 1.0            |
| Insect Bite                           | 183       | 91.5           |
| Poorly Processed/Unsanitary Food/Drink| 2         | 1.0            |
| Does not Know                         | 6         | 3.0            |
| Other                                 | 7         | 3.5            |
| **Infectious Disease Dengue Fever**   |           |                |
| Yes                                   | 110       | 55.0           |
| No                                    | 90        | 45.0           |
| **Dengue Fever Transmission**         |           |                |
| Other than Mosquito                   | 9         | 4.5            |
| Mosquito Bite                         | 99        | 49.5           |
| Missing                               | 92        | 46.0           |
| **Dengue Fever Symptoms**             |           |                |
| Fever 2-7 days                        |           |                |
| Yes                                   | 191       | 95.5           |
| No                                    | 9         | 4.5            |
| **Headache**                          |           |                |
| Yes                                   | 30        | 15.0           |
| No                                    | 170       | 85.0           |
| **Bleeding: red spots on the skin**   |           |                |
| Yes                                   | 138       | 69.0           |
| No                                    | 62        | 31.0           |
| **Nosebleed, blood feces, blood vomiting, etc.** | | |
| Yes                                   | 51        | 25.5           |
| No                                    | 149       | 74.5           |
| **Total**                             | 200       | 100            |

Referring to the data on table 1, DKI Jakarta Residents who have sufficient knowledge about Dengue Fever (DBD) was 99.5%. If there are any Dengue Fever patients, more than 50% of DKI Jakarta’s residents have known the signs and symptoms of individuals who are infected by the disease. However, 91.5% of residents still consider that insect bites are the main cause of Dengue Fever and not the virus.

Table 2. Distribution of Resident Knowledge in DKI Jakarta about Dengue Fever in Higher Education Applied Research (PTUPT) in 2018

| Variable                              | Frequency | Percentage (%) |
|---------------------------------------|-----------|----------------|
| **Characteristics/Behaviour of Infected Aedes Aegypti Mosquito** | | |
| White Spots/Dapple                    |           |                |
| Yes                                   | 90        | 45.0           |
| No                                    | 110       | 55.0           |
| **Biting during the day**             |           |                |
| Yes                                   | 17        | 8.5            |
| No                                    | 183       | 91.5           |
The knowledge of DKI Jakarta resident about the characteristics of Infected *Aedes Aegypti* Mosquito can be seen in the table 2. Based on the data, 45% of the population know the Infected *Aedes Aegypti* Mosquito characteristics by the white spots or striped on its body. In addition to the knowledge, the resident’s PSP (Attitude and Behaviour Knowledge) can be assessed from their attitude on dengue fever disease, ranging from prevention to willingness to make the prevention effort [8,9]. Former research shows that knowledge has a significant relationship with community attitude and behaviour regarding DHF control [10,11].

Based on the data in table 3, it is found that almost all DKI Jakarta residents (99%) think that the dengue disease prevention must be done as soon as possible and those who are responsible for the disease control are all parties, and both government and society must be involved (39.5 %). Around 91.5% of DKI Jakarta residents are willing to follow the efforts to prevent dengue disease because 100% of the residents agree if the routine dengue fever prevention activities would be held.

**Table 3. Distribution of Resident Knowledge in DKI Jakarta about Dengue Fever in Higher Education Applied Research (PTUPT) in 2018**

| Variable                              | Frequency | Percentage (%) |
|---------------------------------------|-----------|----------------|
| **Immediate Prevention**              |           |                |
| Yes                                   | 198       | 99.0           |
| No                                    | 1         | 0.5            |
| Does not Know                         | 1         | 0.5            |
| **Prevention responsibility**         |           |                |
| Government                            | 15        | 7.5            |
| Dengue patients and families          | 35        | 17.5           |
| Communities                           | 56        | 28.0           |
| All parties                           | 79        | 39.5           |
| Others                                | 15        | 7.5            |
| **Routine prevention**                |           |                |
| Agree                                 | 200       | 100            |
| Not Agree                             | 0         | 0.0            |
| **Willingness to follow the prevention effort** | | |
| Willing                               | 183       | 91.5           |
| Not Willing                           | 17        | 8.5            |
| **Total**                             | 200       | 100            |

DKI Jakarta residents’ attitude about the dengue fever prevention (table 4) is very good, such as the need to drain the bathtub (99.5%), agree to 3M (drain, close and bury) plus and the government effort (98.5%), not hanging clothes at home (85.5%), and the need to monitor mosquito larvae (98.5%).
Table 4. Distribution of Resident Knowledge in DKI Jakarta about Dengue Fever Prevention in Higher Education Applied Research (PTUPT) in 2018

| Variable                                           | Frequency | Percentage (%) |
|----------------------------------------------------|-----------|----------------|
| **Prevention Form**                                |           |                |
| Bathtub drain                                      |           |                |
| Not necessary                                      | 1         | 0.5            |
| Necessary                                          | 199       | 99.5           |
| 3M plus and the government efforts                  |           |                |
| Agree                                              | 197       | 98.5           |
| Not Agree                                          | 3         | 1.5            |
| Hanged Clothes                                     |           |                |
| Allowed                                            | 29        | 14.5           |
| Not Allowed                                        | 171       | 85.5           |
| Efforts to monitor mosquito larvae                  |           |                |
| Necessary                                          | 197       | 98.5           |
| Not necessary                                      | 3         | 1.5            |
| Insecticide Fogging                                |           |                |
| Effective                                          | 106       | 53.0           |
| Ineffective                                        | 94        | 47.0           |
| Dengue Fever Prevention                            |           |                |
| Pay attention to the personal health and 3M plus    | 94        | 47.0           |
| Only pay attention to the personal health           | 40        | 20.0           |
| Only 3M plus                                       | 61        | 30.5           |
| Does not Know                                      | 3         | 1.5            |
| Other                                              | 2         | 1.0            |
| **Total**                                          | 200       | 100            |

DKI Jakarta residents’ awareness in preventing Dengue Fever can be seen from the behaviour about 3M plus (table 5), in which 91% of the residents drain and clean the bathtub/TPA (Final Disposal Site) at home, with a minimum frequency of once a week (59.5%). In addition, DKI Jakarta residents are also regularly clean and bury the used goods (69.5%) and close the window, ventilation, or door with mosquito net (67.5%).

Table 5. Distribution of Resident Knowledge in DKI Jakarta about 3M Plus of Dengue Fever in Higher Education Applied Research (PTUPT) in 2018

| Variable                                           | Frequency | Percentage (%) |
|----------------------------------------------------|-----------|----------------|
| **Drain and clean the bathtub/TPA at house**       |           |                |
| Yes                                                | 182       | 91.0           |
| No                                                 | 18        | 9.0            |
| **Frequency of drain and clean the bathtub/TPA at home** |           |                |
| Once a week                                        | 119       | 59.5           |
| Once every two weeks                               | 27        | 13.5           |
| Once every three weeks                             | 19        | 9.5            |
| Once a month                                       | 17        | 8.5            |
| No                                                 | 18        | 9.0            |
| **Clean up/Bury the used goods**                   |           |                |
| Regularly                                          | 139       | 69.5           |
| Seldom                                             | 43        | 21.5           |
| Never                                              | 16        | 8.0            |
| Missing                                            | 2         | 1.0            |
3.3. Environmental Measurement Result

The environmental data measurement was performed simultaneously in the five research areas starting from July 2018 to September 2018. The data measured including temperature and environment. The environmental data from the environmental temperature and humidity measurement result in the research areas are presented in table 6 and table 7. Based on the data of table 6, the highest average environmental temperature in North Jakarta was 31.37 °C and the highest environmental humidity in West Jakarta was 62.06%.

### Table 6. Environmental Temperature (°C) in DKI Jakarta July-September 2018

| Sampling number | West Jakarta | East Jakarta | North Jakarta | South Jakarta | Central Jakarta | Average Temperature |
|----------------|--------------|--------------|---------------|---------------|------------------|---------------------|
| 1              | 31.03        | 30.33        | 31.68         | 32.33         | 30.39            | 31.15               |
| 2              | 30.85        | 31.87        | 31.73         | 30.93         | 31.7             | 31.42               |
| 3              | 32.46        | 31.65        | 31.69         | 31.27         | 30.35            | 31.48               |
| 4              | 31.57        | 30.89        | 31.23         | 31.63         | 30.71            | 31.21               |
| 5              | 29.45        | 30.77        | 30.87         | 30.85         | 30.49            | 30.49               |
| 6              | 30.41        | 31.35        | 31.55         | 30.26         | 30.25            | 30.76               |
| 7              | 31.27        | 31.54        | 31.75         | 31.14         | 30.77            | 31.29               |
| 8              | 30.59        | 31.47        | 30.48         | 30.36         | 30.42            | 30.66               |
| Average Temperature | 30.93 | 31.23 | 31.37 | 31.1 | 30.63 | 31.05 |

### Table 7. Environmental Humidity (%) in DKI Jakarta July-September 2018

| Sampling number | West Jakarta | East Jakarta | North Jakarta | South Jakarta | Central Jakarta | Average Humidity |
|----------------|--------------|--------------|---------------|---------------|-----------------|------------------|
| 1              | 55.16        | 56.34        | 60.35         | 60.8          | 45.41           | 55.61            |
| 2              | 62.63        | 57.88        | 55.42         | 56.58         | 58.65           | 58.23            |
| 3              | 54.63        | 59.82        | 57.54         | 58.72         | 59.95           | 58.13            |
| 4              | 62.83        | 60.44        | 60.25         | 59.45         | 63.8            | 61.35            |
| 5              | 69.61        | 65.25        | 62.43         | 60.36         | 65.27           | 64.58            |
| 6              | 68.1         | 63.37        | 57.85         | 58.87         | 51.86           | 60.01            |
| 7              | 62.4         | 61.55        | 60.52         | 62.77         | 55.34           | 60.52            |
| 8              | 61.08        | 60.73        | 61.68         | 63.25         | 58.72           | 61.09            |
| Average Humidity | 62.06 | 60.67 | 59.51 | 60.1 | 57.38 | 59.94 |
Figure 2. SFD (Stock Flow Diagram) of the Dynamics System of DHF Cases with Knowledge, Attitudes, and Behaviour (PSP) Intervention
Figure 3 shows the Dynamics System model of DHF cases with Community Role Improvement program intervention, which was built from the model contained in the previous figure. This model is the basis for programs simulation that are considered to be able to control the increase of DHF cases.

Figure 3. Dynamics System Model of DHF Cases with Community Role Improvement (PSP) intervention
Figure 4 below shows that naturally if the adult *Aedes* mosquito population increases, the infective *Aedes* also increases, which means that the infectious mosquito population increases. The following figure 5 shows that if there is no disease control intervention, the humans who have been incubated with dengue virus will persist (blue line), and the number of vulnerable humans continues to increase (red line).

Referring to the charts above, it is necessary to conduct a program to control mosquito-borne diseases. The most effective program to reduce infective mosquito population is to increase the community role in controlling breeding places for mosquitoes to lay their eggs [1].

The simulation results are shown in Figure 7. The tendency of the chart seems different before and after the intervention. The red line indicates the state of no intervention, while the blue line indicates the condition after the PSP improvement intervention. The results of interventions on breeding places show an evident decrease compared to before the intervention. Although breeding places were still high at the beginning of the program intervention, it declined rapidly after the intervention. In the case chart, the incidence of DHF is lower compared to before the intervention.

Figure 4. Results of Natural DHF Cases Model Simulation

Figure 5. Results of DHF Cases Model Simulation without Intervention on the Number of DHF patients

**Description:** Red → before intervention; Blue → after intervention
Figure on the left → TPN Chart; Figure on the right → DBD Case Chart

Figure 6. Results of DHF Cases Model Simulation with Knowledge, Attitudes and Behaviour Improvement on Breeding Places and DHF Cases Intervention
Figure 7 shows the results of simulation model, if a disease control program is carried out, namely by improving the community role, the adult *Aedes* population can be reduced so that it continues to decline (green line).

![Figure 7. Results of DHF Cases Model Simulation with Knowledge, Attitudes and Behaviour Improvement on Adult Aedes Population Intervention](image)

4. Conclusion and Suggestions

4.1. Conclusion
The system dynamics model simulation of DHF shows that the significant effect on the decline of Breeding Places and the decrease in DHF cases were achieved by increasing the participation of the community to actively control water places that are potential to be mosquito breeding places.

The simulation in this study has produced a model that can be used for other infectious diseases model. Through the system dynamics modelling, the transmission model of the disease can be known in details, so the most effective interventions can be determined to control the infectious disease cases.

4.2. Suggestions
The intervention program can be improved by adding the role of the Larvae Monitor. They can encourage the community to carry out the Eradication of Mosquito Nests independently and voluntarily as well as improving knowledge, attitudes and behaviour regarding DHF, including recognizing the initial symptoms so that they can receive treatment before it is too late.

The DHF cases can be reduced by improving environmental hygiene including puddles in parks, flower pots, ponds, bird and other pets’ cages, and paying attention to waste disposal sites that have the potential to become mosquito breeding places, especially during the rainy season.

References

[1] Health Department 2003 *Prevention and Control of Dengue Fever and Dengue Hemorrhagic Fever, Complete Guide to Translation from WHO Regional Publication No. 29, “Prevention and Control of Dengue and Hemorrhagic Fever”* WHO and Health Department Cooperation, Jakarta.

[2] Muhammad E and Soesilo B 2001 *Analysis of dynamic system, living environment, social, economy, management* (Jakarta: UMJ Press)

[3] Gagnon A, Bush A and Smoyer-Tomic K 2001 Dengue epidemics and the el nino southern oscillation *Climate Research* 19 35-43

[4] Kovats S, Hajat S, Worall E and Haines A 2003 *El Nino and Health* [http://image.thelancet.com/extrax/02art5336web.pdf](http://image.thelancet.com/extrax/02art5336web.pdf)
[5] Gubler J and Kuno G 2001 Dengue and dengue hemorrhagic fever (New York, USA: CABI Publishing)
[6] Tun-Lin W, Burkot T R and Kay B H 2000 Effects of temperature and larval diet on development rates and survival of the dengue vector Aedes aegypti in north Queensland, Australia Medical and Veterinary Entomology 14(1) 31-37
[7] Eastin MD, Delmelle E, Casas I, Wexler J and Self C 2014 Intra-and interseasonal autoregressive prediction of dengue outbreaks using local weather and regional climate for a tropical environment in Colombia The American journal of tropical medicine and hygiene 91(3) 598-610
[8] Hafeez F, Akram W, Suhaill A and Arshad M 2012 Knowledge and attitude of the public towards dengue control in urban and rural areas of Punjab Pakistan Journal of Zoology 44(1) 15-21
[9] Bloom Benjamin S 1956 Taxonomy of Educational Objectives: The Classification of Educational Goals (New York: David McKay)
[10] Hairi F, Ong C H, Suhaimei A, Tsung T W, bin Anis Ahmad M A, Sundaraj C and Soe M M 2003 A knowledge, attitude and practice (KAP) study on dengue among selected rural communities in the Kuala Kangsar District Asia Pacific Journal Public Health 15(1) 37-43
[11] Santoso S and Budiyanto A 2008 Knowledge, attitude and practice relationship of the community towards dengue hemorrhagic fever (DHF) in Palembang City South Sumatra Province Indonesian Journal of Health Ecology (Jurnal Ekologi Kesehatan) 7(2) Agt 2008 732-739