ORIGINAL ARTICLE

THE ASSOCIATION BETWEEN CLIMATIC FACTORS AND DENGUE FEVER: A STUDY IN SUBANG JAYA AND SEPANG, SELANGOR

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ABSTRACT

Dengue fever is one of the most dangerous vector-borne diseases. According to the World Health Organization (WHO), dengue fever is a mosquito-borne infection caused by virus serotype DEN-1, DEN-2, DEN-3 and DEN-4. In Malaysia, dengue fever cases are on the rise from 6,000 cases in 1995 to over 40,000 in 2010, and this number is still rising. In 2014, the increase of dengue fever cases was alarming. It was reported that up to the end of the year 2014, there were 108,698 notified cases, indicating an increment of 151% compared to the same period of time in 2013 with only 43,346 reported cases. Selangor was the highest contributor of dengue fever cases in 2014. The objective of this paper is to study the relationship between climatic factors namely temperature, rainfall and humidity to the prevalence of dengue fever in Subang Jaya and Sepang district, Selangor. Data on monthly average temperature, precipitation, relative humidity and dengue fever cases for each month in 2014 and 2013 were collected. Data collection was dealt with a few institutions such as Malaysian Meteorological Department, Subang Jaya and Sepang Municipal Council and health district offices. Data were analysed using SPSS (Statistical Package for the Social Sciences) Version 20. General linear model analysis was used to investigate the relationship between the climatic variables and dengue prevalence. Results and Discussion: Based on the general linear model, rainfall and humidity were found to have significant relationships to monthly dengue fever cases (p= <0.001, p= 0.002). Rainfall was identified as the most significant predictor because rainfall can provide more breeding places for Aedes mosquitoes. As for humidity, higher relative humidity had been associated with increased Aedes aegypti feeding activity, survival and egg development. Temperature was not significantly related to monthly dengue fever cases (p= 0.561) in this study. However, this could be due to the short period of study. Conclusion: Climatic factors play an important role in the prevalence of dengue fever. However, there are many other factors of dengue fever that should be considered such as urbanisation as well as community knowledge, attitude and practice.

Keywords: *Temperature, rainfall, humidity, dengue fever, Selangor*

INTRODUCTION

Dengue fever can be defined as a mosquito-borne infection caused by virus serotype DEN-1, DEN-2, DEN-3 and DEN-4[1]. Dengue viruses are transmitted primarily via *Aedes aegypti* and *AedesAlbopictus* mosquitoes as the vectors. Briefly, the clinical manifestations of dengue fever may include fever, severe headache, retro orbital pain, muscle, joint and bone pain, macular or maculopapular rash, and minor hemorrhagic manifestations, including petechiae, ecchymosis, purpura, epistaxis, bleeding gums, hematuria, or a positive tourniquet test result[2].In Malaysia, the first dengue fever case was reported in 1902 in Penang Island. In the 1990's, epidemic had been annual, occurring every year with increasing prevalence[3].

Dengue fever is increasing in Malaysia. Dengue fever cases are on the rise from 6,000 cases in 1995 to over 40,000 in 2010, and this number is still rising[4]. In 2014, the increase of dengue fever cases was alarming. It was reported that up to the end of the year 2014, there were 108,698 notified cases, indicating an increment of 151% compared to the same period of time in 2013 with only 43, 346 reported cases of dengue fever. In 2014, Selangor was the highest contributor with 54,290 cases and 77 deaths[5]. Figure 1 shows the trend of dengue fever from the year 1970 up to 2015[6].

Based on Figure 1, there had been ups and downs shown by the trend, however, in 2014 the increase in number of cases was extreme. In 2014, apart from being the highest contributor to Malaysia's dengue case, Selangor had also been associated with several climate fluctuations. For example, February 2014, heat wave phenomenon hit Malaysia and 312 cases of bush fires were reported nationwide. Selangor recorded the highest number of bush fires with 79 cases followed by Perak with 70[7]. Hence, climate arose as a factor of interest in this study. Therefore, Selangor state was chosen because of the dengue and climate situations. Thus, it would be most relevant to conduct this study in Selangor.To represent Selangor, Subang Jaya and Sepang are chosen.

The objective of this research is to study the relationship between climatic factors and dengue fever.In this research, the climatic factors refers to monthly average temperature (^{o}C), monthly average precipitation (mm) and monthly average humidity (%) shown by Subang Jaya and Sepang principal climate station in the year 2014 and 2013.In this research, dengue fever refers to the

notified monthly dengue fever cases for areas under the administration of Subang Jaya Municipal Council (MPSJ) and Sepang Municipal Council (MPS). Besides the normal dengue fever, dengue hemorrhagic fever and dengue shock syndrome cases are also included.

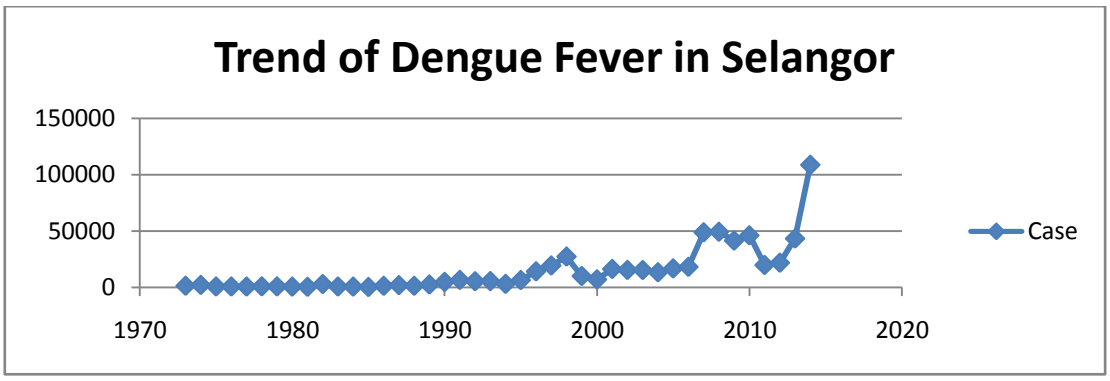

Figure 1: Trend of dengue fever in SelangorSource: [6]

METHODS

Study design and Study Procedures

This is an ecological correlational study involving secondary data on climatic parameters and dengue fever cases for the population in Subang Jaya and Sepang.For the purpose of this research, an urban and rural area in Selangor was chosen. Also, areas with principal climate stations were given priority. Hence, Subang Jaya was chosen to represent the urban area and Sepang was chosen to represent the rural area. In this study, Subang Jaya refers to the areas under the administration of Subang Jaya Municipal Council (MPSJ) and Sepang refers to the areas under the administration Sepang Municipal Council (MPS).

According to Malaysian Meteorological Department, the data on climatic factors given by the principal climate stations are only valid for 20 km radius from the station itself. An example could be used to give a reason for this fact. Thus, not all areas under the administration of MPSJ can be included in the study. To ensure data validity, Google Earth software was used to locate the areas within the 20 km radius. Serdang Lama and Seri Kembangan were excluded from being research location because these areas are out of the 20 km radius as shown in Figure 2.

As for Sepang, Cyberjaya was excluded because it is not within the 20 km radius, leaving only Salak Tinggi, Dengkil, Salak, Sepang and Sungai Pelek. Figure 3 shows the areas within the 20 km radius from Sepang Principal Climate Station. Only dengue cases from these areas were taken into account for this research.

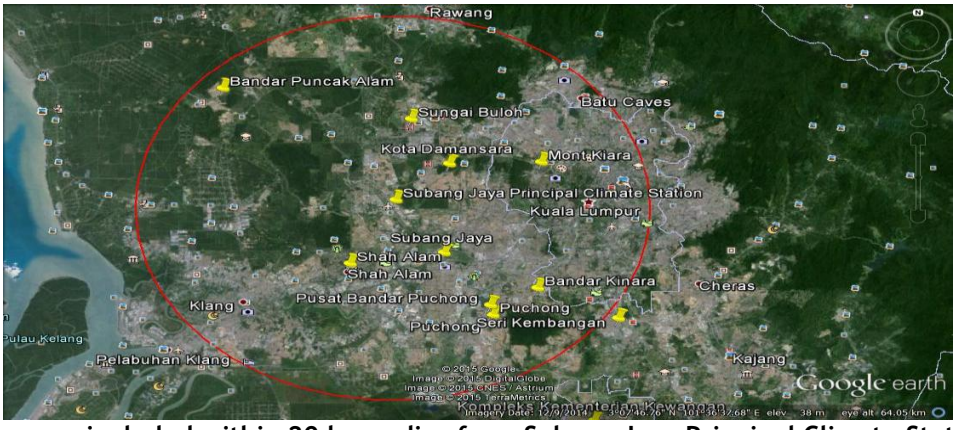

Figure 2: The areas included within 20 km radius from Subang Jaya Principal Climate Station are those within the red circle.

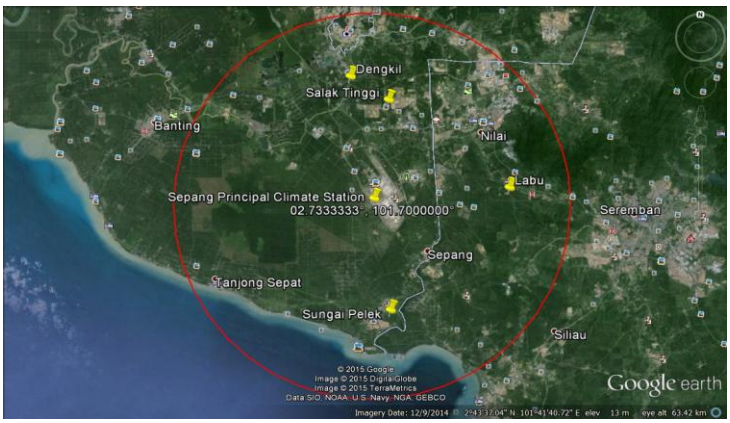

Figure 3: The areas included within 20 km radius from Sepang Jaya Principal Climate Station are those within the red circle

This study involved secondary data collection. Monthly average temperature, monthly average precipitation and monthly average humidity level from January to December 2014 and 2013 in Subang Jaya and Sepang were collected from the Principal Climate Station of Subang Jaya and Sepang. Data collection was dealt with Malaysian Meteorological Department.

Monthly dengue cases from January to December 2014 and 2013 for both areas, Subang Jaya and Sepang were collected from Subang Jaya Municipal Council, Petaling District Health Office, Sepang Municipal Council and Sepang Health District Office.

Statistical Analysis

Statistical analysis was performed by using software SPSS 22.0 (Statistical Package for Social Science). Descriptive statistical analysis was used to obtain mean, median and standard deviation for all distribution variables included in the study. Since all the data obtained was a categorical data, hence chi-square test was used to determine the association and the level of significance adopted for this study was $p<0.05$.

Ethical clearance

An approval letters had been sent to Ministry of Health Malaysia, Malaysian Meteorological Department, Subang Jaya Municipal Council (MPSJ) and Sepang Municipal Council (MPS)to obtain approval conducting the study.

RESULTS

Comparison of climatic parameters in Subang Jaya and Sepang between the years 2013 and 2014

The climatic parameters involved in this study were monthly average temperature, monthly average rainfall and monthly average relative humidity. Figures 4, 5 and 6 show the monthly readings of the climatic parameters that were received from Malaysian Meteorological Department.

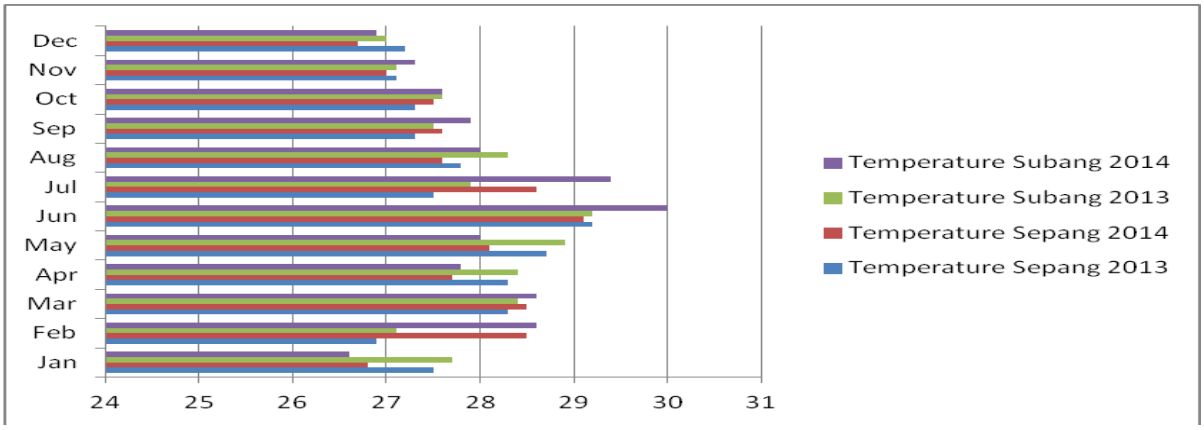

Figure 4: Comparison of monthly average temperature

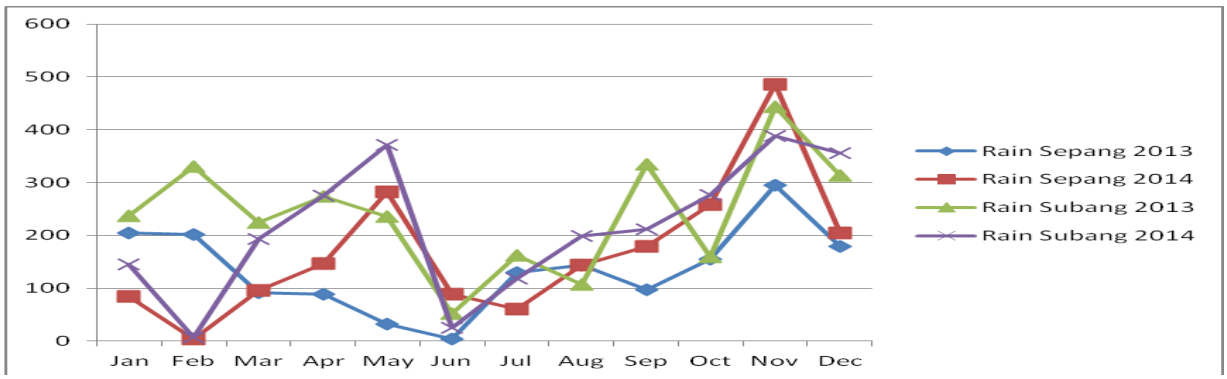

Figure 5: Comparison of monthly rainfall

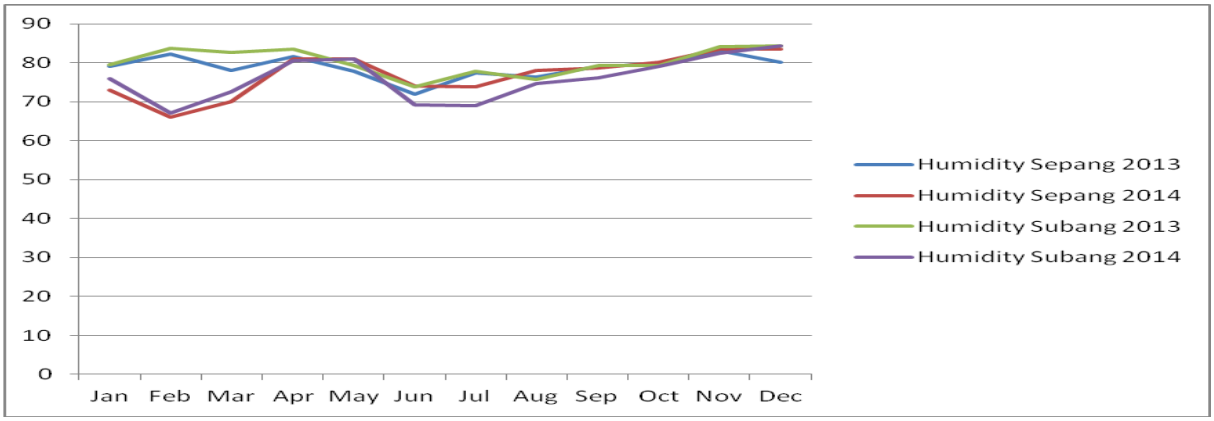

Figure 6: Comparison of monthly relative humidity.

To compare the climatic parameters between the years 2013 and 2014, descriptive statistics were used. Table 1 shows the descriptive statistics of the climatic variables in Subang Jaya.

Table 1: The minimum, maximum, mean, standard deviation and variance of climatic measures in Subang Jaya for 2013 and 2014

Year	Variables	Min	Max	Mean	Std. Deviation	Variance
2013	Temperature	27.0	29.2	27.9	0.72	0.52
	Precipitation	52.6	444.0	239.3	109.04	11888.97
	Humidity	73.9	84.3	80.3	3.43	11.74
2014	Temperature	26.6	30.0	28.1	0.98	0.96
	Precipitation	7.0	388.6	214.0	126.65	16040.65
	Humidity	67.2	84.3	76.0	5.63	31.73

N=12

Based on descriptive statistics, the differences in the monthly temperature, precipitation and humidity can be seen in general. In Subang Jaya, a drier season was reported in 2014 with a higher mean temperature (°C), less precipitation (mm) and less humidity value (%). Hence, it can be concluded that there was a significant difference in climatic parameters between 2013 and 2014 in Subang Jaya.

To compare the climatic parameters in Sepang, descriptive statistics were used. Table 2 shows the descriptive statistics for the climatic variables in Sepang.

Table 2: The minimum, maximum, mean, standard deviation and variance of climatic measures in Sepang for 2013 and 2014 (N=12)

Year	Variables	Min	Max	Mean	Std. Deviation	Variance
2013	Temperature	26.9	29.2	27.8	0.71	0.51
	Precipitation	4.2	294.4	135.3	79.85	6376.64
	Humidity	72.0	83.1	78.9	2.97	8.82
2014	Temperature	26.7	29.1	27.8	0.76	0.58
	Precipitation	3.6	486.4	169.3	128.77	16581.97
	Humidity	66.1	83.6	76.9	5.49	30.09

N=12

In Sepang, according to the descriptive statistics, in 2014 the mean in precipitation and humidity increases. The mean temperature remained the same. Hence, in Sepang, it can be concluded that only rainfall and humidity showed significant difference in between the years. There was no significant difference in monthly average temperature between 2013 and 2014 in Sepang.

Comparison of monthly dengue cases in Subang Jaya and Sepang between 2013 and 2014

In this research, dengue cases were sorted into monthly cases and also into specific locations applicable to the study as shown in Figure 7 and Figure 8.

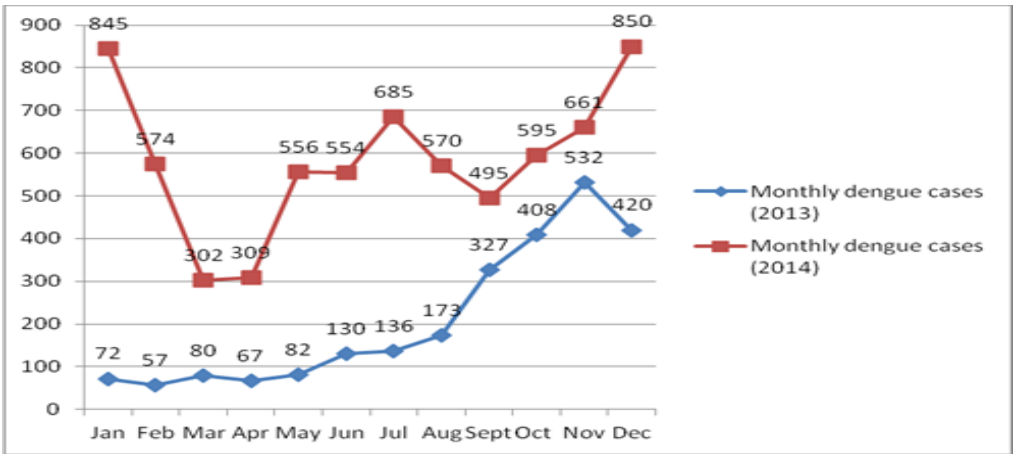

Figure 7: Monthly dengue cases in Subang Jaya for the locations within 20 km radius from the principal climate station
Source: [8]

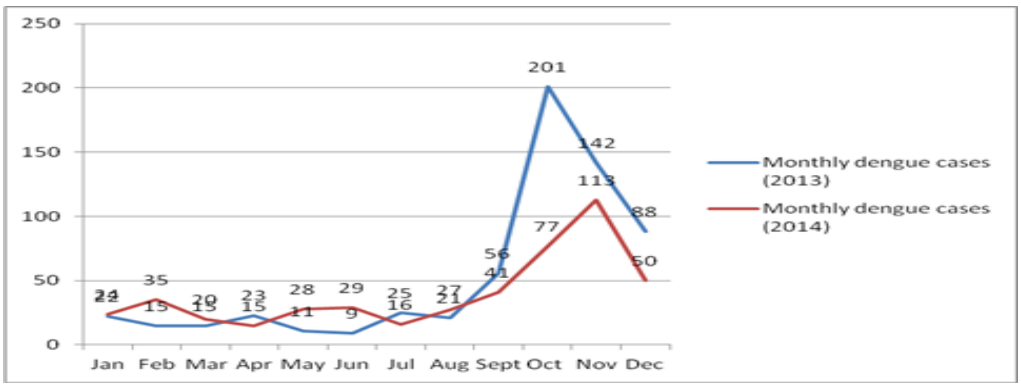

Figure 8: Monthly dengue cases in Sepang for the locations within 20 km radius from the principal climate stationSource: [9]

Based on Figure 7, the monthly dengue cases was higher in 2014 compared to 2013 in Subang Jaya, after excluding Seri Kembangan and Serdang. But as for Sepang, based on Figure 8, dengue cases is higher in 2013 compared to 2014.

Descriptive statistics was used to further observe the measures of dispersion for dengue cases between 2013 and 2014 in Subang Jaya and Sepang (N=12). Table 3 shows the descriptive statistics of dengue fever cases.

Table 3: Median, interquartile range (IQR), standard deviation (SD) and 95% CI for monthly dengue cases.

Location	Year	Median	IQR	SD	95% CI
Subang Jaya	2013	133.0	314.0	167.9	100.3:313.7
	2014	572.0	169.0	170.6	474.6:691.4
Sepang	2013	22.5	65.0	61.3	13.4:91.3
	2014	28.5	27.0	28.8	21.3:57.9

N=12

It can be concluded that for Subang Jaya, the frequency of dengue fever cases increases in 2014. But in Sepang, the frequency of dengue fever cases decreases in 2014.

Comparison of climatic parameters between Subang Jaya and Sepang in 2013 and 2014

To analyse the difference in climatic factors between two study areas, Subang Jaya and Sepang, independent samples t-test was conducted. In this test, the climatic variables for both years were combined (N=24) to be compared between Subang Jaya and Sepang. Table 4 shows the outcome from the test.

Table 4: Comparison of climatic factors between study areas, Subang Jaya and Sepang.

Variables	Levene's Test (p)	t	p
Temperature	0.688	0.919	0.363
Rainfall	0.426	2.134	0.025*
Humidity	0.380	0.164	0.870

*N= 24, *Significant at p<0.050*

The p-values from Levene's test were more than 0.05 for temperature, precipitation and humidity. Hence, the equality of variances was assumed for these factors. Based on the results from the independent samples t- test (Table 3), there were no significant difference in monthly average temperature (p= 0.363) and monthly humidity (p= 0.870) between Subang Jaya and Sepang. However, there was a significant difference in monthly average precipitation (p= 0.025).

Comparison of dengue fever cases between Subang Jaya and Sepang in 2013 and 2014

The monthly dengue cases were also compared between the study areas. In this test, the 2013 and 2014 data were combined, to be compared between Subang Jaya and Sepang (N=24). The p-value from Levene's Test is less than 0.005. The assumption of equality in variances was not met. Hence, non- parametric Mann-Whitney Test was performed instead of parametric independent samples t- test. Table 5 shows the results from the Mann- Whitney Test.

Table 5: Comparison of monthly dengue case between two study areas, Subang Jaya and Sepang

Variables	Levene's Test (p)	Mean rank	Z	p
Dengue Cases				
Subang Jaya	0.000	35.33	-5.36	<0.001*
Sepang		13.67		

*N=24, *Significant at p<0.005*

The p-value from non- parametric Mann-Whitney Test shows that there was a significant difference in the number of dengue fever cases (p= <0.001) between Subang Jaya and Sepang. The number of dengue fever cases was higher in Subang Jaya compared to Sepang.

The relationship between monthly average temperature, monthly average precipitation, monthly humidity and monthly dengue cases.

To study the association between the climatic factors and dengue cases, general linear model was used. Table 6 shows the results from general linear model analysis.

Table 6: Results of general linear model analysis upon the relationship between temperature, precipitation and humidity to dengue cases

Source	Type III Sum of Squares	df	Mean Square	F	p.
Corrected Model	854762.308[a]	3	284920.769	5.866	0.002
Intercept	167678.608	1	167678.608	3.452	0.070
Temperature	16701.702	1	16701.702	.344	0.561
Rainfall	775420.850	1	775420.850	15.965	0.000*
Humidity	548182.220	1	548182.220	11.287	0.002*
Error	2137019.671	44	48568.629		
Total	5325113.000	48			
Corrected Total	2991781.979	47			

*N= 48, *significant at p<0.050*

Based on the general linear model analysis, it was found out that temperature was not a significant predictor (p=0.561). After dropping the insignificant variable at one time, only rainfall and humidity were significant predictors of dengue fever. Table 7 shows the results of generalized linear model analysis after dropping the insignificant variable.

Table 7: Results of general linear model analysis upon the relationship between rainfall and humidity to dengue cases

Source	Type III Sum of Squares	df	Mean Square	F	p
Corrected Model	838060.606[a]	2	419030.303	8.755	0.001
Intercept	606360.108	1	606360.108	12.669	0.001
Rainfall	826945.297	1	826945.297	17.278	0.000*
Humidity	566697.948	1	566697.948	11.841	0.001*
Error	2153721.373	45	47860.475		
Total	5325113.000	48			
Corrected Total	2991781.979	47			

*N=48, *significant at p<0.05*

Based on Table 6 and 7, it can be concluded that there were significant associations between rainfall and humidity and dengue fever. There was no significant association between temperature and dengue fever cases. Table 8 shows the parameter estimate for humidity and rainfall.

Table 8: The Beta value, standard error, t- value, p-.value and 95% confidence interval from general linear model analysis for rainfall and humidity.

Parameter	B	Std. Error	t	p	95% Confidence Interval	
					Lower Bound	Upper Bound
Intercept	2654.099	745.659	3.559	0.001	1152.264	4155.933
Rainfall	1.727	.415	4.157	0.000*	.890	2.563
Humidity	-35.385	10.283	-3.441	0.001*	-56.096	-14.673

*N=48, *Significant at p<0.05*

Based on Table 8, an equation can be generated and was given as:
Dengue case = 2654.099 + 1.727(rainfall) – 35.385(humidity)

Based on the equation, for every unit increase in rainfall, dengue case increases by 1.727 (±2) provided that humidity remain unchanged. For every unit increase in humidity, dengue case decreases by 35.385 (±35) provided that temperature remain unchanged.To determine the most significant predictor, Beta value was referred to. Based on the Beta values given in Table 8, rainfall has a higher Beta value.

Therefore, rainfall was the most significant predictor of dengue fever cases.

DISCUSSION

Comparison of climatic parameters in Subang Jaya and Sepang between the years 2013 and 2014

There was a difference in climatic parameters between 2013 and 2014 in Subang Jaya. As seen from descriptive statistics (Table 1), the parameters did fluctuate a little between the years, especially the monthly rainfall. In Sepang, only rainfall and humidity showed difference in between the years. There was no difference in mean value for monthly average temperature between 2013 and 2014 in Sepang. Generally, Malaysia has uniformly high temperatures[10]. Hence, no variation in temperature is possible.

Comparison of monthly dengue cases in Subang Jaya and Sepang between 2013 and 2014

After adjusting the data into monthly cases and sorting out the addresses of the patients, the finalised number of dengue cases is as shown in Figure 7 and Figure 8. The prevalence of dengue fever is still higher in 2014 for Subang Jaya compared to 2013. However, in Sepang, the prevalence of dengue fever is apparently higher in 2013 compared to 2014.There were many factors that could be associated with the increase of dengue fever in 2014 such as unhygienic surrounding, serotype virus evolution, community habit of improper waste disposal, human migration and also the changing climate[5].

Comparison of climatic parameters between Subang Jaya and Sepang in 2013 and 2014

As for the comparison of climatic parameters between the two study areas, Subang Jaya and Sepang, only rainfall showed significant difference ($p= 0.025$). Although Subang Jaya and Sepang are two different locations, the distance between these two locations are not large enough for temperature and humidity to differ significantly. Both are still within Selangor which is located in the centre of Peninsula.

Comparison of dengue fever cases between Subang Jaya and Sepang in 2013 and 2014

The number of dengue fever was compared between the two study areas. Based on the findings from Table 4, the difference was highly significant ($p<0.001$). The prevalence of dengue fever was higher in Subang Jaya compared to Sepang. There are many factors that can contribute to this difference. Different locations of study areas suggested that urbanisation may play its role in the prevalence of dengue fever. Urbanisation means the increase of people living in urban areas. Based to a census conducted by Department of Statistics Malaysia, it is clear that in Subang Jaya, the population is denser compared to Sepang[12].

A study was conducted in Taiwan by [11] to find the relation of urbanisation to dengue fever. The findings reported that cumulative incidence of dengue fever was matched well with the geographical distribution of *A. aegypti*. *A. aegypti* appeared to live in areas close to dense human habitation[13]. Besides that, urban developments could lead to the increasing sources of artificial water, such as water storage spots, tires or old containers in garbage for vectors to breed [14, 15, 16]. For example, in Subang Jaya, the most obviously potential breeding sites are the construction sites.

Thus, urbanisation is a possible confounder for this study. Another possible confounder for this study is the knowledge, attitude and practice of residents on dengue fever. If the community members are knowledgeable as well as possess a positive attitude and practice towards preventing dengue fever, surely the dengue prevalence can be reduced. Both of these factors were not studied in this research, however, they may impose some effects.

The relationship between monthly average temperature, monthly average precipitation and monthly average humidity to monthly dengue cases

Data on climatic variables namely monthly average temperature, rainfall and humidity, as well as monthly dengue cases for 2013 and 2014 in Subang Jaya and Sepang were combined. Using general linear model, the association between the climatic variables and dengue cases were studied.

The findings showed that rainfall and humidity were significant contributors to dengue cases with p- value of <0.001 and p-value of 0.002 respectively. However, there was no significant relationship between monthly average temperature and monthly dengue cases ($p= 0.561$).

After removing temperature as a non-significant predictor, the p- values for rainfall and humidity are <0.001 and 0.001 respectively. Rainfall was identified as the most significant predictor.

Rainfall had been identified as a significant contributor to dengue fever in many studies [17,18,19]. Generally, rain provides more breeding places for the vectors of dengue fever, *Aedes* mosquitoes. All mosquitoes have aquatic larval and pupal stages. Therefore, water is needed for breeding[20]. Abandoned water containers can be easily filled up with rain. Some of the famous

breeding places for *Aedes* mosquitoes include drinking water containers, discarded car tyres, flower vases and ant traps[21].

Despite the fact that rainfall can be significantly related to dengue fever, the amount of rainfall is an important factor to be considered. Extremely heavy rainfall may wash out breeding sites and thus have a negative effect on vector populations[22]. Besides that, the timing of rainfall may also affect vector life cycle. If the number of rainy days were too low, there would not be enough water for mosquito larvae to complete their development[18].

In this study, significant relationship can also be seen between relative humidity and dengue fever cases. Humidity is actually inter-related to rainfall and temperature. Higher rainfall causes humidity to be high, whereas higher temperature causes humidity to be low. The relative humidity in Malaysia is high, ranging from 70 to 90%[10]. Higher humidity had been associated with increased *Aedes aegypti* feeding activity, survival and egg development[23]. At high humidity, mosquitoes generally live longer and disperse further. Therefore, the feeding activity would increase as they would have a greater chance to feed on human blood and therefore transmit dengue virus. Relative humidity also directly affects the evaporation rate of vector breeding site[18].

In this study, the only climatic variable without significant relationship to dengue cases was temperature. In most areas of Malaysia, the average maximum and minimum temperature per month vary less than 2°C annually[10]. This small fluctuation of temperature and yet large differences in dengue fever cases by month may have caused the insignificance in association. In case of temperature, the data may be needed in longer duration.

Positive association between temperature and dengue fever had been found in many studies [18,19]. According to [22], temperature is a key component in the ecology of dengue virus. Higher temperature was related to faster viral replication within the vector. Temperature can even affect the *Aedes* mosquito ecology, primarily *A. aegypti*. This was proven by a laboratory procedure by [24]. In the laboratory setting, [24] found that immature *Ae. Aegypti* development rates generally increased with incubation temperatures to 34ºC and then slowed.

Several local studies were conducted to find the association between climatic factors and dengue fever[25,26]. In Selangor, a study was conducted by[25] to investigate the environmental factors responsible for the prevalence of dengue fever. Climatic factors were included. Based on the findings of study, the climatic variables were significant, but not for all of the areas in Selangor. The relationship between dengue fever and ambient temperature, for instance, were only found significant in Kuala Selangor and Shah Alam. As for rainfall, significant association were found in Sepang and Kuala Selangor. This indicated that the prevalence of dengue fever do not solely dependent on climatic factors. There were many other factors that can contribute to the prevalence of dengue fever. As for this study, the possible confounders were urbanisation and knowledge, attitude and practice of the community.

CONCLUSION

In conclusion, climatic factors play a role in the prevalence of dengue fever. Rainfall and humidity can be significantly related to the prevalence of dengue fever. Temperature was not a significant predictor according to this study.

However, climate is just one of the environmental factors of dengue fever. There are other factors that must be considered such as the population and the socio demographic background, KAP of the population, urbanisation and also host factors such as immunity. In a big state like Selangor, climate may not be the main factor but instead, aggravates the condition.

From the statistical analyses, the objectives of the study were answered:

1. There were differences in monthly average temperature, precipitation and humidity between the years 2013 and 2014 in Subang Jaya. In Sepang, there were differences in monthly average rainfall and humidity between 2013 and 2014. However, there was no difference in temperature between 2013 and 2014.

2. The number of dengue cases in 2014 was much higher compared to 2013 in Subang Jaya. However, in Sepang, the number of dengue cases was higher in 2013 compared to 2014.

3. There were no significant difference in temperature and humidity between Subang Jaya and Sepang. However, there was a significant difference in rainfall between Subang Jaya and Sepang.

4. There was a significant difference in the prevalence of dengue fever between Subang Jaya and Sepang.

5. There was no significant association between monthly average temperature and monthly dengue cases.

6. There was a significant association between monthly average rainfall and monthly dengue cases.

7. There was a significant association between monthly average relative humidity and monthly dengue cases.

8. Rainfall was the most significant climatic predictor of dengue fever.

Dengue fever is a communicable disease that is continuously catching worldwide attention. The infection seemed to be showing no sign of stop. Hence, prevention is crucial.

Based on the outcomes of this study, climatic factors were included as the factors of dengue fever. Therefore, attention from the authorities, such as the Ministry of Health is needed regarding this matter so that strategic control measures can be taken. Firstly, it is recommended that MOH identify the particular period of time in a year with high number of dengue cases. For example, the months with high predicted rainfall. Once the specific months were identified, strategic control measures such as more frequent inspections can be conducted. Besides that, a special team with more manpower can be formed during this critical period of time.

However, vector control programmes should be continuous. The authorities must regularly do their job in checking up the houses and fogging must be done wherever epidemics are reported, not only during the critical period.

To verify the effect of climate on dengue fever in Malaysia, a broader aspect in terms of climate such as climate change can be used. This can verify the theory about changes that climate brings about to the dengue prevalence.

As to improve this study itself, in the future longer study duration may be needed. Longer study duration can reveal more about the changing patterns of climate to be associated with the changing pattern of dengue cases.

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COMPETING INTERESTS
There is no conflict of interest.

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