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Climate Change and Incidence of Dengue Fever (DF) and Dengue Hemorrhagic Fever (DHF) in Iligan City, Lanao del Norte, Philippines

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Abstract

Dengue has been and is still a serious public health problem in Iligan City, Lanao del Norte. The increase of the number of dengue cases has been attributed to climate change; however, contradicting reports show uncertain relationships between dengue and climatic factors. This study showed the relationship between climatic factors with dengue fever (DF) and dengue hemorrhagic fever (DHF) incidence reported in Iligan City from 2005-2009. The climatic factors include maximum temperature, minimum temperature, rainfall and relative humidity. Pearson's correlation was used to explore the primary association between the DF and DHF incidences and the preceded climatic factors. Multiple regression analysis was also used to fit the statistical model. The result showed that the total number of dengue cases (both DF and DHF) used as the dependent variable gave a predicted regression model of Y (dengue incidence) = - .307 (temp max) + .375 (temp min) + .024 (rainfall) – .323 (relative humidity) which means that these constants have a significant correlation to dengue cases suggesting that an increase or decrease of its values could affect the number of dengue cases.

Keywords: Dengue fever, dengue hemorrhagic fever, multiple regression analysis, Pearson's correlation

Introduction

Dengue, a Flaviridae infection transmitted by domestic *Aedes aegypti* is currently the second deadliest mosquito-borne illness and one of the most prevalent emerging human diseases with no preventive vaccines or antiviral cures available[1]. An important observation related to dengue transmission is that, in tropical areas like Philippines, the density of mosquitoes and the number of dengue cases starts to increase in number during the rainy season which is from July – November[2].

Iligan City is a highly urbanized city north of the province of Lanao del Norte, Philippines with a type of climate that is not very pronounced with rains and is more or less evenly distributed throughout the year. With its tropical and geographical location, the city houses a good environment for the dengue carrier mosquitoes. It has been known to have the major dengue related cases for the past years[3].

The relationship between climate and dengue has been assessed in multiple settings using different statistical methods[4,5]. It has been proposed that climate variables can increase the predictive power of dengue models[6]. Increased temperature has been associated with dengue in Thailand, Indonesia, Singapore, Mexico and Puerto Rico while rainfall has been found to correlate with dengue in Indonesia, Trinidad, Venezuela, Barbados and Thailand[7]. Accordingly, temperature could be accompanied with increases in the population of the *Aedes* species and dengue fever infections. Furthermore, mosquito population dynamics vary for different geographic regions where dengue is transmitted suggesting that the influence of climate on dengue may be site-specific[8].

This study shows the relationship between climatic factors (maximum and minimum temperature, mean temperature, rainfall and relative humidity) and reported cases of dengue fever (DF) and dengue hemorrhagic fever (DHF) in Iligan City using Pearson's correlation and linking dengue fever and dengue hemorrhagic fever cases to temperature and rainfall by using regression analysis.

Material and Methods

Climatic Factor Data: Climatic data for Iligan City over the period of 2005-2009 was provided by Philippine Atmospheric, Geophysical and Astronomical Services (PAG-ASA) office located in Cagayan de Oro City, Region X. Climatic data comprised monthly reports of maximum temperature, minimum temperature, mean temperature, rainfall and relative humidity.

Dengue Fever (DF) and Dengue Hemorrhagic Fever (DHF) Cases: The total number of DF and DHF cases was obtained from Dr. Uy Hospital, Gregorio T. Lluch Memorial Hospital and Mindanao Sanitarium Hospital. Dengue cases reported from 2005-2009 in a monthly basis was collected. The data showed that the year 2005 has the highest number of dengue cases with the total of 547 dengue fever cases and 399 dengue hemorrhagic fever cases. On the other hand, 2008 got the lowest number of DF and DHF cases with 128 and 87 respectively.

Correlation Study between Climatic Factors and Dengue Cases: Climatic factors such as temperature (maximum and minimum), rainfall and relative humidity were linked with dengue fever cases and dengue hemorrhagic fever cases through multiple regression analysis, a flexible method of data analysis used whenever a quantitative variable (the dependent or criterion variable) is to be examined in relationship to any other factors (expressed as independent or predictor variables)[9].

Pearson's correlation was used to explore the primary association between the DF and DHF incidence and all climatic factors. First, Pearson's correlation coefficient (r) was calculated. The sign of the correlation coefficient determines the strength of the correlation. Coefficient of determination (r^2) which is the square of the correlation coefficient was then calculated to determine the proportion of the variance of one variable explained by the other. Lastly, hypothesis testing was conducted by calculating the p-value of each variable (dengue cases, DF cases and DHF cases) and compared the result to the fixed-level testing (α=0.05) to know if the variable is significant or not.

Results and Discussion

Cases and Climatic Factors: Dengue cases and climate data in Iligan City in 2005 to 2009 were collected. Figure 1 and 2 shows the sets of dengue cases with highest number of dengue fever in July 2005 and November in 2009. The highest numbers of dengue hemorrhagic fever cases were in September in 2005 and November in 2009. However, there was an observed decline in the number of cases in the year 2006-2008.

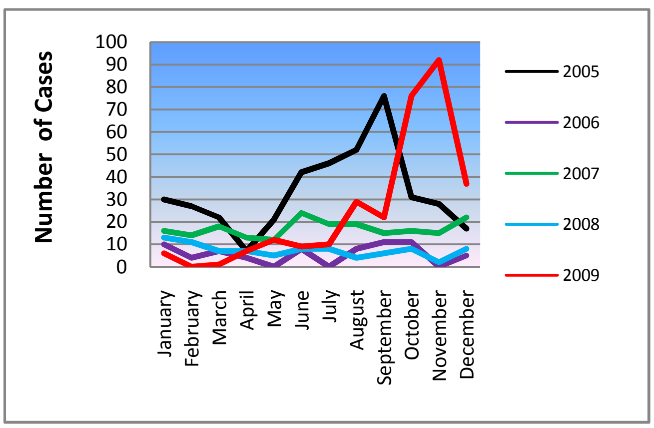

Figure -1
Monthly reports of dengue fever (DF) cases for 2005-2009

A report published by the Philippine Star tells that experts proclaimed that dengue season in the Philippines or in any tropical countries are in July to November during rainy season. According to PAG-ASA[10], the typhoons that hit the country also contributed to the increase of dengue related diseases. However some studies said that rain is not the primary cause of dengue. Heavy rains and flood could help in eliminating possible breeding sites of dengue vector. The problem lies after the rain stop, when stagnant water is accumulated in a particular area and high temperature increases the vector's population since it becomes very mobile at high temperatures and breeds faster.

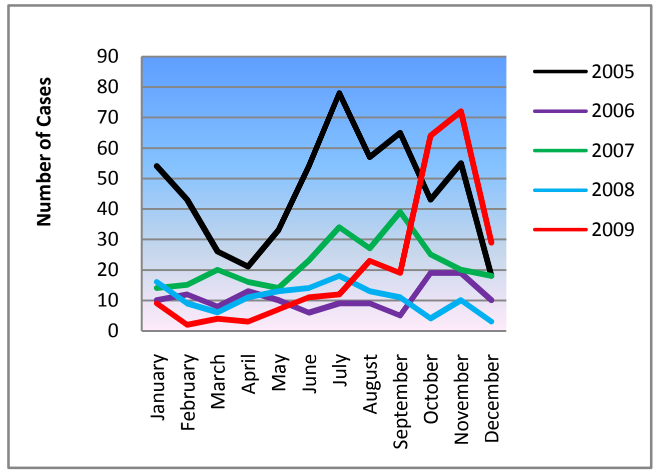

Figure-2
Monthly reports of dengue hemorrhagic fever (DHF) cases for 2005-2009

Pearson Correlation Coefficient Analyses: Table 1 shows the small negative values of Pearson correlation coefficient which indicates an inverse and weak linear relationship between the predictors (maximum temperature and relative humidity) to the dependent variables (dengue cases, dengue fever cases and dengue hemorrhagic fever cases). This means that an increase in the values of maximum temperature and relative humidity has a little and near insignificant corresponding decrease in dengue fever, dengue hemorrhagic fever and dengue cases. Rainfall has values that are near zero (DF: r=.017; DHF: r=.079 and Dengue Cases: r=.049) that implies a very small effect on the dependent variables and is considered insignificant.

Minimum temperature on the other hand, has a strong but not a perfect linear relationship to the dependent variables since the Pearson coefficient of the said predictor is near +1. This means that an increase or decrease on the values of minimum temperature has direct or indirect effect on the number of dengue fever cases, dengue hemorrhagic fever and dengue cases. One study showed that rainfall, temperature, and humidity have significant relation with DF/DHF incidences and can be related to the forecast expected number of dengue cases[11]. This conclusion was also made in a study showed with a result that indicated that the temperature, rainfall and relative humidity were associated with the dengue incidences in Southern Thailand[11].

Multiple Regression Analyses: Multiple regression analysis was carried out for each of the observations of the occurrence of DF and DHF cases and monthly climatic data of five years (2005-2009). The independent variables were used to see changes in the dependent variables. The variables used in the models are shown in table 1. Number of DF cases and DHF cases was used as the dependent variable and the maximum temperature, minimum temperature, rainfall and relative humidity were considered as the independent variables (table 2). Using the standardized beta coefficients, the relationship is described by the predicted regression model as:

Y(dengue incidence) = 321.331 - .307 (temp max) + .375 (temp min) + .024 (rainfall) – .323 (relative humidity)

This analysis of the climatic factors such as temperature, rainfall and relative humidity with the dengue cases has revealed that dengue generally occurs when average temperature rose above normal. It also occurs when rainfall was comparatively lower and humidity was higher than average[11]. The influence of elevated temperature on increasing dengue cases can be explained by the biological effect of the *Aedes* mosquito and the dengue virus. Laboratory evidence shows that temperature affects the development of larvae, decreasing the size of mosquitoes, increasing their range and biting rates and increasing their survival time[12]. Moreover, replication of dengue virus is enhanced by high temperatures.

Table-1
Pearson correlation coefficient of dengue cases, DF cases and DHF cases and the climatic factors

		Temp max	Temp min	Rainfall	Relative Humidity
DF	Pearson Correlation	**-.112**	**.302**	**.017**	**-.127**
	Sig. (2-tailed)	.396	.019	.898	.332
	N	60	60	60	60
DHF	Pearson Correlation	**-.078**	**.238**	**.079**	**-.147**
	Sig. (2-tailed)	.553	.067	.550	.263
	N	60	60	60	60
Dengue Cases	Pearson Correlation	**-.098**	**.279**	**.049**	**-.142**
	Sig. (2-tailed)	.456	.031	.708	.281
	N	60	60	60	60

Table-2
Coefficients of dependent variables (Dengue Cases)

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			Correlations			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	321.331	271.617		1.183	.242					
	temp max	-8.856	4.116	-.307	-2.152	.036	-.098	-.279	-.262	.731	1.368
	temp min	15.706	6.248	.375	2.514	.015	.279	.321	.307	.668	1.497
	rainfall	.010	.067	.024	.143	.887	.049	.019	.017	.515	1.943
	relative humidity	-3.731	1.834	-.323	-2.035	.047	-.142	-.265	-.248	.590	1.694

a. Dependent Variable: dengue cases

Table-3
Coefficients of dependent variables (Dengue Fever Cases)

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			Correlations			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	117.573	138.601		.848	.400					
	temp max	-4.570	2.100	-.307	-2.176	.034	-.112	-.282	-.262	.731	1.368
	temp min	9.566	3.188	.442	3.001	.004	.302	.375	.361	.668	1.497
	rainfall	-.014	.034	-.067	-.398	.692	.017	-.054	-.048	.515	1.943
	relative humidity	-1.648	.936	-.276	-1.761	.084	-.127	-.231	-.212	.590	1.694

a. Dependent Variable: dengue fever

Regression Analysis of Dengue Fever Cases and Climatic Factors*:* Table 3 shows that maximum temperature and minimum temperature is significantly correlated to the number of dengue fever cases in Iligan City. Rainfall and relative humidity which have p-values of .692 and .084 respectively exceeds the fixed-level testing (α=0.05) and are considered to be insignificant. This is described in the predicted regression model that an increase or decrease in maximum temperature and minimum temperature affects the dengue fever cases.

Predicted Regression Model: ***Y(dengue fever cases) = 117.573 – .307 (temp max) + .442 (temp min)***

This predicted regression model is illustrated in figure 3 which shows calculated average number of dengue fever cases in 2005-2009 and was related to the average temperatures (maximum and minimum), rainfall and relative humidity of the same years. It also shows that rainfall and relative humidity is not consistent of its relationship with the number of dengue fever cases. Although in 2007-2009, the said climatic factors seemed to be related to DF cases as the values increased when the number of cases increased.

Regression Analyses of Dengue Hemorrhagic Fever and Climatic Factors: Table 4 shows that the minimum temperature and relative humidity are significantly correlated to the number of dengue hemorrhagic fever in Iligan City since their p-value fitted to the fixed-level testing of 0.05. Maximum temperature is insignificant since its p-value is .069. This analysis is shown in the predicted regression model below and expounded in figure 4.

Y(dengue hemorrhagic) = 146.844 + .335 (temp. min) – .295 (relative humidity)

Figure 4 shows calculated average number of dengue fever cases from 2005-2009 and was related to the average temperatures (maximum and minimum), rainfall and relative humidity of the same years.

It was found in the study that the mean and minimum temperatures were positively associated with the transmission of DHF in Southern Thailand[13]. As the minimum temperature increased, the transmission rate of DHF also increased. It is possible that most of the physiological functions of vectors in Iligan City are subject to optimal minimum temperature.

Moreover, relative humidity influences longevity, mating, dispersal, feeding behaviour and oviposition of mosquitoes and rapid replication of the virus. At high humidity, mosquitoes generally live longer and disperse further. Therefore, they have a greater chance of feeding on infected people and surviving to transmit the virus to other people. Relative humidity also directly affects the evaporation rates of vector breeding sites.

Conclusion

The model summary of the data using the entire number of dengue cases reported as the dependent variable and the climatic factors (maximum temperature, minimum temperature, rainfall and relative humidity) as predictors were calculated using Pearson's Correlation and showed that 18.2% of the total variation of dengue incidences in Iligan City can be explained by the independent variables.

Dengue fever cases and dengue hemorrhagic fever cases was also analysed separately using the same statistical tool. It was in the model summary of dengue fever that 20.2% of the total variation of dengue fever cases is explained by the predictors, which are the climatic factors, while 14.4% is the result for dengue hemorrhagic fever cases.

Multiple regression analysis showed that maximum temperature, minimum temperature, rainfall and relative humidity are significant predictors of dengue cases in Iligan City. Maximum temperature and minimum temperature is significantly correlated to the number of dengue fever cases while rainfall and relative humidity which have p-values of .692 and .084 respectively exceeds the fixed-level testing (α=0.05) and are considered to be insignificant. The minimum temperature and relative humidity are significantly correlated to the number of dengue hemorrhagic fever cases while maximum temperature is insignificant (p-value is .069; α=0.05).

Having these results, it can be concluded that maximum temperature, minimum temperature and relative humidity are linearly related to the dengue cases in Iligan City. This means that an increase of the independent variables will also increase the number of the dependent variable. In this matter, independent variables are the climatic factors (maximum temperature, minimum temperature, rainfall, relative humidity) and the dependent variables are the overall number of dengue cases, number of dengue fever cases and the number of dengue hemorrhagic fever cases.

However, there are published studies which showed that rainfall is a significant predictor of dengue fever and dengue hemorrhagic fever. Thus, this paper recommends a broader scope of dengue cases reported annually and climate reports, more or less 10 years ago, since this study has only focused on the data published five years ago and may have affect the result of the statistical analyses.

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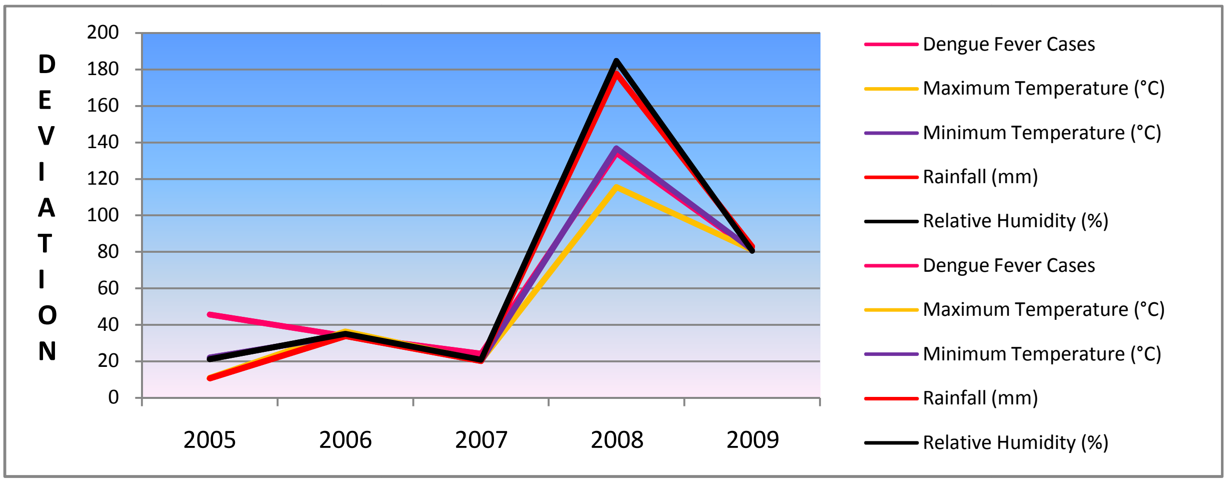

Figure-3
Relationship between DF cases and climatic factors from 2005-2009

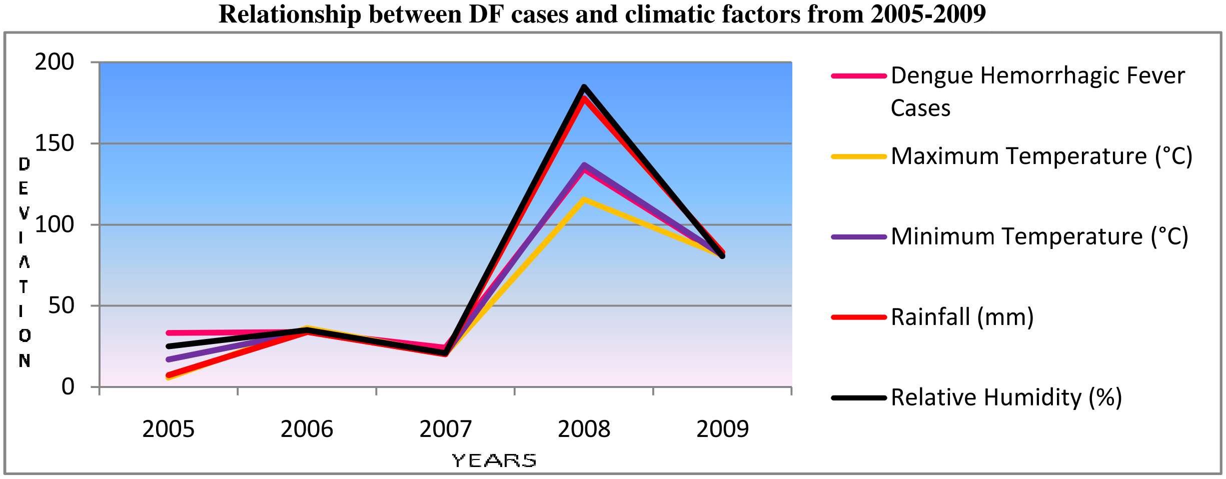

Figure -4
Relationship between DHF cases and climatic factors from 2005 -2009