Correlation of Climatic Factors and Dengue Incidence in Metro Manila, Philippines

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Dengue is a serious public health problem in Metro Manila, Philippines. Increasing dengue incidence has been attributed to climate change; however, contradicting reports show inconclusive relationships between dengue and climatic factors. This study investigates temperature and rainfall as climatic factors affecting dengue incidence in Metro Manila from 1996 to 2005. Monthly dengue incidence and climatic data for Metro Manila were collected over a 10-y period (1996–2005). Climatic factors temperature and rainfall were linked with dengue incidence through regression analysis. A predictive model equation plots dengue incidence (Y) *versus* rainfall (X), which suggests that rainfall is significantly correlated to dengue incidence ($r^2 = 0.377$, $p < 0.05$). No significant correlation between dengue incidence and temperature was established ($p > 0.05$). Evidence shows dengue incidence in Metro Manila varies with changing rainfall patterns. Intensified surveillance and control of mosquitoes during periods with high rainfall are recommended.

INTRODUCTION

Dengue is a serious public health problem in the tropical regions, particularly in Metro Manila, Philippines. Dengue infections are caused by a virus categorized in the family of *Flaviviridae*. There are four dengue serotypes based on the viruses serotype responses. Dengue infections are transmitted by the *Aedes aegypti* mosquito. The *Aedes* mosquito does not require an intermediate animal vector for the dengue virus. The *Aedes* mosquito is commonly found in urban settlements where it maintains a man–mosquito–man relationship. This relationship creates a system that continuously makes dengue infections a reemerging public health threat; 20 million cases are estimated to occur each year (1). The problem intensifies as more people continue to be at risk of acquiring the disease.

The present increase in dengue incidence has been attributed to various factors influencing the behavioral pattern of this infectious disease. Although the various factors are not fully understood, it is believed that the environment, particularly the climate, plays a vital role in people's health and well being.

Climate influences many key determinants that affect one's health. Changes in climate have been believed to favor the spread of diseases to new populations, and this greatly heightens people's concern toward the emergence and reemergence of infectious diseases. The risk of dengue epidemics arising from the occurrence of climate change is alarming because it enhances the vector–virus relationship (2). It is likewise believed that both temperature and rainfall affect the abundance and distribution of the mosquito vectors responsible for the disease (3). Several studies have suggested that temperature and rainfall considerably increase the toll of dengue infections (4, 5). However, Kanchanapairoj, McNeil, and Thammapalo (6) gave contradicting evidence on the relationship of climatic factors to dengue incidence. Such evidence shows that the relationship of dengue incidence with the climatic factors remains inconclusive. To date, limited research has been conducted on how climatic factors influence the burden of ill health, particularly on dengue in the Philippines. This study investigates the influence of temperature and rainfall as primary climatic factors on dengue incidence in Metro Manila for the 10-y period from 1996 to 2005. This study intends to evaluate the influence of only temperature and rainfall on dengue incidence in Metro Manila so as to establish and provide a better understanding of the complex link between climate and health. This information can be valuable to health practitioners who develop effective measures for the improvement of public health.

MATERIALS AND METHODS

Metro Manila, also called the National Capital Region, was chosen as the study area. Metro Manila is comprised of 16 surrounding cities and municipalities. It is the seat of the country's political, economic, and sociocultural sectors. Metro Manila is bordered by the province of Bulacan to the north, Rizal to the east, and Cavite and Laguna to the south (Fig. 1).

Monthly dengue incidence (number of cases per 100 000 people) data for Metro Manila were collected over a 10-y period from 1996 to 2005 from the epidemiologic reports of the National Epidemiology Sentinel Surveillance System (NESSS) of the Department of Health (Manila, Philippines). Monthly climatic factors, particularly mean temperature and mean rainfall data, for Metro Manila for the same time period were collected from the Philippine Atmospheric, Geophysical, and Astronomical Services (PAGASA, Quezon City, Philippines). This study was dependent on the records obtained from these government institutions.

Temperature and rainfall were linked with dengue incidence through a multiple linear regression analysis. The model equation that was developed followed a regression relationship:

$$Y = \alpha + \beta X,$$

where Y is the dengue incidence, α is the intercept parameter, β is the slope parameter, and X is the monthly measurement of the climatic factors (temperature and rainfall). The developed linear model suggests that every increase in the climatic factors, no matter how small, results in an incremental increase in dengue incidence. This linear model assumed that dengue incidence is a function of temperature and rainfall measurements. The criterion used a fixed preset α (for entry set, $\alpha = 0.05$; for removal set, $\alpha = 0.10$). A stepwise regression procedure was used in building the model. The linear model was developed, and all statistical analyses were performed using SPSS software.

RESULTS

The details of the monthly mean rainfall measurements and dengue incidence in Metro Manila are presented in Figures 2 and 3, respectively. For the 10-y period (1996–2005), the dengue incidences for Metro Manila varied from 0.367 to 20.358; the highest incidence (2036 cases) occurred in September 1998. The monthly mean rainfall measurements varied from 0 to 1389.6 mm; the highest recorded measurement was in July 2002. The monthly mean temperature readings varied from 18.27°C to 30.63°C; the highest recorded temperature was in May 1998.

Figure 1. Map of the study area.

Significant differences were observed for the monthly rainfall measurements ($t = 3.885$, $p < 0.05$).

The predictive model equation plots dengue incidence (Y) *versus* rainfall (Xc) as follows:

$$Y = 2.117 + 0.004164X \quad (r^2 = 0.337, p < 0.05).$$

The r^2 value was 0.337, which indicates that 33.7% of the error is explained by the model. No significant correlation on temperature and dengue incidence was established ($p > 0.05$).

DISCUSSION

This was a retrospective study, and its scope was limited between dengue and its primary climatic factors, rainfall and temperature. This study depended on epidemiologic reports and climatic records obtained from government institutions for all of Metro Manila. It only determined the climatic factors that are correlated with dengue incidence in Metro Manila for the 10-y period from 1996 to 2005. Amarakoon et al. (7) suggest that both high rainfall and temperature create a favorable environment, enhancing mosquito breeding and dengue transmission rates. However, the results of the study indicate that of the climatic factors only rainfall plays an important role in the occurrence of dengue incidence in Metro Manila from 1996 to 2005 (Table 1). Results showed that high rainfall was correlated with the dengue incidence in Metro Manila. This is supported by Promprou, Jaroensutasinee, and Jaroensutasinee (8), who stated that high rainfall leads to more breeding sites of the vector, leading to an increase in dengue incidences; although it was also presented in Promprou, Jaroensutasinee, and Jaroensutasinee (8) that temperature played an important role in dengue incidence in Thailand, since changes in temperature affect the mosquito vector. No significant correlation between temperature and dengue incidence was apparent in this study. The periods of high incidence of dengue occurred at any point in the year during the 10-y period of 1996 to 2005 and did not appear to be associated with the mean monthly temperatures. The results of this study were likewise supported by Hay et al. (9), who asserted that there is not enough evidence to establish that temperature is associated with the incidence of dengue. Sheppard et al. (10) likewise support the results of this study, since they asserted that changes in the incidence of dengue were not correlated to temperature, since this does not affect the mosquito vector's biology, abundance, movement, and survival. It is likely that the existence of other factors, like the population becoming immune to the infection, the possible introduction of

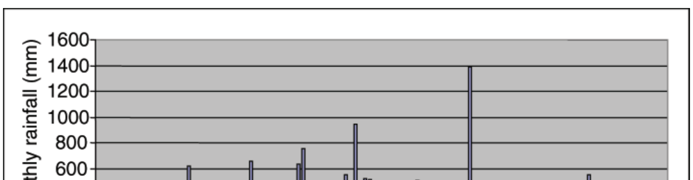

Figure 2. Mean monthly rainfall in metro Manila, 1996–2005.

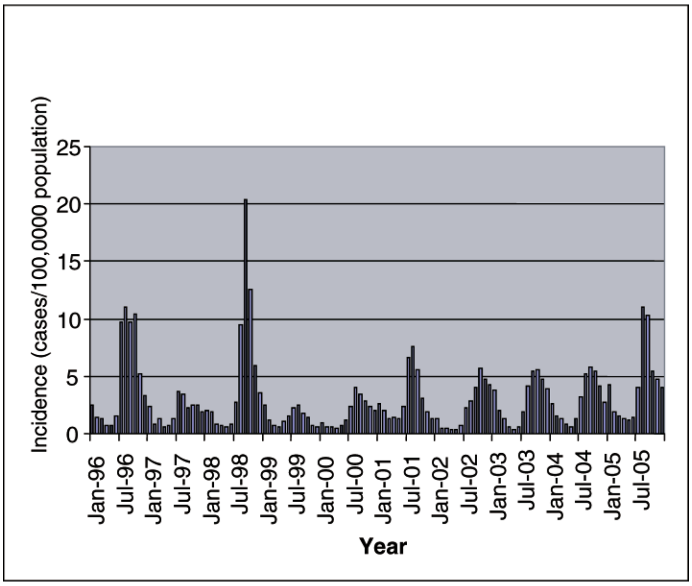

Figure 3. Dengue incidence in metro Manila, 1996–2005.

Table 1. Regression results of climatic factor influencing dengue incidence in Metro Manila (1996–2005).

	Linear model		
r^2		0.337	
Adj. r^2		0.113	
F test		15.092	
df		118	
p		0.000	
	Coefficient	*T*	p
Constant	2.117	5.916	0.000
Rainfall	4.614e−03	3.885	0.000

new serotypes, and the demographic factors could have influenced the transmission of dengue in the area (11).

CONCLUSION AND RECOMMENDATIONS

This study assessed the influence of temperature and rainfall as primary climatic factors on dengue incidence in Metro Manila from 1996 to 2005. Results showed that dengue incidence in Metro Manila is influenced by changing rainfall patterns. These changing rainfall patterns influence the life cycle of mosquitoes, since rain increases the existence of breeding sites of mosquitoes. Temperature was not significantly related to dengue incidence. This study suggests that surveillance and control of mosquitoes must be intensified during periods of high rainfall.

Disease surveillance and control of mosquitoes are necessary. Disease surveillance will enable public health practitioners to be aware of the intensity of dengue morbidity and the periods of increased dengue activity in their respective communities. The creation of diagnostic centers will facilitate surveillance, and these centers would provide early warning of the changes in incidence and would then yield for intervention. An integrated approach that combines environmental management, chemical control, and biological methods in the control of mosquitoes must likewise be implemented. Environmental management measures must focus on changing the environment such that it would prevent or minimize vector propagation or man–vector–pathogen contact. Chemical control measures must emphasize the use of nontoxic larvicides and insecticides, whereas biological control measures must emphasize the introduction of living organisms that will prey, parasitize, compete with, or reduce the abundance of the mosquitoes.

The complexity of issues arising from the human–environment linkages affecting the Philippine environment is an increasing concern, particularly in the climate and disease link. Considerable progress is required to facilitate our understanding on how changes in climate can influence the spread and development of infectious diseases. To do this effectively, future research must reflect the other important weather factors, like relative humidity, pressure, and wind movements, that can likewise influence the complex link of climate and diseases. Future longitudinal studies that will examine how these weather factors may affect dengue morbidity and mortality rates are also needed. The links between health and the changes in the society, the economic systems, and the environment and the conjunction of these factors remain unclear. There is a need to investigate and define these other possible factors, since these factors may significantly influence the occurrence of these infectious diseases and affect the public's long-term health and well being. More in depth studies are likewise needed in determining the prevalent dengue serotypes and the impact of climate change on the biology of the vectors responsible for the transmission of these infectious diseases.

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