Analysis of Climatic Factors and Recorded Clinical Cases of Dengue in Region IV-A CALABARZON

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ABSTRACT

Considered as a major public health concern, dengue is measured as a leading vector-borne viral disease transmitted by mosquitoes to humans. It is also an emerging disease. The drastic changes noted in the recent epidemiology of the disease are increasing morbidity-mortality and geographical factors. It currently threatens the world's population and remains a puzzling disease in many ways, such as the relationships between virus-vector and host-virus, and variability in clinical expression. The study sought to explain the trends in the country's dengue research specifically in Region IV-A. The researchers seek for different databases and identify published studies in the Philippines. In this research paper, the relationship between various climatic factors and the clinical cases of dengue in the Region IV-A CALABARZON from the year 2012-2018 was determined, where the disease is of major concern, to better understand the forms of dengue research and key findings and gaps. This study is a quantitative research design in a descriptive correlational method, and it covered the Region IV-A CALABARZON which consists of the provinces of Cavite, Laguna, Batangas, Rizal, and Quezon. The data used in this study were archived from the Department of Health (DOH) and Philippine Atmospheric, Geophysical, and Astronomical Services Administration-Department of Science and Technology (PAGASA-DOST). The findings suggest that there is an association between climatic factors and dengue cases in the provinces in the region on the gathered data from 2012 to 2018.

Keywords: *Dengue, climatic factors, clinical cases*

INTRODUCTION

Dengue is a disease that has undertaken significant development over the past millennium (Brady, Golding, Pigott, Kraemer, Messina, Reiner Jr., et al., 2014). On a global scale, it is a major public health concern (Shrivastava, Shrivastava, & Ramasamy, 2017) and the most significant vector-borne viral disease that is transmitted to humans by mosquitoes (Murray, Quam, & Wilder-Smith, 2013). The burden of this disease has an estimated 30-fold upturn over the past 5 decades (World Health Organization - South-East Asia [WHO-SEA], 2019). There is an obscure burden estimate; from 2010 to 2014, the World Health Organization (WHO) reported an upsurge from 2.4 million to over 3 million reported dengue cases from three affected areas in the globe which consists of the Americas, South-East Asia, and Western Pacific. Consequently, the WHO's 2012 Global Survey indicated an approximate total of 50-100 million infections annually (WHO, 2012). Due to this incident, dengue was categorized by the WHO as the 'most important mosquito-borne viral disease in the world' (WHO, 2012) because of substantial geographic spread of the virus and its vector into areas who are previously unaffected and the subsequent costly burden of disease it brings (Gubler, 2011) such as increased rate of morbidity and mortality.

Diaz-Quijano and Waldman (2012) conducted an ecological study exploring the factors that contribute to the dengue mortality burden. Association between dengue mortality in Latin America and the Caribbean and duration of the epidemic, rainfall, and population density were established (Diaz-Quijano et. al., 2012).

Currently, dengue is undoubtedly a worldwide concern; however, approximately 75% of the population globally that are at risk to dengue resides in Asia-Pacific countries (WHO, 2012). It is one of the most inflicting diseases in South-East Asia (SEA) and has been severely endemic for decades (Ooi &

Gubler, 2010). SEA is the area with the most elevated dengue rate, with a series of epidemics occurring every three to five years (Ooi et. al, 2010). Extreme dengue is endemic in most SEA nations, with paces of serious dengue being 18 times greater in this locale compared with the Americas (Shepard, Undurraga, & Halasa, 2013).

Within the local context, dengue is considered as an epidemic and considered one of existing infectious diseases in the Philippines (Department of Health [DOH], 2011). With the case fatality rate (CFR) of 0.55% or 3,195 deaths, the DOH reported 585, 324 dengue cases from the year 2008 to 2012. Among the 10 countries which are part of the Association of Southeast Asian Nations (ASEAN), the Philippines ranks fourth in the extent of dengue cases (Mateo, 2011).

Review of Literature

Factors affecting Dengue Cases

The increasing epidemic of dengue infections worldwide may be attributed to several factors. Climate change around the globe in recent years take an upturn on the risks to human health (Banwell, Rutherford, Mackey, Street, & Chu, 2018). It has a strong association on the transmission of dengue and its mosquito vector (Li, Lu, Liu, & Wu, 2018). Elevating temperatures and fluctuating precipitation are said to be the prime contributors to the upsurge of dengue epidemics in different regions of the world (Duarte, Diaz-Quijano, Batista, & Giatti, 2019).

Various studies have shown the effect of climate variability on the transmission of dengue epidemics. Temperature plays a major role in the distribution of dengue mosquitoes and their bite frequency and incubation period (Zameer, Ashraf, Mukhtar, & Ahmad, 2013). Varying climatic conditions can affect the Aedes mosquitoes – vector – and dengue virus through a series of processes (Morin, Comrie, & Ernst, 2013). Diurnal temperature range – the variation between a high temperature and a low temperature that occurs during the same day – is also a significant aspect for dengue spread by Ae. Aegypti (Lambrechts, Paaijmans, Fansiri, Carrington, Kramer, Thomas, & Scott, 2011).

Moreover, precipitation gives rise to habitats for the aquatic stages of the mosquito life cycle and have a strong influence on vector distribution (Morin et al., 2013). Regulation of the size, population, and behavior of Aedes can be associated with the effects of precipitation and evaporation on available water sources (Chien & Yu, 2014). In some areas, precipitation varies with La Niña and El Niño conditions, which affects mosquito distributions (Kolivras, 2010). Other climate variables, such as humidity and rate of evaporation affect vector competence, biting behavior, and adult mosquito survival, but have been given less focus (Campbell, Lin, Iamsirithaworn, & Scott, 2013).

Rising levels of precipitation and appropriate local temperature were the variables most strongly related with elevated dengue risk; in some regions, dengue is associated with humidity and vapor pressure (Bhatt, Gething, Brady, Messina, Farlow, Moyes, … & Myers, 2013, Estallo, Ludueña-Almeida, Introini, Zaidenberg & Almirón, 2015). Climatic changes resulting in increased temperature and rainfall may, therefore, be associated with increased dengue incidence and outbreak risk. Thus, environmental change and environmental risk factors and erratic preventive practices may also contribute to the growth of dengue cases in the country (Colón-González, Fezzi, Lake, & Hunter, 2013; Borja, 2010).

Theoretical Framework

This research study is grounded on the framework developed by Morin et. al. (2013). Each number in the figure corresponds to the associations between climate variables, vectors, and virus. Habitat accessibility for mosquito larvae is predominantly influenced by (1) temperature and (2) precipitation. Temperature is a major regulator of (3) mosquito development, (4) viral replication within infected mosquitoes, (5) mosquito survival, and (6) the reproductive behavior of mosquitoes. Habitat accessibility is needed for (7) survival and (8) mosquito reproduction. Mosquito propagation is amplified by (9) faster mosquito development, (10) and increased survival. Increased mosquito propagation (11) heightens the likelihood of spread by limiting the time for the virus to develop in the mosquito. Increased survival of the adult mosquito (13) intensifies the amount of viral replication.

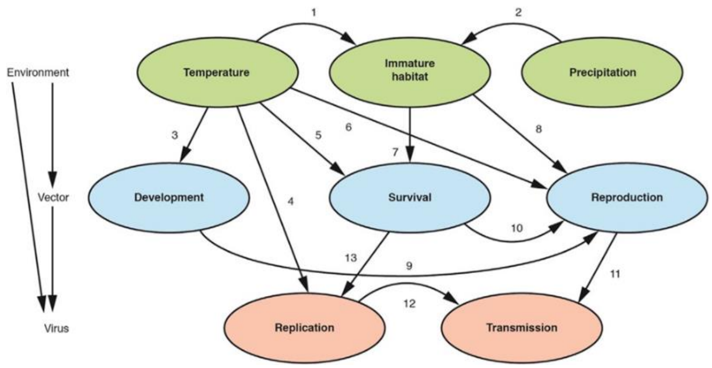

Figure 1. Biophysical Influences on Dengue Ecology by Morin et. al. (2013)

Objectives of the Study

This research study investigated the relationship between various climatic factors and the clinical cases of dengue in the Region IV-A CALABARZON from the year 2012 to 2018. Specifically, this research study (1) evaluated each climatic factor that may affect the number of clinical cases of dengue; (2) determined if there is a relationship between climatic factors such as total amount of rainfall, relative humidity, and mean minimum/maximum temperature, and clinical cases of dengue; and (3) offered possible concepts and plans of action on how to address the problem of dengue in the locale.

METHODOLOGY

This study is a quantitative research design in a descriptive correlational method describing the relationships among variables. This design was employed to investigate the relationship between climatic factors and recorded clinical cases of dengue in Region IV-A from the year 2012 to 2018. The study covered the provinces of Cavite, Laguna, Batangas, Rizal, and Quezon. The researchers have chosen this because there are no existing studies conducted in the area regarding dengue incidence and its association with climatic variables such as rainfall, humidity, and temperature. It has also been reported by the Department of Health (DOH) that most of the dengue cases were from Region III (14%), NCR (13%), Region IV-A (12%), and Region VII (10%) (DOH, 2018). Since Region IV-A is one of the primary contributors to the elevated dengue cases in the country, this is also the reason why the researchers choose this locale. This study employed an archival data collection. Data on recorded annual clinical cases of dengue for the past 7 years from 2012 to 2018 were collected from the Department of Health (DOH) website whereas data regarding climatic variables such as monthly rainfall, relative humidity, and mean minimum and maximum temperature was gathered from the office of Philippine Atmospheric, Geophysical, and Astronomical Services Administration-Department of Science and Technology (PAGASA-DOST) through email communication.

The researchers requested the data from the Freedom of Information (FOI) website offered by the government particularly from the Department of Health (DOH) and PAGASA-DOST. After a series of communication with the receiving officer, the request has been accepted and the researchers were directed to the specific department from which they acquired the data. The researchers filled out a form of request (Appendix A) for faster processing and signed the Terms and Conditions of handling the Climatological Data (Appendix B). The DOH sent the link of the website from which the researchers acquired the data for dengue cases whereas the PAGASA-DOST sent the needed climatological data through electronic mail. Gathered data were analyzed using the Pearson Correlation Coefficient. It is a statistical measure that analyzes the relationship, or association, between two continuous variables. It provides information about the magnitude of the association, or correlation, as well as the direction of the relationship – may it be positive or negative.

RESULTS AND DISCUSSIONS

Table 1 shows the number of reported cases of Dengue in Region IV-A CALABARZON from the year 2012-2018. After a sudden onset in the year 2014, the dengue cases in the region elevated the following year. The year 2015 holds the highest number of recorded clinical cases of dengue in the region with 36,033 reported cases. Conversely, the year 2014 bears the lowest reported dengue incidence with 151,111 recorded dengue cases.

Table 1. Dengue cases in Region IV-A CALABARZON from 2012-2018

Year	Number of Reported Dengue Cases
2012	29,843
2013	30,219
2014	15,111
2015	36,033
2016	24,589
2017	22,318
2018	25,705

Source: Department of Health (DOH) Epidemiology Bureau

Table 2 illustrates the annual total rainfall amount (mm) in the provinces of Cavite, Laguna, Batangas, Rizal, and Quezon from the year 2012-2018. The figures present the average annual total rainfall in CALABARZON showing variations each year. It achieved its peak average in the year 2013 having 3098.38 mm for the entire region and 1944.24 mm on the year 2015 demonstrating the lowest value.

Table 2. Annual total rainfall amount (mm) in CALABARZON

Year	Cavite	Laguna	Batangas	Rizal	Quezon	Average
2012	3667.0	2144.3	2476.2	3906.5	2746.9	2988.18
2013	3800.7	2438.7	2869.3	3036.1	3347.1	3098.38
2014	2099.2	2076.5	1905.1	2503.6	3118.3	2340.54
2015	1734.3	1793.2	1626.7	2207.4	2359.6	1944.24
2016	1989.2	1414.2**	1709.0	2645.8	3153.2	2374.3
2017	1937.6	2470.6	2215.9	2546.2	4143.9	2662.84
2018	2464.8	1803.7	2119.2	3093.0	2760.4	2448.22

Source: Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA-DOST), Climatology and Agrometeorology Division (CAD), Climate and Agrometeorological Data Section (CDS)
*Note: -2.0 means no data; T means trace; ** means annual values with missing months*

Table 3 indicates the percentage of relative humidity per year of different provinces in CALABARZON region with its corresponding average from the year 2012-2018. The numerical values gathered show that Cavite is the lowest contributor when it comes to annual relative humidity and Rizal being the highest in the whole region.

Table 3. Annual relative humidity (%) in CALABARZON

Year	Cavite	Laguna	Batangas	Rizal	Quezon	Average
2012	79	84	81	90	83	83.4
2013	79	83	81	88	83	82.8
2014	78	82	81	86	83	82
2015	79	80	80	88	82	81.8
2016	78	84	82	88	85	83.4
2017	77	86	83	89	88	84.6
2018	77	86	81	87	88	83.8

Source: Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA-DOST), Climatology and Agrometeorology Division (CAD), Climate and Agrometeorological Data Section (CDS)

Table 4 illustrates the annual minimum temperature (°C) in the provinces of Cavite, Laguna, Batangas, Rizal, and Quezon. Among the provinces, the Rizal province holds the lowest mean minimum temperature whereas the province of Cavite has the highest mean minimum temperature. In terms of years, the year 2016 recorded the peak mean minimum temperature with 23.66 °C in the region.

Table 4. Annual mean minimum temperature (°C) in CALABARZON

Year	Cavite	Laguna	Batangas	Rizal	Quezon	Average
2012	25.9	23.5	23.9	19.7	22.5	23.1
2013	26.0	23.5	23.9	19.9	22.1	23.08
2014	25.9	24.8	23.1	19.6	22.3	23.14
2015	26.1	24.1	23.2	20.0	22.7	23.22
2016	26.6	23.9	23.8	20.5	23.5	23.66
2017	26.6	23.9	23.7	19.4	22.7	23.26
2018	26.4	23.8	23.7	19.2	23.4	23.3

Source: Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA-DOST), Climatology and Agrometeorology Division (CAD), Climate and Agrometeorological Data Section (CDS)

Based on the data in Table 5 provided by PAGASA-DOST on the mean maximum temperature per year from 2012-2018 in the various provinces in Region IV-A, it shows that there is a positive-negative increase of 1% since the year 2012 to the year 2018. The average temperature annually is around 30 °C. Furthermore, the year 2016 indicates the warmest record in the whole region with a temperature of 30.88 °C.

Table 5. Annual mean maximum temperature (°C) in CALABARZON

Year	Cavite	Laguna	Batangas	Rizal	Quezon	Average
2012	25.9	23.5	23.9	19.7	22.5	23.1
2013	26.0	23.5	23.9	19.9	22.1	23.08
2014	25.9	24.8	23.1	19.6	22.3	23.14
2015	26.1	24.1	23.2	20.0	22.7	23.22
2016	26.6	23.9	23.8	20.5	23.5	23.66
2017	26.6	23.9	23.7	19.4	22.7	23.26
2018	26.4	23.8	23.7	19.2	23.4	23.3

Source: Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA-DOST), Climatology and Agrometeorology Division (CAD), Climate and Agrometeorological Data Section (CDS)

Table 6 shows the association between dengue cases and the total rainfall amount in Region IV-A CALABARZON. Out of all the provinces, Quezon holds a moderate association between dengue cases and total rainfall amount while Laguna, Batangas, and Rizal have the weakest association compared to other provinces. Conversely, the amount of rainfall in the province of Cavite has a weak association with dengue incidence. Several studies around the globe emphasized the influence made by climatic and ecological variables to the pervasiveness of both the vector A. aegypti and dengue virus (Karim, Munshi, Anwar, & Alam, 2012). It is aligned with the study of Costa and his colleagues (2010) that rainfall affects the prevalence of dengue in a certain area through elevating the frequency of mosquito habitats and sustaining the level of water in the newly created habitats. Furthermore, as indicated by Hii, Y. L., Zhu, H., Ng, N., Ng, L. C., and Rocklöv, J. (2012), rainfall has a critical effect on vectors and dengue viruses. The lag time among weather and dengue cases could be somewhat represented by the effect of climate conditions on the natural advancement of the mosquito vector including long egg hatching periods and high possibility of Aedes' eggs to endure waterless for several months.

Table 6. Association between dengue cases and total rainfall amount

Dengue Cases vs. Total Rainfall Amount	r	p-value	Interpretation
Cavite	.275	.550	Weak association
Laguna	-.091	.845	Very weak association
Batangas	.121	.796	Very weak association
Rizal	.157	.737	Very weak association
Quezon	-.516	.236	Moderate association

Legend: ±0.0 – No association; ±0.01 – ±0.20 - Very weak; ±0.21 – ±0.40 – Weak; ±0.41 – ±0.60 – Moderate; ±0.61 – ±0.80 – Strong; ±0.81 – ±0.99 - Very Strong; ±1.0 – Perfect association

Table 7 illustrates the relationship between dengue incidence and relative humidity in the CALABARZON region. Among the provinces, Cavite, Batangas, and Rizal resulted to have a moderate association between dengue cases and relative humidity. On the other hand, relative humidity in Laguna and Quezon displayed a weak relationship with the dengue cases in the region. It agrees with the study led by Alshehri & Saeed (2013). In their study, it has been found out that humidity promotes the transmission of dengue fever through influencing the activities and survival of the A. aegypti. Moreover, low humidity is the reason why mosquitoes feed more recurrently to make up for dehydration, whereas high relative humidity causes an intensification of the metabolic process in adult mosquitoes. Likewise, the findings of the study by Banu and his colleagues (2014) indicate that climatic factors specifically temperature and relative humidity were positively associated with the incidence of dengue.

Table 7. Association between dengue cases and relative humidity

Dengue Cases vs. Relative Humidity	r	p-value	Interpretation
Cavite	.606	.149	Moderate association
Laguna	-.346	.447	Weak association
Batangas	-.508	.245	Moderate association
Rizal	.505	.248	Moderate association
Quezon	-.355	.435	Weak association

Legend: ±0.0 – No association; ±0.01 – ±0.20 - Very weak; ±0.21 – ±0.40 – Weak; ±0.41 – ±0.60 – Moderate; ±0.61 – ±0.80 – Strong; ±0.81 – ±0.99 - Very Strong; ±1.0 – Perfect association

Table 8 shows if there is an association between dengue cases and mean minimum temperature in Region 4A-CALABARZON. Among these provinces, the province which resulted to have a strong association with dengue cases and mean minimum temperature is Laguna. Meanwhile, Cavite and Quezon show a very weak association. According to Gomes, Nobre, & Cruz (2012), dengue analyses must be centered around specific seasons or months of the year. Also, their study supports the results of this study as minimum temperature for seasons of the year hold especially strong relationship with dengue. Also, the results were consistent with the study of Alshehri & Saeed (2013) as auspicious temperature for mosquito cultivation may escalate the metabolic process of mosquito vectors causing an elevation in the biting rate, thus increasing egg production and mosquito propagation.

Table 8. Association between dengue cases and mean minimum temperature

Dengue Cases vs. Mean Minimum Temperature	r	p-value	Interpretation
Cavite	-.148	.751	Very weak association
Laguna	-.624	.135	Strong association
Batangas	.239	.606	Weak association
Rizal	.290	.528	Weak association
Quezon	-.017	.971	Very weak association

Legend: ±0.0 – No association; ±0.01 – ±0.20 - Very weak; ±0.21 – ±0.40 – Weak; ±0.41 – ±0.60 – Moderate; ±0.61 – ±0.80 – Strong; ±0.81 – ±0.99 - Very Strong; ±1.0 – Perfect association

Table 9 indicates the association between dengue cases and mean maximum temperature in different provinces of Region IV-A. There is a very weak association between the two variables in the provinces of Laguna and Rizal. A weak relationship between dengue incidence and mean maximum temperature in the provinces of Cavite, Batangas, and Quezon has been established. The results were coherent with the study of Choi and his colleagues (2016). Their findings suggest that dengue incidence has a weak correlation with maximum temperature in Banteay Meanchey in Cambodia. However, the results were supported by the study led by Chen and his associates (2010) as their findings proposed that higher temperature amplifies the transmission rate of dengue fever infection in southern Taiwan. Furthermore, it has been found out in the study of Lai (2018) that rising temperature majorly contributes to the spread of dengue fever. High-temperature seasons are significantly correlated with the incidence of dengue fever in southern Taiwan.

Table 9. Association between dengue cases and mean maximum temperature

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CONCLUSIONS

Varying climate conditions significantly affect the occurrence of dengue disease in a certain place. Each climatic variable – rainfall, humidity, minimum and maximum temperature – is associated with dengue incidence with varying degrees in the provinces of Cavite, Laguna, Batangas, Rizal, and Quezon. The findings suggest that the total rainfall amount in Quezon province is moderately related to the dengue cases in the whole region. More so, relative humidity in Cavite, Batangas, and Rizal province is moderately related to the disease as well. Furthermore, the minimum temperature in Laguna province is strongly associated with the elevated dengue cases in the region. Thus, these findings show that there exists an association between climatic factors and dengue incidence in the region based on the data from 2012 to 2018.

Since the relationship between climate variability and dengue incidence has been established, it is suggested that public health offices should strengthen their programs with regards to the spread of dengue diseases given the climatic conditions. Being mindful of the atmosphere in particular areas where there is an elevated case of dengue to get ready for the possible precipitation which might occupy the containers outside the house that can be served as the breeding site of the mosquitoes should be carried out. One way to forestall mosquito breeding and mitigate the increasing number of reported dengue incidence annually is to implement the 4S Strategy proposed by the Department of Health (DOH).

It is also recommended that an in-depth analysis of each climatic factor in specific areas within the region where a strong association was ascertained should be carried out. Relevant, refined, and detailed protocols should be developed for investigating climatic variables and dengue incidence to improve the quality of the research. Through these studies, epidemiologic contingency plans can be made by health offices in the region.

REFERENCES

Alshehri, M. S. A., & Saeed, M. (2013). Dengue fever outburst and its relationship with climatic factors. World Applied Sciences Journal, 22(4), 506-515.

Banu, S., Hu, W., Guo, Y., Hurst, C., & Tong, S. (2014). Projecting the impact of climate change on dengue transmission in Dhaka, Bangladesh. Environment international, 63, 137-142.

Banwell, N., Rutherford, S., Mackey, B., Street, R., & Chu, C. (2018). Commonalities between Disaster and Climate Change Risks for Health: A Theoretical Framework. International Journal of Environmental Research and Public Health, 15(3), 538. MDPI AG. Retrieved from http://dx.doi.org/10. 3390/ijerph15030538

Bhatt, S., Gething, P. W., Brady, O. J., Messina, J. P., Farlow, A. W., Moyes, C. L., ... & Myers, M. F. (2013). The global distribution and burden of dengue. Nature, 496(7446), 504.

Borja M,. (2010). Final Report of Burden of Dengue in the Philippines. Manila, Philippines: Department of Health.

Brady, O. J., Golding, N., Pigott, D. M., Kraemer, M. U., Messina, J. P., Reiner Jr, R. C., ... & Hay, S. I. (2014). Global temperature constraints on Aedes aegypti and Ae. albopictus persistence and competence for dengue virus transmission. Parasites & vectors, 7(1), 338.

Campbell, K. M., Lin, C. D., Iamsirithaworn, S., & Scott, T. W. (2013). The complex relationship between weather and dengue virus transmission in Thailand. The American journal of tropical medicine and hygiene, 89(6), 1066-1080.

Chen, S. C., Liao, C. M., Chio, C. P., Chou, H. H., You, S. H., & Cheng, Y. H. (2010). Lagged temperature effect with mosquito transmission potential explains dengue variability in southern Taiwan: insights from a statistical analysis. Science of the total environment, 408(19), 4069-4075.

Chien, L. C., & Yu, H. L. (2014). Impact of meteorological factors on the spatiotemporal patterns of dengue fever incidence. Environment international, 73, 46-56.

Colón-González, F. J., Fezzi, C., Lake, I. R., & Hunter, P. R. (2013). The effects of weather and climate change on dengue. PLoS neglected tropical diseases, 7(11), e2503.

Costa, E. Santos, E. and J. Correia. (2010). "Impact of small variations in temperature and humidity on the reproductive activity and survival of Aedes aegypti (Diptera, Culicidae)". Revista Brasileira de, Vol. 54 (3), pp. 488-493.

Department of Health. (2011). National Objectives for Health Philippines, 2011–2016: Health Sector Reform Agenda Monograph No. 12. Manila, Republic of the Philippines: Health Policy Development and Planning Bureau (HPDPB), Department of Health.

Department of Health. (2012). Disease Surveillance, Dengue Morbidity. Retrieved September 28, 2019 from http://dev1.doh.gov.ph/disease-surveillance.

Department of Health. (2018). Monthly Dengue Report. Report No. 12. Retrieved November 8, 2019 from https://www.doh.gov.ph/sites/default/files/ statistics/2018_Monthly_Dengue_Report%20_N12.pdf

Department of Health. (2019). Dengue Reports. Retrieved October 25, 2019 from

Díaz-Quijano, F. A., & Waldman, E. A. (2012). Factors associated with dengue mortality in Latin America and the Caribbean, 1995–2009: an ecological study. The American journal of tropical medicine and hygiene, 86(2), 328-334.

Duarte, J. L., Diaz-Quijano, F. A., Batista, A. C., & Giatti, L. L. (2019). Climatic variables associated with dengue incidence in a city of the Western Brazilian Amazon region. Revista da Sociedade Brasileira de Medicina Tropical, 52.

Estallo, E. L., Ludueña-Almeida, F. F., Introini, M. V., Zaidenberg, M., & Almirón, W. R. (2015). Weather variability associated with Aedes (Stegomyia) aegypti (Dengue vector) oviposition dynamics in Northwestern Argentina. PLoS One, 10(5), e0127820.

Gomes, A. F., Nobre, A. A., & Cruz, O. G. (2012). Temporal analysis of the relationship between dengue and meteorological variables in the city of Rio de Janeiro, Brazil, 2001-2009. Cadernos de Saúde Pública, 28(11), 2189-2197.

Gubler, D. J. (2011). Dengue, urbanization and globalization: the unholy trinity of the 21st century. Tropical medicine and health, 39(4SUPPLEMENT), S3-S11.

Hii, Y. L., Zhu, H., Ng, N., Ng, L. C., & Rocklöv, J. (2012). Forecast of dengue incidence using temperature and rainfall. PLoS neglected tropical diseases, 6(11), e1908.

Kolivras, K. N. (2010). Changes in dengue risk potential in Hawaii, USA, due to climate variability and change. Climate Research, 42(1), 1-11.

Lai, Y. H. (2018). The climatic factors affecting dengue fever outbreaks in southern Taiwan: an application of symbolic data analysis. Biomedical engineering online, 17(2), 148.

Lambrechts, L., Paaijmans, K. P., Fansiri, T., Carrington, L. B., Kramer, L. D., Thomas, M. B., & Scott, T. W. (2011). Impact of daily temperature fluctuations on dengue virus transmission by Aedes aegypti. Proceedings of the National Academy of Sciences, 108(18), 7460-7465.

Li, C., Lu, Y., Liu, J., & Wu, X. (2018). Climate change and dengue fever transmission in China: evidences and challenges. Science of the Total Environment, 622, 493-501.

Malenab, M. C. T., Espaldon, M. V. O., Lalican, N. M., Balangue, T. O., & Abucay, E. R. (2015). Analysis of climate variability and dengue occurrence in social-ecological systems: the case of Bay, Los Baños and Calamba in Laguna, the Philippines.

Mateo, IC., (2011). Philippines Ranks 4th in ASEAN-Wide Dengue Incidence. GMA News Online. Diliman, Quezon City, Philippines: GMA Network Inc.

Morin, C.W., Comrie, A.C., Ernst, K., (2013). Climate and dengue transmission: evidence and implications. Environ. Health Perspect. 121 (11–12), 1264–1272.

Murray, N. E. A., Quam, M. B., & Wilder-Smith, A. (2013). Epidemiology of dengue: past, present and future prospects. Clinical epidemiology, 5, 299.

Ooi, E. E., & Gubler, D. J. (2010). Dengue in Southeast Asia: epidemiological characteristics and strategic challenges in disease prevention. Cadernos de saude publica, 25, S115-S124.

Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA-DOST), Climatology and Agrometeorology Division (CAD), Climate and Agrometeorological Data Section (CDS).

Shepard, D. S., Undurraga, E. A., & Halasa, Y. A. (2013). Economic and disease burden of dengue in Southeast Asia. PLoS neglected tropical diseases, 7(2), e2055.

Shrivastava, S.R.; Shrivastava, P.S.; & Ramasamy, J. (2017)(. Taking major strides in dengue vaccine research: World Health Organization. Ann. Trop. Med. Public Health 2017, 10, 743.

Wiwanitkit, V. (2006). An observation on correlation between rainfall and the prevalence of clinical cases of dengue in Thailand. Journal of vector borne diseases, 43(2), 73.

World Health Organization – South-East Asia. (2019). Dengue. Neglected Tropical Diseases. World Health Organization-Southeast Asia. Retrieved from http://www.searo.who.int/entity/vector_borne_tropical_diseases/data/data_factsheet/en/ (28 September 2019)

World Health Organization. (2012). Global strategy for dengue prevention and control 2012-2020.

Zameer, M., Ashraf, A., Mukhtar, N., & Ahmad, B. M. (2013). Knowledge, attitudes and practices study of dengue viral infection and its association with environmental factors and health issues, Lahore Pakistan. African Journal of Environmental Scienceand Technology, 7(7), 711-717.