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RESEARCH ARTICLE

Relationship between chikungunya virus prevalence, rainfall, and urbanization in the Philippines

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ABSTRACT

Background: The Chikungunya virus (CHIKV) is regarded as a new virus even though it has infected people in the Philippines since the 1960’s and has been instigating sporadic outbreaks since. This virus is commonly mistaken for dengue due to similarities in symptoms since they do share similar vectors of transmission, the *Aedes aegypti* and *Aedes albopictus* mosquitoes. **Aims and Objectives:** This study is done to determine the prevalence rates of CHIKV in each region of the Philippines and to determine if rainfall and urbanization play a key role in prevalence, as some studies on dengue may suggest. **Materials and Methods:** CHIKV data were obtained from the National Epidemiological Center of the Department of Health, 2010 regional levels of urbanization from the National Statistics Office official website and rainfall data from the Philippine Atmospheric, Geophysical and Astronomical Services Administration. The collected data were analyzed using STATA v.12. **Results:** Results show that nationwide prevalence of CHIKV from January to July of 2012 and 2013 increased by 38.62%. No linear relationship was established between prevalence rates and rainfall per region as well as the level of urbanization. The highest prevalence rates were obtained from regions V, X, and XI for 2012 while regions IV-B, VI, and CARAGA had the highest prevalence for 2013. ARMM had no confirmed cases reported for both years. **Conclusion:** There is no correlation between the amount of rainfall and urbanization in the prevalence of CHIKV in the Philippines during the period studied.

KEY WORDS: Chikungunya; Prevalence; Rainfall; Urbanization

INTRODUCTION

Chikungunya, similar to dengue, is an arthropod-borne viral disease transmitted by mosquitoes. This alphavirus of the Togaviridae family was first described in 1952 after an outbreak in Tanzania.[1] This oddly termed virus owes its name to the African Kimakonde language which means “to walk bent over” due to joint pains associated with the disease - a major distinguishing factor from the dengue virus[2] and is sometimes known as the Buggy Creek Virus.[3] This virus, compared to dengue, is a re-emerging disease that has been raising the alarm in the Philippines, particularly, since arboviral infections like these are extensive in tropical areas. Even though it has been creating sporadic outbreaks in the country since the 1960’s, only in 2012 have there been official reports of Chikungunya virus (CHIKV) infection in the Philippines, according to the National Epidemiological Center (NEC) of the Department of Health. Hence, not much is known on CHIKV’s behavior and epidemiology in the country. According to Pulmanausahakul *et al.*,[4] there have been cases of the CHIKV here in the Philippines as early as the late 1960’s. In 1968, Macasaet[5] conducted and published a study of the virus in Dumaguete City. In 1996, there was again an outbreak of the CHIKV in an agricultural village in Indang, Province of Cavite.[6] CHIKV outbreaks are not new to the Philippines; however, very little efforts have

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been made to document and record data regarding infections in the country. The NEC of the Department of Health has records of the outbreaks that occurred recently (from 2012 to 2013). They have said that no routine surveillance reports were done on CHIKV as much as that for dengue outbreaks, leptospirosis, and other recurring diseases. Hence, not much is known regarding its prevalence, which will be helpful in assessing CHIKV's impact. Incidence only takes into account new cases. Prevalence, however, includes both new and old which makes it the assessment method of choice.

Studies have shown that three lineages of the CHIKV are circulating, two are of African origin, and one is the Asian genotype.[4] Outbreaks occurred sporadically in Africa from the 1950's to 1970's and in Asian countries, specifically the Philippines, from late 1950's to 1960, 1985,[7] and 1996.[4] The Pacific Ocean islands had their share of CHIKV outbreaks in 2003.[8] The virus later had a great turning point when it hit the La Reunion Island in France on 2005–2006 claiming 237 lives.[9] The culprit for said outbreak due to a mutation in the virus, resulting in "enhanced infectivity" and increased transmissibility by *Aedes aegypti* and *Aedes albopictus*,[4] an extremely resilient and persistent day-and-night biter acclimated to both tropical and temperate environments.[10] *A. albopictus* is solely responsible for the 2006 outbreak in Italy.[7] More recently, hundreds of cases were recorded all throughout the Philippine archipelago between 2012 and 2013.[11] An odd quiescence period is noticeable in between outbreaks. The reason for which is yet to be known.[12] In the Philippines, and other neighboring countries, there have been notable "silent" periods varying from 7 years to 32 years. This results into a "immunologically naïve population" which may result in massive outbreaks.[10]

Environmental factors such as increased rainfall and humidity also contributed to the rise in outbreaks. The Department of Health, in fact, mentioned that they observed that the virus spread in Mindanao after typhoon Sendong hit the region in 2011, a characteristic usually observed in other parts of the world where Chikungunya fever emerges after heavy rains.[13] Based on a study done by Day and Shaman,[14] rainfall affects the life and behavior of mosquito vectors in various ways. During months of intense precipitation, ovipositor sites for the mosquitoes are increased. Majority of CHIKV cases are often recorded during the monsoon and post-monsoon seasons.[15,16] The risk of desiccation, on the other hand, is decreased by the surface humidity. Thus, their flight range and longevity is improved.[14] Urbanization goes hand in hand with rainfall. Urbanization instigates usage of water drums for storage, pots and old tires scattered around and other old containers which may serve as breeding sites when filled with water.[17] According to Resolution No. 9 issued on October 23, 2003, a barangay area is considered urban if the following criteria are met: (1) If a barangay has a proportion size of 5000 or more. (2) If a barangay has at least one establishment with a minimum of 100 employees, and (3) if a barangay has 5 or more establishments with a minimum of 10 employees and 5 or more facilities within the 2-km radius from the barangay hall. High-density population, even if mosquito index is low, exposes them to threats posed by mosquitoes such as CHIKV and dengue.[18]

The objective of the study is to determine the prevalence of the CHIKV in the Philippines for the past 2 years. Specifically to determine regions in the Philippines where the virus is more prevalent, determine if urbanization has an effect on CHIKV prevalence, and determine if rainfall has an effect on the prevalence of CHIKV in the Philippines. Since there are scarce researches on CHIKV, specifically in the Philippines, this paper research was conducted to fill in the gap in the hopes to establish an understanding of the epidemiological dynamics of the virus and its infectivity.

MATERIALS AND METHODS

This study used data collected by the NEC of the Department of Health in the Philippines. Auxiliary data were also obtained from the National Statistical Coordination Board (NCSB) and the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) official websites.

The records given included an overview of the CHIKV (symptoms and clinical features), confirmed chikungunya fever cases by month for 2012 and 2013 (as of July), confirmed chikungunya cases and deaths by region for 2012 and 2013 (as of July), and confirmed chikungunya cases by age group and gender for 2013 (as of July) presented in graphs.

Population size of the Philippines by region was obtained from the official website of the NCSB whereas the regional levels of urbanization and rainfall were retrieved from the National Statistics Office's and PAGASA's official website.

The regional confirmed cases (2012 and the first half of 2013) data from the NEC were re-grouped using STATA version 12 to better understand the degree of increase or drop in the number of Chikungunya cases each region experienced. The same data were also used to determine the prevalence of the disease per 100,000 people in the region. To calculate for regional prevalence, the following formula is used: Prevalence = (number of chikungunya cases per region/total population per region) *100,000.

RESULTS

The number of chikungunya cases for the year of 2012 amounted to 777. As of July of 2013, the partial count of confirmed chikungunya cases was 562. There are also more regions that have experienced an increase in CHIKV infections in a span of a year and a half compared to those who had a decrease (indicated by a negative percent) in the number of cases. Only ARMM was spared from the CHIKV infection for both 2012 and 2013. The prevalence for 2012 was 0.61, and it increased by 37% to 0.84 for 2013 (until July). The highest prevalence rates computed for 2012 belonged to Region XI (2.82), Region V (1.46), and Region X (1.26). For 2013, the top three were Region VI (2.46), Region IV-B (2.40), and the CARAGA Region (1.85). Once again, there was a notable increase in prevalence rates from 2012 to 2013 [Figure 1] along with the confirmed number of CHIKV infected individuals per region [Figure 2].

Figure 3 shows the monthly tally of confirmed cases for 2012 and 2013 (until July) shown in columns and the amount of rainfall for each month. For 2012, CHIKV cases increased as the months progressed. It was in October when the Department of Health recorded the highest number of confirmed cases (157). This jump in the number of CHIKV cases recorded followed months of heavy rain (June to July). The same pattern can be said for 2013 wherein after relatively intense rainfall (May to June), a dramatic increase in the number of CHIKV cases (259) was recorded during the month of July [Figures 3 and 4].

Nearly 71.7% of all CHIKV cases for 2012 were recorded from June to October of 2012 while for 2013, 50.45% of the CHIKV cases were recorded during June to July. During the same period, the highest levels of precipitation (in mm) were also noted (monsoon season). A scatter plot was done for 2012 and 2013, shown in Figures 5 and 6, respectively, to see if there is a linear relationship between the amount of rainfall and the CHIKV cases. Both plots show positive, although poor robustness, in correlation. An R^2 value of 0.1587 was obtained for 2012 with $P > 0.05$ whereas for 2013, the R^2 value was 0.6112 with $P > 0.05$. The p-value obtained for 2012 suggests that the positive correlation between rainfall and the number of CHIKV cases is not significant and due to chance. For 2013, however, P value suggests that the positive correlation between rainfall and the number of CHIKV cases is significant.

The correlation analysis done on the three sets of pooled data showed poor correlation between the level of urbanization and CHIKV prevalence in 2012 ($R^2 = 0.04$, $P > 0.05$) and

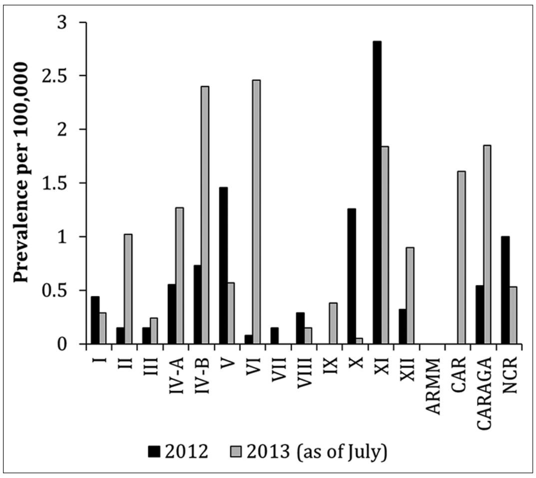

Figure 1: Regional prevalence for the year 2012 versus 2013 in the Philippines

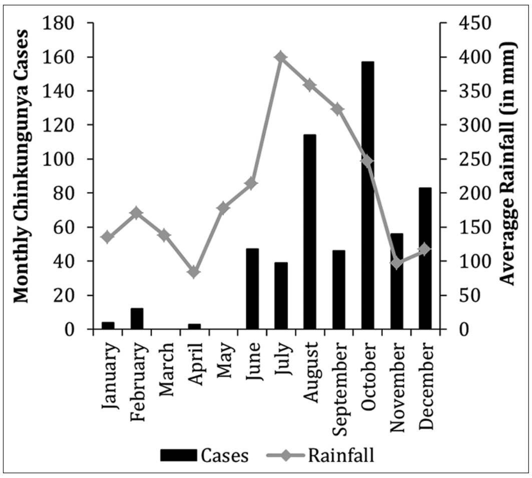

Figure 3: Monthly count of chikungunya cases versus the average amount of rainfall for 2012

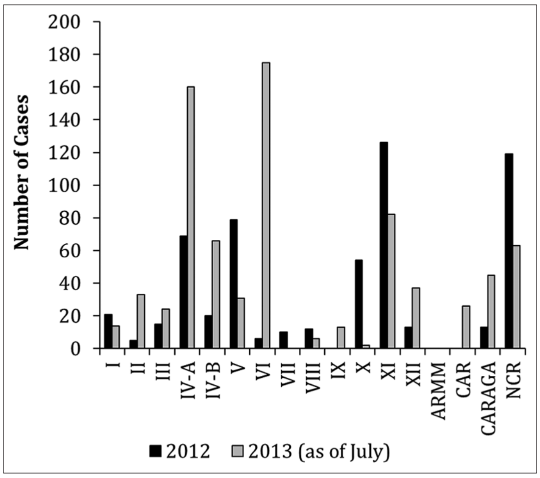

Figure 2: Regional Chikungunya cases for the year 2012 versus 2013 in the Philippines

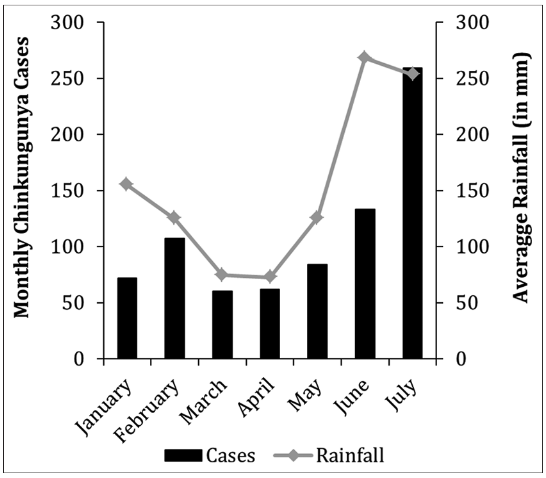

Figure 4: Monthly count of chikungunya cases versus the average amount of rainfall for 2013

2013 as of July (R^2 = 0.00, P > 0.05). The above data are graphed [Figure 6] on a scatter plot to further see the trend of prevalence in areas urban and rural. Based on literature, urbanized areas are breeding grounds for vector-borne diseases the likes of CHIKV and dengue. Given that in National Capital Region (NCR) is 100% urban; one might expect to have more cases of CHIKV. However, this is not the case in this study. In fact, if one refers to Figure 7, prevalence rates in NCR for both years are relatively smaller compared to those of the less urbanized regions. Bicol region was only 15.3% urban, yet it garnered a prevalence of 1.46/100,000 individuals in 2012. The Western Visayas, MIMAROPA, and CARAGA regions were only 34.7%, 22.3%, and 27.5% urban but had prevalence rates of 2.46, 2.40, and 1.85, respectively.

DISCUSSION

Data gathered from the NEC of the Department of Health suggests that, demographically, 68.9% of the 777 confirmed cases of CHIKV in the Philippines during 2012 were that of women. This finding is in concurrence with the results of a study done by Barve *et al.*[19] in Western India, Ditsuwan *et al.*[15] in Southern Thailand, Bhagwati *et al.*[20] in Rajkot District, India, and Balasubramaniam *et al.*[21] in Chennai, India. One possible reason as to why more women are more affected is that the former remain at home more often as compared to men.[21] Furthermore, adults were more affected a common finding in other studies done on Chikungunya. More than half of the total cases of CHIKV were noted from individuals aged 21 and over and 18.8% belonging to the 31–40 years age group. Kumar *et al.*[22] attributed the increased susceptibility of adults to the "movement of people outdoors" when vector activity is at its peak (daytime) and to the variations in people's immune response. It has been shown that the two mosquito vectors, *A. aegypti* and *A. albopictus* inhabit urban areas and rural settings, respectively.[10,20] The latter, however, has been able to adapt to the urban setting as well. Thus, one might expect to have more infections in urban areas, where populations are dense, and people live in close proximity.

For additional comparison, nationwide prevalence rates were computed. Cases of CHIKV from January to December 2012 and January to July 2013 were divided by the total population (92,335,113). The prevalence for 2013 is 38.62% higher compared with 2012. Hence, we can clearly say that prevalence rate of CHIKV increased substantially. Possible explanations as to why this is so could possibly be increased awareness and deeper understanding of the virus as the outbreaks emerge and/or added techniques in differential diagnosis from diseases of similar nature.

According to some studies mentioned by Wiwanitkit,[23] the prevalence of Dengue virus has a positive correlation with the degree of rainfall experienced since it greatly influences the spread of vector mosquitoes. These vectors, which are of the *Aedes* species, are similar to those of the CHIKV. During pre-monsoon season, mosquitoes breed[24] and on the arrival of heavy rainfall, ovipositor sites increase. Moreover,

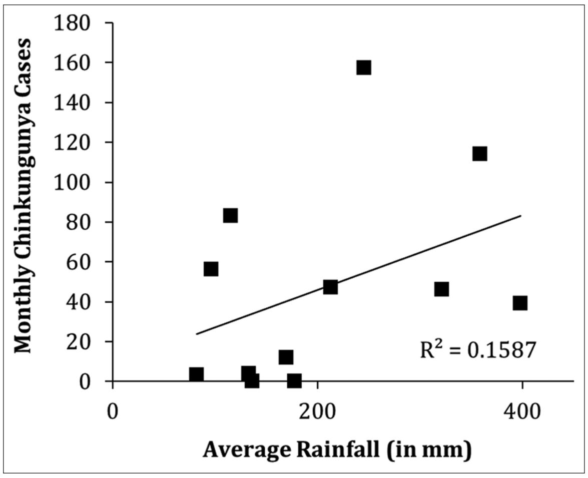

Figure 5: Scatter plot showing the monthly number of Chikungunya cases reported and average rainfall (in mm) for the year 2012

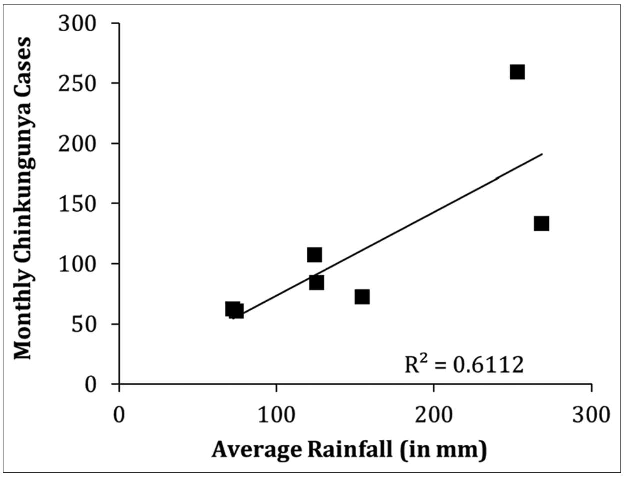

Figure 6: Scatter plot showing the monthly number of Chikungunya cases reported and average rainfall (in mm) for the year 2013.

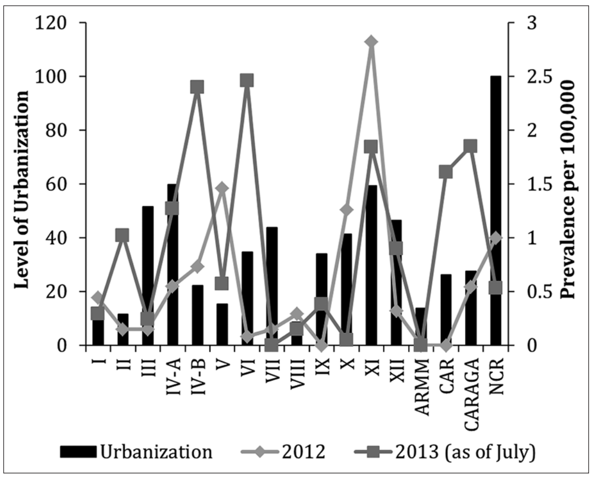

Figure 7: Scatter plot for levels of urbanization with respect to prevalence rates for 2012 and 2013 (as of July)

rainfall accompanied by surface humidity increases the flight range of blood-parched mosquitoes by reducing the risk of desiccation.[14]

The findings in the paper contradict to the notion that urbanization, which technically means highly dense populations, creates a feeding buffet for the vector mosquitoes and consequently increase virus transmission.[18] A possible explanation for high rural prevalence can be deduced from the nature of the vectors *A. aegypti* and *A. albopictus*. The former is well adapted to urban environments while the latter inhabits areas with vegetation. In addition, *A. albopictus* eggs are very resilient to changes in temperature which makes them viable even if its cold or dry. *A. albopictus* is also known to bite during night and day and is more aggressive, quiet, long-lived compared to *A. aegypti*.[25] One could then presume that the persistence of CHIKV infections in rural areas may be due to this mosquito. Even in the absence of dense populations, believed to be a major contributory factor in outbreaks, *A. albopictus* still proves to be effective in CHIKV transmission. As evidenced by the correlation coefficients obtained, the degree of urbanization in the specific region did not reflect its CHIKV prevalence for both years.

Based on the author's understanding, this is the first report to establish different factors that may have an affect on the prevalence of chikungunya in the Philippines. Moreover, it is expected that more reports will be sent to the Department of Health for a better understanding of the virus.

CONCLUSION

The prevalence of the CHIKV was assessed in this research. Included only in this paper are the cases for 2012 until July of 2013 due to the lack of records prior. It was found that during both years, the region that had the highest prevalence for 2012 were regions V, X, and XI while regions IV-B, VI, and CARAGA had the highest prevalence for 2013. Although there have been studies done on dengue which show strong correlation between rainfall and dengue prevalence, this finding only parallels the results of the regression analysis done on data from January to July of 2013. Results suggest that 61.12 % of the variance in the number of CHIKV cases is explained by the variance in the amount of rainfall. No correlation between the amount of rainfall experienced in a specific region and their respective prevalence rates has been established for January–December 2013. Regarding the demographics of CHIKV infection in the Philippines for January to July 2013, one could infer from this study that women comprise 68.9% of the 777 positively diagnosed with CHIKV which is possibly due to domesticity. Even though multiple publications have shown the presence and proliferation of the vectors of CHIKV, the *Aedes* mosquitoes in urban, suburban, and rural areas, this study has concluded that the degree of urbanization is not necessarily indicative of the prevalence of CHIKV in an area. There has also been an increase in prevalence in a span of a year (38.62%). Further studies should be done to further figure out specific factors (e.g., humidity, temperature, and population density) which may shed more light on the prevalence of the Chikungunya disease. It will also be beneficial to conduct an entomological study to determine the distribution of vector mosquitoes followed by insecticide spraying.

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