GEOGRAPHIC INFORMATION SYSTEM OF DENGUE FEVER: A CASE STUDY IN THE PHILIPPINES

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ABSTRACT—

Philippines have been dealing with dengue fever outbreak over the past decades. The Department of Health (DOH) recorded 146,062 cases of dengue fever from January through July 2019 twice more than the same period in the previous year. This outbreak has been an alarming issue not only to the World Health Organization (WHO) but also in local community like the Philippines. Since dengue fever is an alarming health concern, there is a need to develop a mapping model that could trace the occurrences of past and present dengue fever cases. The application of Geographic Information System (GIS) serves the purpose. It will be a reliable source in creating effective health campaign and activities in the local community. The GIS will also cause policy implementation in the eradication of dengue fever, in the same manner, it will cause health fund and resources allocation either from the government or non-government agencies. Along this trend the application of GIS in this particular study is very timely.

Keywords- Dengue, Geographical Information System, Dengue Fever analysis, Demographic data

I. INTRODUCTION

Dengue Fever (DF) has been an alarming epidemic that has been impacting human health. According to the World Health Organization (WHO), dengue fever is the most serious and fastest-growing mosquito-borne illness in the world. It has recorded a 30-fold rise in global occurrence in the last 50 years. It is believed that there are 50 million dengue infections and if remained uncontrolled, more will suffer from this illness. Dengue fever is triggered by a virus spread by Aede aegypti and Aedes Albopictus female mosquitoes that eat indoors and outdoors during daytime. WHO recorded large number of dengue cases in Asia as registered in Bangladesh (101,000), Malaysia (131,000), Philippines (420,000) and Vietnam (320,000). These data prove that Philippines has increasing growth cases of dengue fever. According to the Department of Health (DOH) in 2017 among the regions in the Philippines, Region 3 (Central Luzon) recorded 16% of the total of 152,224, which is the 2nd highest dengue case next to National Capital Region (NCR). In 2018 Region 3 topped with a 23% increase and garnered 14% of the total dengue cases at 216,190.

The province of Nueva Ecija has a huge jump with 100% increase in dengue cases, which is alarmingly thrice the number of incidences in 2017. Records from the Nueva Ecija Provincial Health Office showed that a total of 1,989 cases have been recorded as of August 7, 2018 against the 968 cases in 2017, which showed an increase of 105.48%. Among the reported patients infected with dengue fever in Nueva Ecija, Cabanatuan City which is the center of trade and education, has recorded the highest number of dengue cases. [1] Certainly, dengue has become a major national health issue in the Philippines, where Cabanatuan City has the greatest number of dengue infection in Central Luzon in 2018 with a 100% increase compared to 2017 data. [2]

WHO classified dengue fever into 2-major categories: dengue (with/without warning signs and severe dengue). The dengue sub classification, with or without warning signals, is intended for medical professionals to arrange patients for hospital entry, maintaining careful monitoring in order to reduce the likelihood of contracting more severe dengue. Dengue fever and the more serious variant, dengue hemorrhagic fever (DHF), was triggered by either of the four dengue virus serotypes (types 1, 2, 3 and 4). With four distinct dengue virus serotypes that may cause the disease, the vaccine must be immunized to all four varieties in order to be effective. Vaccination against only one serotype could possibly lead to severe DHS when infected with another serotype due to Antibody-Dependent Enhancement. [3]

II. LITERATURE REVIEW

GIS Technology

The first geography rule of Waldo Tobler, Everything is related with everything else. But near-by things are more connected than distant things, how data drawn would result in a strongly suggested result if grouped. [4]

According to J. Duncombe et.al, the advanced development in GIS technologies will significantly contribute to the prevention and management in dengue. [5]

According to Zaidi and Tariq, In order to study the pattern of dengue distribution, the GIS can be used as an efficient tool for managing and analyzing spatial and temporal data and for establishing their relationship between study parameters. GIS is used in many parts of the world to monitor and mitigate epidemics and to make rapid mapping of risk-prone areas.

Dengue fever can be transmitted to humans through bites of infected mosquitoes, Aedes Aegypti (yellow fever

mosquito) and Aedes Albopictus (Asian tiger mosquito). The Aedes Aegypti mosquito has a silver lyre shaped marking on its dorsal surface with white banded legs. It harbors in large urban areas with or without plant areas, whereby it bites, rests and lay eggs mainly indoors and outdoors. The Aedes Aegypti mosquito is a sneaky biter and has a high preference for biting humans rather than feeding the blood of domestic mammals, making the dengue virus easily accessible. It is considered the main dengue vector in the world. While Aedes Albopictus mosquito has a single longitudinal silvery dorsal strip and white banded legs. Its habitat is associated with thickets and arboreal vegetation. It is mostly an outdoor garden mosquito. Aedes Albopictus mosquito is an aggressive biter. They bite humans and also a variety of domestic and wild vertebrates making them the secondary dengue vector thus reduce their ability to transmit the virus. "Main production of mosquito usually takes place in human-made containers, tree holes, and bamboo internodes holding water," as stated by the Center for Disease Control and Prevention. [6]

According to D, Hosangadi, "Dengue is prevalent mostly in the world's urban and semi-urban tropical or subtropical zones." [7] This means that it is frequently available case in that specific area. According to Bilal Tariq, Dengue mosquito-borne disease is becoming a serious public health problem worldwide, especially in tropical and subtropical areas, and dengue fever is among the main mosquito-borne diseases in addition to malaria. [8]

Geographic Information System Data

The Geographic Information system Data Epidemic Intelligence Service (Foster, Adams, Dunn and Dent) states that "Standard mapping techniques will produce informative visualizations and provide orientation for studying the location, the physical attributes of the investigation area, and descriptive characteristics of the population(s) of interest." [9]

III. OBJECTIVE

While the use of GIS which can be utilized by the City Health Office in Cabanatuan, it will help to monitor cases of dengue fever in hotspot areas in the city mainly for developing more efficient health policies and possible intervention either to prevent or limit the number of dengue cases in Cabanatuan. Likewise, this study will characterize demographic data of people affected by Dengue Fever.

IV. METHODS

Evolving technologies and data analytics in the Philippines could theoretically open up possibilities for the creation of advanced digital monitoring systems and evolving predictive models for early indications of dengue outbreaks and the geographic spread of dengue cases and associated factors for a more oriented dengue preventive system and improved allocation of health resources for dengue patients.

a. Site of Study

Figure 1 showing the map of Nueva Ecija with Cabanatuan City as the capital. It is a first class city in the

Figure 1. Map of Nueva Ecija with Cabanatuan City shown at the center [16]

province of Nueva Ecija, Philippines. As of the 2015 census, it has a population of 302,231 making it Nueva Ecija's most populated city and Central Luzon's fifth-most populous city.

Untvweb.com reported that a total of 1,538 cases of dengue infection was recorded in Nueva Ecija from January to July 2018. The figure almost triple the number of cases during the same period in 2017 which recorded 566 cases [10]. The Provincial Health Office expressed concerns of rapid rise of dengue infection. Most of the cases were recorded in Cabanatuan City with 307 cases. Cabanatuan City, the center of trade and education in Nueva Ecija, reported the highest number of dengue cases in Region 3 in 2018. [1]

b. Data Source

Data gathered on weekly Dengue Fever (DF) cases from January 2017 to December 2018 were obtained from Cabanatuan City Health Office sourced from the 89 barangays in Cabanatuan City. Barangay is the smallest government administrative unit in the Philippines. It also includes the demographic data of DF infection categorized by gender, age group, and the Disease Reporting Unit (DRU). The DRU Category may either be a hospital or City Health Office/Officer (CHO) or Rural Health Unit (RHU) where DF infected were admitted.

c. Data Models in GIS

Computers need clear instruction to convert the data on the spatial Features in graphical representations. Computer

based system can manage and display spatial data in two

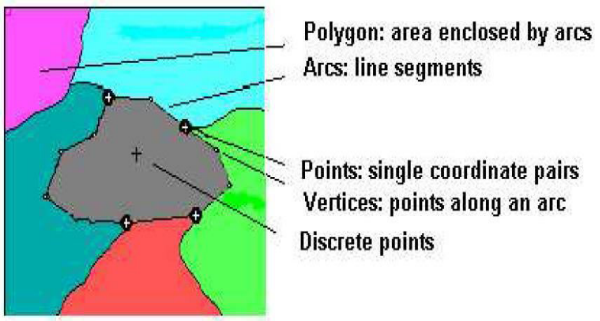

Figure 2. Example of Vector Data in GIS [11]

major methods; these are raster and vector approaches. An example of vector data is shown in figure 2.

d. Statistical Analysis of Data

Spatial data were tested and analyzed using GIS software. The positions of barangays were translated to two dimensional coordinates using a map projection, its latitude and longitude decimal coordinates. The data were stored in the data analytic software of the City Health Office.

ArcMap (also known as ArcGIS Desktop) is an Esri GIS software. ArcMap is a full-fledged GIS desktop. It reads and writes a number of geospatial data formats, provides a wide range of processing and analytical tools, and can be used to create detailed maps. ArcMap has been around for two decades and it is slowly being phased out by Esri in favor of ArcGIS Pro. [12] ArcMap is used to create the map that connects the dengue cases in 2017 and in 2018 in the City of Cabanatuan where it was joined via the geodata code of their shapefile from the philgis.org website.

V. RESULTS AND DISCUSSION

Dengue has been a very important public health problem in the Philippine. Just recently there had been a report of 8 deaths in Nueva Ecija. Two each in San Jose City and Pantabangan, one each in Cabanatuan City, Gapan City, Cabiao and Gabaldon. The growing dengue cases with 1,576 as of July 10, 2020 Cabanatuan City had the most number with 171. [13]

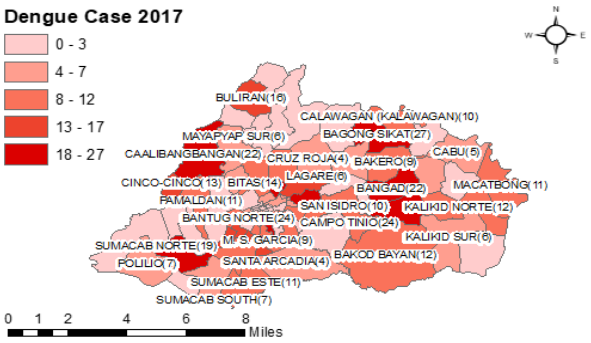

Figure 3. Spatial Distribution of Dengue Fever Cases per Barangay in 2017

The figure shows that barangay Bagong Sikat has the greatest number of Dengue Fever (DF) cases at an exactly 27 count in Cabanatuan during 2017.

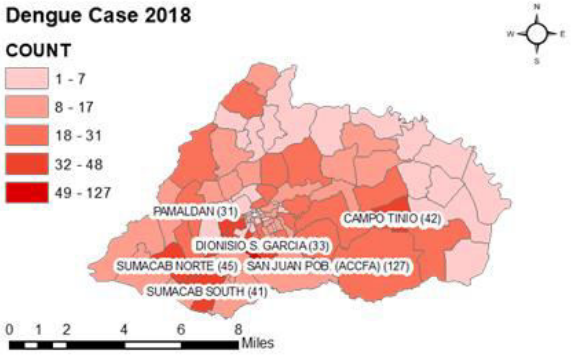

Figure 4. Spatial Distribution of Dengue Fever Cases per Barangay in 2018

Figure 4 shows that San Juan Pob. (ACCFA) has the greatest number of Dengue Fever (DF) at 127 cases in Cabanatuan year 2018.

On 22nd August 2018, the Epidemiology Bureau (EB) of the Department of Health received an Event-based Surveillance and Response (ESR) report on Dengue Outbreak in 36 cases in Barangay San Juan ACCFA, Cabanatuan City, Nueva Ecija. On 3rd September of the same year, the Field Epidemiology Training Program (FETP) team was sent to the area with the following objectives: 1) to verify the diagnosis; 2) to determine the existence of an outbreak; 3) to identify the source and mode of transmission; 4) to identify risk factors; and 5) to recommend control and preventive measures. [14]

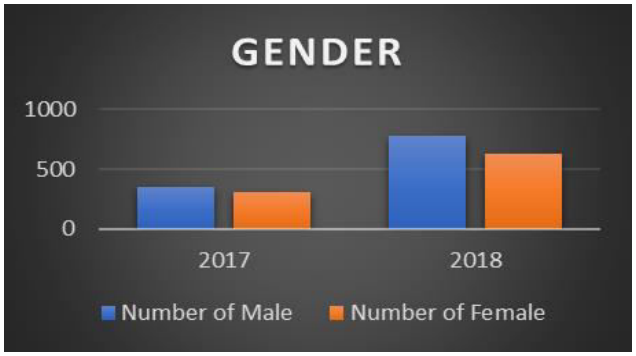

Figure 5. Number of Dengue Case classified to Gender

Demographic results in Figure 5 show that 345 are male patients (52.51%) while 312 are female patients (47.49%) in 2017 and 783 are male patients (55.65%) while 624 are female patients (44.35%) in 2018.

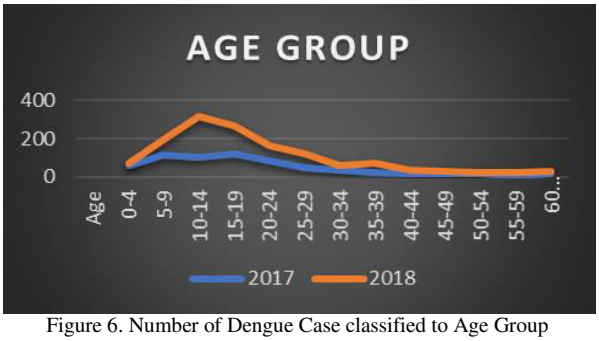

Figure 6. Number of Dengue Case classified to Age Group

In figure 6, demographic results in age group show that, children aged 15 to 19 years old topped the list of patients with 121 (18.42%); followed by 5 to 9 years old with 113 (17.20%), and 10 to 14 years old with 102 (15.53%) in 2017 and 10 to 14 years old topped the list of patients with 316 (22.46%); followed by 15 to 19 years old with 268 (19.05%), and 5 to 9 years old with 197 (14%) in 2018.

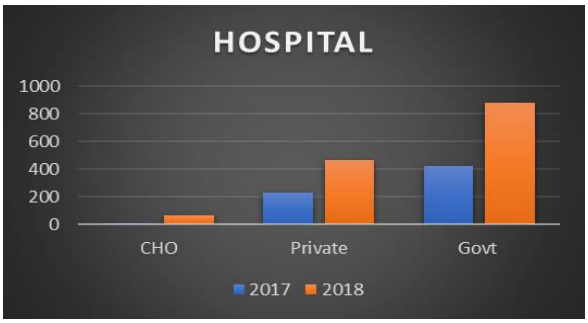

Figure 7. Number of dengue cases admitted in 3 categorical Hospitals

Results in Figure 7 show that majority of the Dengue Cases were admitted in Government Hospitals classifying the major DF case classified as poor families.

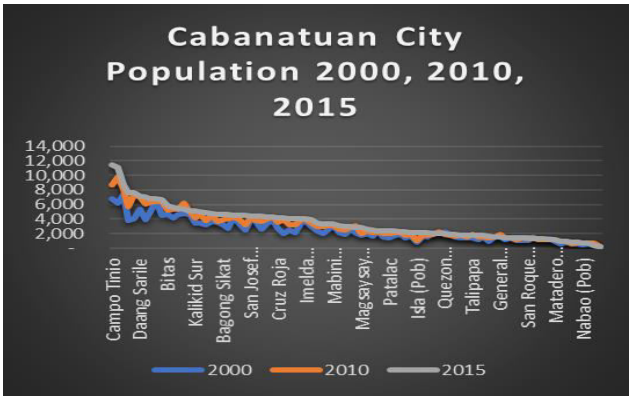

Figure 8. Cabanatuan City population distribution per barangay (Philippine Statistics Authority)

Figure 8 shows the rapid population growth in Cabanatuan City due to the influx of workers from rural areas can be considered as one of the reasons in the increase of Dengue Fever cases. The number of people located in poor barangays and living in congested housing that generally have unhygienic conditions with absence of window screens are susceptible to be victims of dengue.

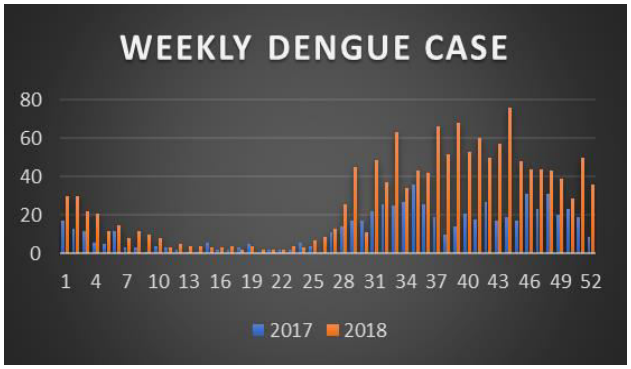

Figure 9. Weekly Distribution of Dengue Cases in Cabanatuan City

The Figure 9 shows that there is a great increase of Dengue Cases from week 36 to 44 in the months of August to October which fall during rainy season and when there are typhoons resulting to floods in different barangays. According to a dengue expert specialist in the Philippines, Dr. Richard Mata in his YouTube blog, Aedes Aegypti could lay an egg even in a small amount of water stored in a bottle cap. [15]

VI. CONCLUSIONS AND RECOMMENDATIONS

The largest number of Dengue Cases in Cabanatuan City can be found in Barangay Bagong Sikat and Barangay San Juan Pob (ACCFA). In terms of Demographic information, results indicated that majority of the Dengue cases are males from 15 to 19 years old in 2017 and also males from 10 to14 years old in 2018. Additionally, most of the Dengue patients decided to be admitted to public hospital. There is a great number of Dengue Cases in weeks 36 to 44.

The use of GIS in determining Dengue Cases was proven to be effective, hence, the results from the study can be a reliable and relevant information to be used in the following:

1. Strict Implementation of Health Policies for Dengue Cases
2. Prevention of Dengue Outbreaks
3. Health care interventions
4. Budget Allocation and Priorities for Health
5. Effective implementations of Heath Programs in the different barangays in the City of Cabanatuan.

The use of GIS in determining the lack of needed facilities and insufficient number health workers suitable for number of Dengue Cases may be considered.

Therefore, the use of GIS in preventing Dengue outbreak is highly recommended.

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CONFLICT OF INTEREST

The authors declare no conflict of interest regarding the publication of this paper.

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