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Seasonal variability on the epidemiology of Dengue in Tangub City, Misamis Occidental, Philippines

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Abstract

Seasonal variability contributes to the abundance of dengue mosquito vector. In this study, the prevalence rate of dengue on different seasons, by population characteristics and geographical location in the City of Tangub were determined. Dengue cases and climatological information from 2016-2021 were obtained through secondary data gathering. Based on the data, dengue cases are highest on the year 2019. Specifically, dengue was more prevalent during rainy period. In terms of gender and age, males with ages of 10 to 19 were more prone to contracting dengue. Notably, for the last six-years dengue was predominant in built-up areas. The association between climatological factors and dengue incidence was further determined. On hot season, the heat index (-0.12) and precipitation (-0.04) is negatively correlated to dengue cases. While heat index and dengue cases on rainy season have no correlation, precipitation revealed a weak positive correlation (0.04) towards dengue infection. And on cool-dry season, heat index and precipitation showed a weak positive (0.4) and weak negative correlation (-0.10) to dengue cases, respectively. Generally, the climatological variables show no significant correlation ($p>0.05$) towards dengue cases. This paper revealed that dengue is highest during rainy days however, climatological factors are not reliably considered as effective predictors to dengue cases.

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Introduction

Dengue is a significant health challenge that is widespread in more than a hundred nations encompassing an estimation of three hundred ninety (390) million infected individuals annually (Bhatt, 2013). Transmission of dengue viral infection are carried by the family Flaviviridae specifically dengue vector *Aedes* mosquito (Edillo, 2012). The annual infection rate of dengue still increases due to factors such as population growth, urbanization, inadequate public health infrastructure, poor solid waste management, and inconsistent preventive practices (Aurelio *et al.*, 2018). According to World Health Organization (2014), Philippines rank fourth among the ten Southeast Asian Nations at higher risk of dengue infection. In fact, dengue had become endemic in different regions and results to a major public health problem in the Philippines (Herriman, 2017).

Furthermore, the virus disproportionately affects children and young people, with 73% of recorded cases under the age of 19 (Muyot, 2019). In contrast, epidemiological review of Bravo (2011) shows that prevalence rate was highest among children ages between 5-14 years old and over 80% of dengue-related deaths in the Philippines occurred among people under the ages of 20. For the prevalence rate of dengue cases based on gender, according to the data reported by the national surveillance systems adolescent and young adult males are found to be at high risk of dengue (Arima, 2011). Gender differences in reported dengue surveillance data may be due to the exposure-associated behaviors or activities, such as working-age males exposed to outdoor environments during the day when dengue virus-infected *Aedes aegypti* mosquitoes are active (Yew *et al.*, 2009; Prasith, 2013). The difference in the male to female morbidity rates was associated with the difference in the proportion of working males and females, indicating that the risk of dengue increased with the increasing time spent away from home (Ooi, 2006).

Seasonal variability encompasses climatological factors such as temperature, humidity, and precipitation contribute to the abundance of dengue vector (Xu *et al.*, 2017). Southeast Asian countries potentially have a high risk of dengue transmission due to its subtropical humid monsoon climate (Halstead, 2006). In the Philippines, dengue is considered as seasonal occurring diseases as it is notifiable during the rainy and cool-dry season (June-February). According from the studies of Wai *et al.* (2012) and Tsuzuki *et al.* (2009), rainy and dry seasons has a tendency to increase mosquitos' activity in growth, survival, and transmission as both seasons serve as a good breeding site for their growth and development.

The warming of the climate increases the risk of dengue transmission. Some areas in Tangub City have been affected by changes in the weather patterns which result in extreme heat and heavy rains that lead to flooding incidents. This phenomenon significantly influences the dengue mosquito vectors' replication, growth, and rapid transmission. Tangub is also considered as a growing city due to its increasing population and building of infrastructures like the on-going project of Panguil Bay Bridge. Similarly, the anticipated urbanization may lead to the resident's poor solid waste management practices. These contributing factors are evident in the city, resulting to an adaptive habitat of dengue. At present, no study has been conducted related to seasonal occurrences of dengue in Tangub City. In this context, this study intends to interpret which season dengue is prevalent, determine the age and gender that are more susceptible to dengue infection and identify the geographical area prone to dengue. The findings of this study will serve as basis for the local governments to enhance formulated preventive measures and create strategic plan to raise community awareness subsequently, improving both preparedness and response activities during dengue outbreaks.

Materials and methods

Location of the Study

The study focused in Tangub City, Misamis Occidental situated in the northern shore of Panguil Bay and is nestled at the southern curve of the D-shaped Province of Misamis Occidental. Tangub covers a total land area of of 162.78 km^2. It is located within the geographic coordinates of 8.0667 north latitude and 123.7500 east longitudes (Fig. 1).

The city consists of fifty-five (55) barangays, twenty-three (23) of these are built-up areas, fifteen (15) are coastal barangays, and thirty-two (32) are mountainous areas.

The climatological factors in the year 2021 shows an average heat index of 34℃ (35℃-32℃), and an average precipitation of 5.2mm (6.6mm-3.7mm).

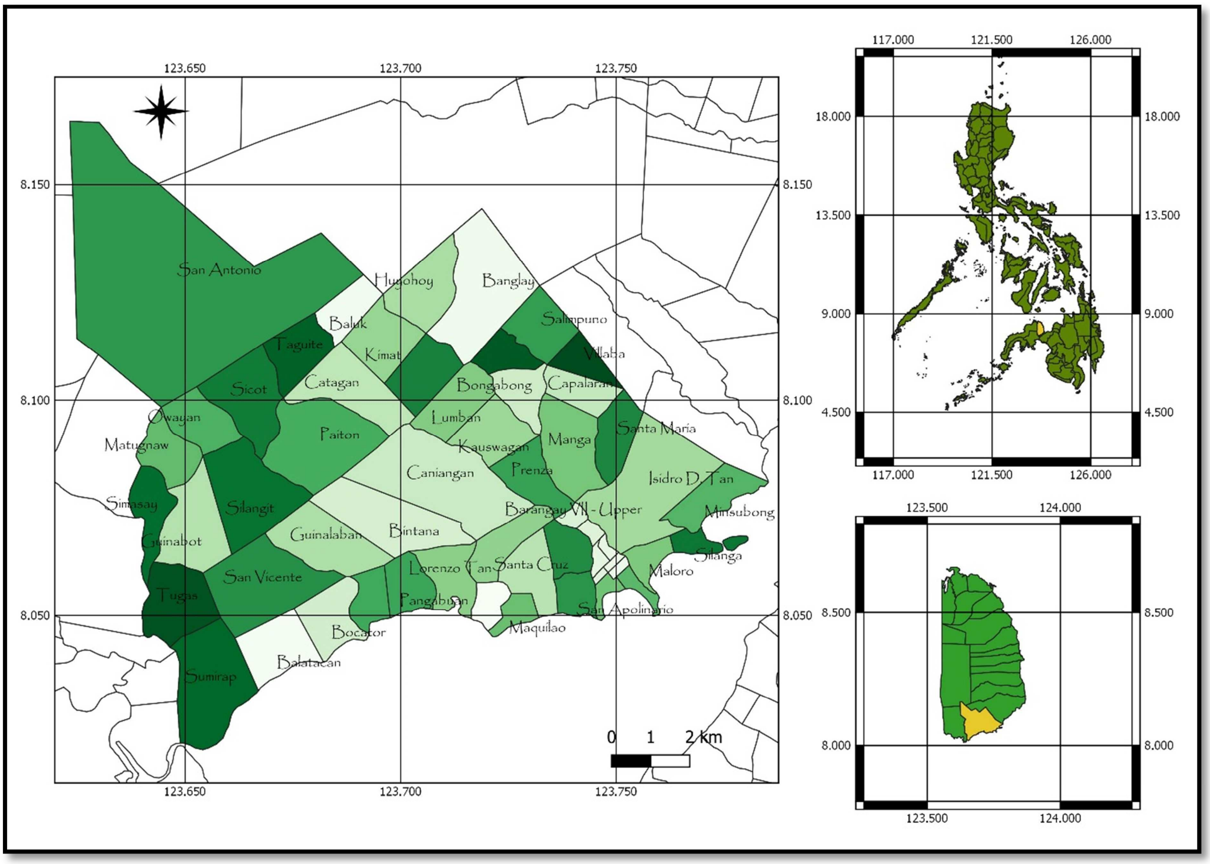

Fig. 1. Geographical location of the study area. Inset is the map of the Philippines highlighting the Province of Misamis Occidental (upper right) and the City of Tangub (lower right).

Data collection

The dengue cases for the year 2016-2021 were collected from the City Epidemiology Surveillance Unit (CESU) of Tangub. While the climatological data (heat index and precipitation), was provided by Philippine Atmospheric, Geophysical and Astronomical Services (PAG-ASA) Office, Region X at Cagayan de Oro City, Philippines. For the annual total number of population of the City, the data was gleaned from the Philippine Statistics Authority (PSA) official site.

Data Analysis

The prevalence rate of dengue by season, population characteristics, and geographical location was analyzed by using the morbidity frequency which measures the prevalence rate per 1000 population for each variable.

The basis for the degree of prevalence was indicated by dengue incidence for that time-period in the study. This means that the highest dengue incidence shows a highest prevalence whereas low prevalence shows a low dengue incidence (Ahrens and Pigeot, 2007).

Prevalence rate formula

(eqn. 1)

$$\text{Prevalence} = \frac{\text{All new and pre-existing cases during a given time period}}{\text{Total population during the same time period}} \text{ x } 1000$$

Further, Pearson's correlation coefficient was used to understand the association between climatological variables to dengue cases.

Pearson correlation coefficient formula

(eqn. 2)

$$r = \frac{\sum(Xi - \bar{x})\sum(yi - \bar{y})}{\sqrt{\sum(Xi - \bar{x})^2\sum(yi - \bar{y})^2}}$$

Results and discussion

Prevalence rate of Dengue on different seasons

The highest prevalence rate was in the year 2019 with 2 per 1000 individual, while year 2017, 2020 and 2021 recorded 0 (Table 1). It can be observed that the highest recorded heat index was in the year 2020 and 2021 having 35°C/95°F; however, the computed prevalence rate is zero. The ideal heat index of *Aedes aegypti* proliferates and is highly active at heat index above 35°C which causes a decline in their mortality rate (Chan and Johansson, 2012). However, the highest heat index has the lowest prevalence rates. For precipitation the highest amount was 18.33mm in the year 2016 with only 1 per 1000 individual prevalence rate. According to Iguchi *et al.*, (2018), ranging value of precipitation from 10-20mm shows a light amount of precipitation causes an increase in dengue incidence due to the flourish of favourable breeding sites. Furthermore, during hot season *Aedes aegypti* mosquitoes experience dehydration which makes them dependent on the available water consequently serving as their breeding sites (Canyon *et al.*, 2000).

Table 1. Prevalence rate of dengue cases during Hot Season.

Hot Season (March-May)				
Year	Number of Dengue cases	Heat Index (°C/°F)	Precipitation (mm)	Prevalence Rate
2016	40	31/87	18.33	1
2017	23	33/92	10.2	0
2018	81	34/93	8.06	1
2019	97	33/92	8.33	2
2020	31	35/95	4.46	0
2021	22	35/95	6.6	0

During rainy season, the highest prevalence rate was in the years 2018 and 2019 with 5 per 1000 individuals, while the years 2017, 2020 and 2021 recorded 1 per 1000 individual (Table 2). The highest and lowest prevalence rate had a consistent value of heat index 34°C/93°F except for year 2016. The heat index exceeded the country's average amount of 21 to 32°C which indicates that 34°C/93°F was above the normal range. This means that surpassing the country's average heat index amount leads to *Aedes* mosquito to have a favorable environmental condition. According to Tun-Lin *et al.* (2000), the ideal heat index preferable for all *Aedes* mosquito life cycle phases including survival, reproduction, hatching and feeding rate is between 20 to 30°C. Elevated heat index between the given range causes an increase in the mortality rate of *Aedes aegypti* and increase dengue incidence for it drives *Aedes* mosquito to transmit rapidly (Rohani *et al.*, 2009). However, the amount of precipitation had a close value ranging from 10-15mm except for year 2021 with only 5.3mm. Studies conducted in Davao region observed that moderate amount of precipitation ranging from 20-30mm and below shows a higher dengue incidence (Iguchi *et al.*, 2018). However, our findings showed a light amount of precipitation with a higher dengue incidence recorded. This is corroborated by Ehelepola *et al.* (2015), where the relative risk of dengue infection was high during a light to moderate amount of precipitation as it increases the breeding site of mosquito larvae (Eastin *et al.*, 2014; Hii *et al.*, 2009). Whereas, excessive amount of precipitation is detrimental to mosquito larvae development as it flushed out their breeding site which result in *Aedes* population abundance to decline (Seidahmed and Eltahir, 2016). On the contrary, studies in Sri Lanka oppose that excessive amounts of precipitation lead to flushing events as their result was hypothetically explained that increase amount of precipitation creates an additional breeding site for unaffected shaded areas and heavy rains result to a deeper water level that leads *Aedes* mosquito aquatic life cycle be completed (Ehelepola *et al.*, 2015). It is observed that the highest prevalence rate among all seasons is during the rainy season. This season recorded a larger amount of precipitation due to weather variability such as rain lasting for days, and humid climate which causes favorable environmental condition for *Aedes'* growth and reproduction (Chan and Johansson, 2012).

Table 2. Prevalence rate of Dengue cases during Rainy Season.

Rainy Season (June-November)				
Year	Number of Dengue cases	Heat Index (°C/°F)	Precipitation (mm)	Prevalence Rate
2016	138	31/88	19.13	2
2017	62	34/93	15.7	1
2018	295	34/93	12.38	5
2019	338	34/93	10.91	5
2020	74	34/94	12.93	1
2021	35	34/94	5.3	1

On cool-dry season, it is presented in Table 3 that the highest prevalence rate was in the year 2016 and 2019 with 2 per 1000 individuals, while year 2021 recorded 0. And the highest recorded heat index was in the year 2016 and 2020 with 33°C/91°F. According to Focks *et al.* (2000), heat index ranging from 15 to 30°C beyond during cool-dry season causes the decline of *Aedes* mortality rate as the environmental condition is favorable for their larvae development. Similarly, a study in French Guiana reported that a heat index higher than 32°C leads to the survival of *Aedes* mosquito for 76 days (Fouque *et al.*, 2006), shorter life cycle and increased feeding rate (Chan and Johansson, 2012). In relation to precipitation in the Philippines, amount varies due to geographical location, as for the entire Mindanao the average annual precipitation is 960mm (Rigaud *et al.*, 2018). Specifically, for Tangub City the average amount of precipitation during cool-dry season was 6.1mm. During this season, the City has the highest amount of precipitation with 9.13mm in 2017 having forty-two (42) infected individuals. In general, having the highest amount of precipitation decreases dengue incidence as it causes heavy rains and flooding incident that result in wiping out breeding site of mosquito dengue vector (Seidahmed and Eltahir, 2016) whereas having a low to medium amount of precipitation caused an additional breeding site for *Aedes* mosquito as it holds or stocked water to any unoccupied container like object which result to an increase infected individual (Chompoosri *et al.*, 2012). For the highest prevalence rate on year 2016, significant events of El Niño occur as this year was recorded as the warmest year in the Philippines (World Meteorological Organization, 2016).

According to Reiny (2019), occurrence of El Niño caused changes in precipitation and heat index as it exceeds normal range which triggered disease outbreaks such as dengue. On the same year, in Tangub City, both hot and rainy season has a value of 31°C for heat index whereas cool-dry season has a value of 33°C. These indicate that El Niño was evident in Tangub City on year 2016 during cool-dry season. In addition, year 2019 also has a similar prevalence rate in 2016.

Table 3. Prevalence rate of Dengue cases during Cool-Dry Season.

Cool-Dry Season (December-February)				
Year	Number of Dengue cases	Heat Index (°C/°F)	Precipitation (mm)	Prevalence Rate
2016	128	33/91	7.56	2
2017	42	31/88	9.13	1
2018	54	32/90	8.26	1
2019	100	32/89	3.03	2
2020	77	33/92	3.76	1
2021	33	32/90	3.7	0

Furthermore, the highest prevalence rate of dengue incidence for each season was in the year 2019. This is due to Tangub City being considered as one of the progressive component cities which encompasses 8.54% population growth from the year 2015-2020 with an annual rate of 1.74% (Bohra-Mishra *et al.*, 2017). Population growth increases human activities and practices such as water storage and waste disposal, which may contribute to the proliferation of *Aedes aegypti* (Chaturvedi, 2008; Banerjee *et al.*, 2013; Li *et al.*, 2014; Kesetyaningsih *et al.*, 2018). In addition, establishment of public infrastructure was progressive in Tangub City as it ranks 53rd among 112 components cities in the entire Philippines (Marcotullio *et al.*, 2014). The building of public infrastructures changes land-use which may lead to climate changes that either raises or lowers dengue risk infection (Kalnay and Cai 2003). On the other hand, most of the year that had lowest prevalence rate was in 2021. Hypothetically, this is due to restrictions in areas where dengue mosquito is prevalent during COVID-19 (Kusumawathie, 2005) whereas studies in Singapore linked that staying at home result to a high risk of exposure to dengue (Lim *et al.*, 2021).

Trend of dengue cases on different seasons

In Fig. 2, year 2019 recorded the most dengue cases with 97 infected people, while year 2021 tabulated the fewest cases with only 22 infected people. In Fig. 3, the highest documented dengue cases was in the year 2019 with 338 infected individuals while the lowest was in the year 2021 with only 35 infected individuals. Furthermore, Fig. 4 shows that the highest dengue cases was in the year 2016 with 128 infected individuals while the lowest was in the year 2021 with only 33 infected individuals.

In general, the figures show a fluctuating trend of dengue from year 2016 to 2021. Based on the results, the climatological factors are not reliably accurate as an effective predictor to dengue (Pasay *et al.*, 2013). In general, the inconsistency of dengue cases over the course of the six-year study in Tangub City revealed the same result with Thailand studies, which observed that dengue outbreak occurs in a year, it will lead to the following years to lessen infected individuals (Hay *et al.*, 2000). This is due to individuals becoming immune to the circulating dengue serotypes, as a result, this prevents another dengue outbreak in the years to come (Rahman *et al.*, 2002).

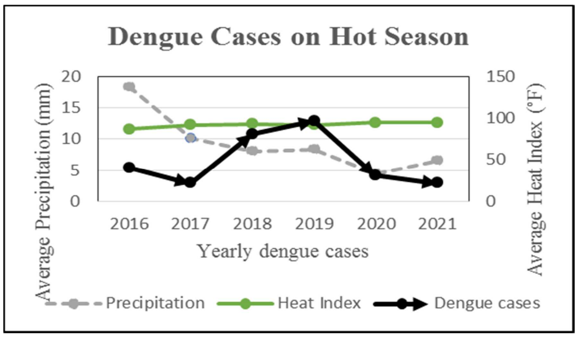

Fig. 2. Dengue cases in relation to heat index and precipitation during Hot season.

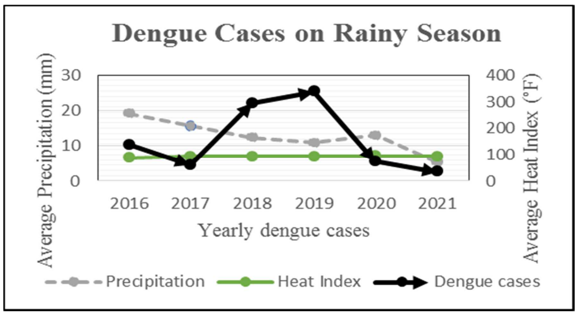

Fig. 3. Dengue cases in relation to heat index and precipitation during Rainy season.

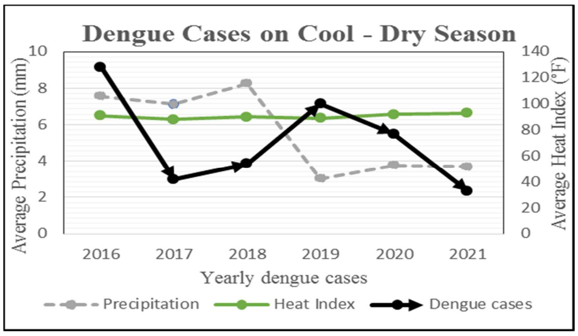

Fig. 4. Dengue cases in Relation to Heat Index and precipitation during Cool-Dry season.

Association between climatological variables to dengue

Table 4 shows the correlation values between climatic factors such as heat index and precipitation to dengue cases. Results revealed that climatic factors differ for each season. For hot season (Table 4A), heat index (-0.12) and precipitation (-0.04) both acquired negative correlation coefficient indicating an inverse and weak negative relationship to dengue cases. For heat index, contradictory results are seen from previous studies. Preferably, an increase of 35°C or beyond that amount of heat index (Table 1) increases *Aedes* mosquitos' growth, survival, and feeding rate which caused a rapid transmission of dengue virus (Chan and Johansson, 2012). For precipitation, results varied from different countries. Studies in Cambodia shows that precipitation has a positive correlation to dengue incidence (Choi *et al.*, 2016) as during this season, there is an insufficient amount of precipitation, resulting for some areas to store water in containers which provide a breeding site for dengue vector (Weeraratne, 2013). Whereas studies conducted in Saudi Arabia (Alshehri, 2013), Tobago and Trinidad in South America (Wegbreit, 2000), and Thailand (Thammapalo *et al.*, 2005) revealed a negative correlation to dengue incidence. Multiple studies also opposed the idea that climatic factors influence dengue incidence as they observed that heat index (Chadee *et al.*, 2007; Goto *et al.*, 2013; Yang *et al.*, 2009) and precipitation (Chang *et al.*, 2015) does not have any correlation with the disease.

Meanwhile, in the rainy season (Table 4B), the correlation coefficient for heat index is zero (0.0), implying no correlation to dengue cases. The result had similar observation from multiple studies conducted in the island of Trinidad and Tobago located in South America (Chadee *et al.*, 2007), areas in Sri Lanka (Goto *et al.*, 2013) and in Lucknow, North India (Pandey, 2012) where weather data such as heat index has no correlation to dengue instead other limiting factors were focused such as human knowledge, awareness, and practices (Bhattacharya, 2003). Precipitation on the other hand, had a value of 0.04 indicating that when the amount of rainfall increases, dengue cases also increase. This is supported with the study of Chompoosri *et al.* (2012)

stating that precipitation leads dengue vectors to have an adaptive breeding site resulting to an increased dengue density.

In cool-dry season (Table 4C), heat index indicates a direct and weak positive correlation to dengue with 0.4 value. This was supported by the study of Focks *et al.* (2000), which revealed an ideal range of heat index for larvae development that ranges from 15 to 30°C.

Beyond that range, a dengue mosquito become adaptive and changes its physiological processes leading to its rapid transmission (Jahan and Rahman, 2020). For precipitation, the value indicates an inverse and weak negative relation to dengue cases with -0.10. This is consistent with the study of Anosike *et al.* (2007) which stated that breeding site of *Aedes* mosquitoes on nature-formed container or any open storing materials on dumpsite are affected whenever there is an increased amount of precipitation poured as it flushed out *Aedes* larvae which resulted in a slight decline of dengue cases (Seidahmed and Eltahir, 2016).

In contrast, studies in Sri Lanka expected to have a negative correlation to dengue cases as the precipitation during the study period was >20mm. The following season which was the drying periods has a lower dengue incidence as it takes time for the breeding sites to develop following a heavy destruction from an excessive amount of precipitation on rainy season (Benedum, 2018).

Table 4. Correlation between climatological variables to dengue cases.

Table 4A. Correlation matrix of Dengue cases and climatological factors on hot season

	Hot Season	Heat Index	Precipitation
Hot Season	294	0.81	0.9
Heat Index	-0.12		0.0
Precipitation	-0.04	-0.9	

Table 4B. Correlation matrix of Dengue cases and climatological factors on rainy season.

	Rainy Season	Heat Index	Precipitation
Rainy Season	942	0.9	0.9
Heat Index	0.0		0.1
Precipitation	0.0	-0.6	

Table 4C. Correlation matrix of Dengue cases and climatological factors on cool-dry season.

	Cool-dry Season	Heat Index	Precipitation
Cool-dry Season	434	0.4	0.8
Heat Index	0.3		0.5
Precipitation	-0.1	-0.3	

*Note: *p<0.05*

Moreover, the data collected from 2016 to 2021 dengue cases in Tangub City has been analyzed and found out that throughout the season, climatological factors such as heat index and precipitation were not significantly correlated to dengue cases. On hot season, heat index and precipitation have a p value of 0.81 and 0.93. Meanwhile, on rainy season, both heat index and precipitation have a p value of >0.9. And on cool-dry season, p value for heat index is 0.9 and 0.84 for precipitation. These results was supported by the study of Pasay *et al.*, (2013), which stated that the climatic factors are not reliably considered as an effective predictors of dengue cases. Instead, other factors may be considered as predictor that may influence dengue cases such as preventive measures, dengue vector control, educating people towards the occurrences of dengue, demographic factors, presence of new serotypes and population immunity (Clark and Bradley, 2002; Itrat *et al.*, 2008; Bouzid *et al.*, 2014; Wong *et al.*, 2015).

Prevalence rate of Dengue by population characteristics and geographical location

Yearly prevalence rates of dengue were calculated by population characteristics (age and gender) and geographical location (built-up, coastal, and mountainous area) in Tangub City. The prevalence of dengue in Tangub City by age group is shown in Table 5. The highest yearly prevalence rate was found in year 2018-2019 having prevalence rate ranges from 3-4 per 1000 population which falls on age group 10-19-year-old. In the years 2016, 2017 and 2020, Tangub dengue cases among people aged 10 to 19 had prevalence rates that ranged from 1-2 per 1000 population. Similar studies reported that age group 11-25 years old had highest prevalence rate of dengue cases due to their younger age that are susceptible to dengue infection as there is a lack of substantial immunity (Karyanti *et al.*, 2014). However, as age increases this immunity resisting to dengue virus infection also increases resulting dengue fever prevalence rate to decline (Huy *et al.*, 2010).

Table 5. Prevalence rates of dengue by age-group in Tangub City, 2016-2021.

Year	2016		2017		2018		2019		2020		2021	
	Cases	Prevalence rate	Cases	Prevalence rate	Cases	Prevalence rate	Cases	Prevalence rate	Cases	Prevalence rate	Cases	Prevalence rate
Age group												
(0-9)	89	1	44	1	98	2	182	3	59	1	17	0
(10-19)	106	2	57	1	217	3	225	4	68	1	29	0
20-29	37	1	9	0	74	1	62	1	26	0	18	0
30-39	29	0	5	0	12	0	29	0	17	0	15	0
40-49	19	0	7	0	12	0	16	0	7	0	11	0
50-59	7	0	3	0	8	0	11	0	2	0	1	0
60-69	9	0	2	0	7	0	6	0	6	0	2	0
>70	10	0	3	0	2	0	4	0	3	0	0	0
Total	306	4	127	2	430	7	535	8	182	3	93	1

Note: Prevalence rate per 1000 population

Table 6 presents the prevalence rates of female and male per 1000 population each year. The data collected show that the highest annual prevalence rates occurred in the years 2018 and 2019, with prevalence rates ranging from 3 to 4 per 1000 population and remained relatively stable around 1 per 1000 population in the years 2017 and 2020. Moreover, for the year 2016, men have a high prevalence rate of 2 per 1000 population, while women have a prevalence rate of 1 per 1000 population. The same is true for the year 2021, showing that men have a prevalence rate of 1 per 1000 population, compared to women's prevalence rate of 0 per 1000 population. According to Yew *et al.* (2009), the data presented in his study showed that infected men have a higher prevalent rate of dengue virus due to the reason that men dominate in workforce and once get infected by dengue virus they must present medical certificates, these shows a discrepancy on his study towards male-female differences in disease severity. In contrast, studies conducted from several Asian countries such as Cambodia, Malaysia, Sri Lanka, Singapore, Philippines (Anker and Arima, 2011) and in India (Agarwal *et al.*, 2000) reported that males were more likely to contract dengue fever than females, reasons to the high preponderance of males on dengue fever is due to differences in sociocultural environment which shows that males are more expose to outdoor activities than female (Prasith *et al.*, 2013).

Table 6. Prevalence rates of dengue by gender in Tangub City, 2016-2021.

Year	2016		2017		2018		2019		2020		2021	
	Cases	Prevalence rate	Cases	Prevalence rate	Cases	Prevalence rate	Cases	Prevalence rate	Cases	Prevalence rate	Cases	Prevalenc e rate
Sex												
Male	170	2	70	1	218	3	257	4	90	1	55	1
Female	136	1	57	1	212	3	278	4	98	1	38	0
Total	306	3	127	2	430	6	535	8	188	2	93	1

Note: Prevalence rate per 1000 population

Furthermore, Table 7 shows the prevalence rate of dengue cases based on geographical location in Tangub City. According to the data, the total prevalence rate for this 6-year study period among three geographical locations is highly variable. The highest prevalence rate was found in built-up areas which had a total rate of 12 per 1000 population. This is strongly supported by Gentile *et al.* (2013), which stated that built-up areas have a higher risk of dengue cases because of their dense population, incorrect urbanization, informal settlements, and locations where proper sanitation has not been implemented. For the coastal areas, it had a total prevalence rate of 7 per 1000 population. Similar research studies found out that mosquito larva near the coast apparently indicated that there has been a noticeable shift in the way their anal papillae transport ions (Donini *et al.*, 2007).

Aedes aegypti living in the salt area adapt to this changing environment, which has a higher content of salt leading mosquito larvae to change its morphological and physiological traits to survive and had a breeding place (Clark and Bradley, 2002). Increasing levels of seawater are directly proportional to the number of mosquitoes tolerant to salt content; this explained why coastal areas had an increased number of infected individuals (Martini, 2019). In addition, mountainous areas had a total prevalence rate of 7 per 1000 population. In relation to the result, an Indian study found that the dengue vector's life cycle is influenced by mountains with higher relative humidity (Naish *et al.*, 2014). An increase in moisture levels will control *Aedes* larvae survival (Luz *et al.*, 2008), similar studies stated that relative humidity as contributing factors of dengue virus has a greater effect than temperature-rainfall on high land (Halide and Ridd, 2008).

Table 7. Prevalence rate of dengue cases in Tangub City based on geographical location.

Year	2016		2017		2018		2019		2020		2021	
	Cases	Prevalence rate	Cases	Prevalence rate	Cases	Prevalence rate	Cases	Prevalence rate	Cases	Prevalence rate	Cases	Prevalence rate
Location												
Built-up	109	2	49	1	334	5	202	3	39	1	30	0
Coastal	124	2	36	0	55	1	183	3	97	1	18	0
Mountainous	73	1	42	1	41	1	150	2	52	1	45	1
Total	306	5	127	2	430	7	535	8	188	3	93	1

Note: Prevalence rate per 1000 population

Conclusions

Throughout the season, rainy period has the highest prevalence rate of dengue due to precipitation that last for days and humid climate that causes favorable environmental condition for *Aedes* mosquito. However, seasonal variability alters the occurrences of dengue thus, strengthening preventive vector control should be implemented. In addition, age group 10-19 has the highest yearly prevalence because children are more expose to *Aedes* mosquito breeding site. For gender, male has higher prevalence rate as they actively participate activity in an open field area which exposed them to *Aedes* mosquito. For geographical location, built-up has the highest prevalence rate due to the City's growing population, on-going public infrastructures, informal settlements, and improper solid waste management. Moreover, the fluctuating trend among all seasons shows that the inconsistency of dengue cases is due to individuals becoming immune to the circulating dengue serotypes. As a result, dengue outbreak may lessen for the following years. Because of this inconsistency, researchers suggest to accomplish a local strategic plan that combines environmental sanitation, enhanced social responsibility and application of chemical and biological control methods. Based on degree of correlation of the climatological factors, results show that the variables are not an effective predictor to dengue cases as it often changes. Instead, social factors may reconsider as an effective predictor such as preventive measures, dengue vector control, educating people towards the occurrences of dengue, demographic factors, presence of new serotypes and population immunity.

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