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A study on the Relationship between the rainy season and Dengue outbreak in the Colombo District of Sri Lanka

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Abstract

Introduction – Dengue is a mosquito-borne viral disease considered a global health problem. It is considered one of the major health concerns in Sri Lanka because of being a tropical country. Even though dengue cases are being reported throughout the year, there are some significant differences between incident rates in some months. The highest incident rate is usually reported from the western province.

Aim – This study aims to understand the relationship between dengue incidences and monsoon seasons in the Colombo District of Sri Lanka, and the effect of the rainy season on spreading the disease. The results of this study are expected to be helpful in the implementation of new dengue prevention methods and in strengthening the existing preventive methods.

Study Design – The study is a statistical analysis using SPSS – 16 version. Graphical analysis is carried out between monthly rainfall and dengue incidences in the Colombo District of Sri Lanka from January 1st of, 2010, till December 31st of, 2019.

Methodology – The number of reported dengue cases in the Colombo district during the mentioned ten-year period is obtained from the Bureau of Health Information, Colombo municipal council. Those obtained data are analyzed using bivalent graphs opposite the months and rainfalls of the relevant months. The discussion will be based on the results of the graphs.

Introduction

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Dengue is a viral disease that is spread by mosquitoes. It is transmitted by mosquitoes of the species Aedes, most commonly Aedes aegypti, and vaguely by Aedes albopictus. The causative agent of Dengue is a virus of the family Flaviviridae, but it has four serotypes that cause Dengue. They are DENV-1, DENV-2, DENV-3 and DENV-4. The clinical presentation of dengue can include a range from mild to severe. It can cause very mild fever up to fatal dengue hemorrhagic fever. (WHO, 2022 Naish S. et al., 2014)

Due to being a tropical country, dengue fever has a long history in Sri Lanka. The first dengue epidemic was reported from 1965 to 1968, and then, several endemic and epidemic outbreaks were reported until the late 20th century. (Sirisena and Noordeen, 2013) However, dengue hemorrhagic fever has become a serious public health concern in Sri Lanka since the twenty-first century. From the year 2000, back-to-back large-magnitude Dengue epidemics were reported. The 2017 dengue outbreak is considered the largest reported during the last three decades. Colombo district reported the highest incident rate during this outbreak. (Lazarus 2021) Today Dengue has taken second place after COVID–19 as the most concerned infectious public health hazard in Sri Lanka and first place in the vector-borne viral diseases of the whole island. (NDCU, Sri Lanka)

In Sri Lanka, the disease is primarily spread by Aedes aegypti and seldom by Aedes albopictus. All four serotypes of Dengue (DENV 1, 2, 3, 4) have been circulating within the island since the early 21st century. The clinical presentation of Dengue varies from person to person and according to age. There can be very mild symptoms that are mostly undiagnosed and also symptoms of dengue hemorrhagic fever, which is fatal. (WHO,2022 and Sirisena,2013)

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In the early 21st century, dengue fever and dengue hemorrhagic fever are most commonly reported in children, especially below nine years of age in Sri Lanka. But during the last few years, the proportion of childhood dengue infection has declined, and at the same time, there is a disproportionate increase in adult dengue cases. Even though dengue incidence rate has increased in all age groups during the last few years, the most considerable increment is seen within the elderly population. (Malavige et al, 2021)

Research Problem

The largest dengue outbreak in recent years was reported in 2017, with 186,101 suspected cases and 440 deaths. (Tissera et al, 2016) Forty-four thousand two hundred three dengue cases have been reported during the first eight months of 2022, and more than 41% of the cases were reported from the Western province. (Epidemiology Unit, 2022) Recent studies show a pattern of two peaks of dengue spreading in the country within a year.

The climate is considered a key factor in developing and spreading Dengue. (Liyanage et al. 2016) Sri Lanka has only two major seasons. They are the rainy or monsoon season and the dry season. There are only two monsoon seasons: May to September, South-West monsoon, and November to February, North-East monsoon. (Farooket al. l, 2022) Monsoons in Sri Lanka are associated with heavy rains that last a few weeks. The Colombo district gets more rain during the South-East monsoon because it is in Western Province. The highest number of dengue cases are reported closely with these monsoon seasons. (Prabodanie et al, 2020 and NDCU, Sri Lanka)

Considering all these data, it is essential to identify the cause of this massive dengue spreading within the island in two peak timelines and its Relationship between the two rainy

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seasons. It will be beneficial in preventing dengue incidences and deaths in the future and strengthen the existing dengue preventive methods.

Literature Review

Dengue fever is considered one of the rapidly spreading vector-borne infections. Globally dengue incident rate has increased 30 times during the last 50 years. (WHO, 2021) Recent studies suggest that the major factor contributing to the spreading of dengue is climate patterns. It is associated with high dengue incident rates. Climate patterns provide a positive environment for vector development, growth, and dengue transmission. (Silva et al., 2017) Past studies indicate that temperature, precipitation, humidity, and population density are tightly associated with dengue transmission. (Zhu et al. 2016)

Rainfall provides the environment for Aedes eggs to grow into the larval stage. Larvae living habitat is freshwater containers like tins, cans, flower pots, tires, and coconut shells. (Wagner et al., 2020) Developed larvae transform into adult mosquito stage, and mosquito transmission occurs best at 10 – 34 degrees Celsius. (Mordecai et al, 2017) The high density of vector mosquitoes during the rainy season increases the fast transmission of dengue during dry seasons.

In Indonesia, rainfall and humidity mainly affect dengue transmission, while the average temperature does not play a significant role. (Kesetyaningsih et al, 2018) In Australia, heavy

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floods associated with rainfall also play a role in the transmission of dengue vectors, although it is currently identified only in the Queensland region. (Beebe et al., 2008) Urbanization has greatly affected the mortality and morbidity rates associated with Dengue in Sri Lanka. The Colombo district, being the smallest in geometry and largest in population, has a high dengue incident rate which is difficult to control due to urbanization.

Climate factors mainly associate the vector indices in the process of dengue transmission. In Thailand, studies have been conducted to implement an alert system that can trace climatic threshold parameters with vector indexes to prevent dengue spread. (Tran et al., 2020)

Dengue fever and dengue hemorrhagic fever does not have a specific cure. Only symptomatic management is available, and the mortality rate of dengue hemorrhagic fever is very high. Therefore, eradicating dengue, even though fairly impossible, is simply based on ceasing vector survival. But there have been some strategic, financial, and other aspects of negative impacts on the dengue prevention programs in Sri Lanka. (Udayanga et al, 2018) But the health sectors and the government are making a huge effort to prevent dengue as much as possible. These preventive measures include identifying potential risk areas, educating people about preventive measures and vector control programs, and many others. (Udayanga et al, 2020)

This study is also aimed at identification of the Relationship between rainfall patterns in the transmission of dengue fever and then using this knowledge to implement new dengue preventive measures and strengthen the existing preventive measures.

Methodology

Study Area

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Sri Lanka is an island which is situated in the Indian ocean. It is a tropical country as its location is closer to the equator. The country has different climate zones according to rainfall and altitude. (Prabodanie et al, 2020)

The island has four major seasons based on rainfall.

1) The first inter-monsoon season – From March to April
2) South–West monsoon season - This season is from May to September. It brings heavy rainfalls up to 3000 mm, mainly affecting the country's Western Province. (Figure 1 a)
3) Second inter-monsoon season – Last from October to November
4) North-East monsoon season – This season last from December to February. It mainly affects the northern and eastern parts of the country. (Figure 1 b)

   (Department of Meteorology, 2021)

The study area of this analysis is limited only to the Colombo District of Sri Lanka. Colombo District is the Western Province's central district with the country's highest population. At the same time, Colombo has continuously reported the highest incident rates of dengue throughout the years. So in this study, I mainly analyze the Relationship between dengue incidences and monsoon seasons in the Colombo district of the island.

Colombo is the business capital of Sri Lanka, the smallest district on the island with the largest population. The climate in this district can be described as tropical. The average annual temperature is considered to be 26.5 °C, while the annual rainfall is about 2387 mm | 94.0 inches. (en.climate-data.org) According to the rainfall, Colombo falls into the wet zone of the

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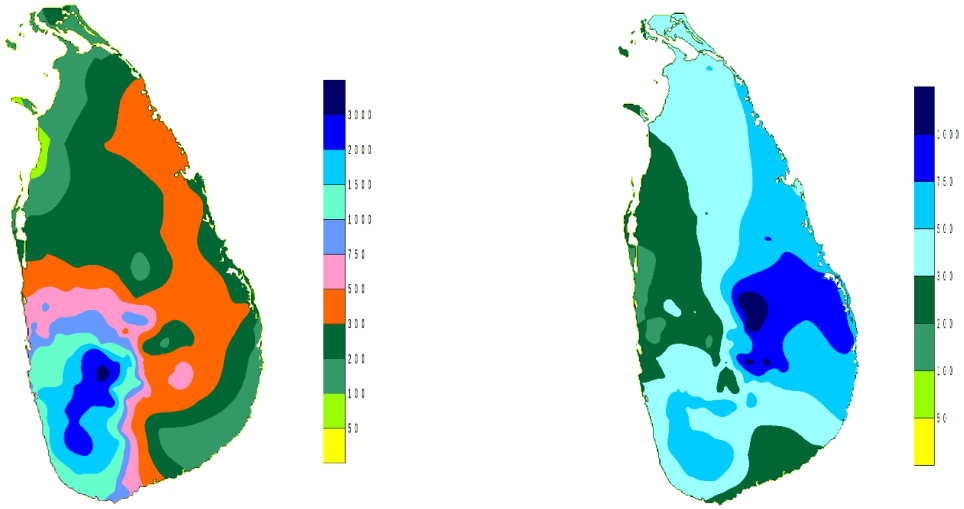
country, with an average annual rainfall being more than 2000mm. (Department of Meteorology, 2021)

Figure 1 – Monsoon seasonal effects on various parts of Sri Lanka



a – South -West monsoon b – North -East monsoon

(Source – Department of Meteorology, Sri Lanka)

Figure 2 – Colombo District situation

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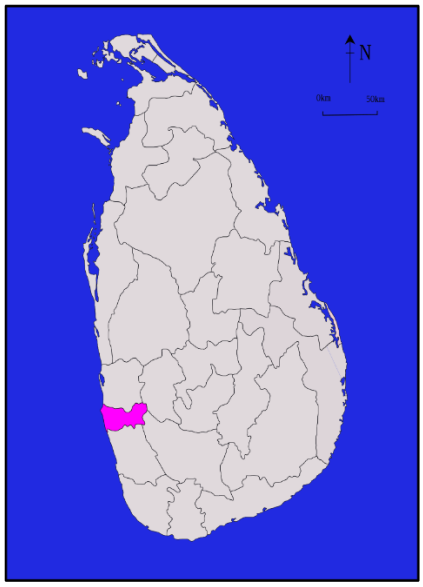

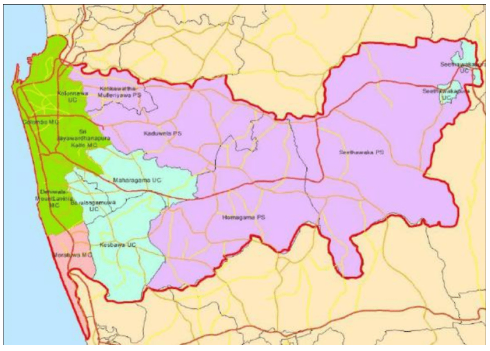

a – Colombo District

b – Study area of Colombo district

(Source – Jayasekara and Diunugala, 2019)

Data Collection

Data used in this study are notified of dengue cases in the Colombo district from the 1st of January 2010 – the 31st of December 2021 and the average rainfall of the Colombo district. Dengue incidences were obtained from the Bureau of health information and the Colombo municipal council, and the rainfall data were obtained from the meteorological unit of Sri Lanka. Therefore, the data used in this analysis is secondary data. Obtained raw dengue incidence data were organized in an excel sheet. The excel sheet included 12 columns with the name of the month and ten rows according to the year from 2010 – 2019. The table included monthly reported dengue cases in each year for the mentioned ten years. The rainfall data included average monthly rainfall in the Colombo district.

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Data Analysis

The collected data was analyzed using SPSS – 16 version, and the correlation between rainfall and dengue incidences was obtained.

Table – 1 Monthly dengue incidences in the Colombo District, 2010 - 2019

	January	February	March	April	May	June	July	August	September	October	November	December
2010	244	232	71	49	106	296	428	262	68	79	35	55
2011	160	144	215	173	309	632	520	254	198	156	223	340
2012	324	160	166	142	277	325	427	227	142	182	203	252
2013	273	227	181	246	207	284	465	296	205	303	427	591
2014	364	219	133	162	269	466	396	176	223	287	425	498
2015	531	326	155	118	140	153	184	153	80	132	320	429
2016	543	308	170	150	169	475	474	306	217	121	163	710
2017	688	425	535	524	460	590	1054	462	114	195	319	388
2018	382	133	84	117	158	329	437	191	82	77	213	284
2019	280	112	139	121	171	216	386	239	268	731	752	800

Source – Bureau of health information, Colombo municipal council, Sri Lanka.

Table 2 – Monthly rainfall of the Colombo District from 2010 – 2019

	January	February	March	April	May	June	July	August	September	October	November	December
2010	105	29	136	418	650	247	158	62	359	246	605	272
2011	129	91	115	417	133	59	51	141	36	175	322	156
2012	85	118	21	313	96	93	7	166	159	328	191	157
2013	42	148	60	143	291	237	184	20	209	233	167	30
2014	23	21	103	186	105	115	31	242	239	287	427	362
2015	24	106	168	228	184	139	17	53	435	315	331	312
2016	178	48	179	287	334	275	140	73	141	538	835	213

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2017	221	125	184	117	260	220	102	330	170	695	552	114
2018	106	14	68	445	313	128	154	256	220	396	265	155
2019	102	194	305	582	310	342	265	188	175	509	246	154

Source – meteorology department, Sri Lanka.

Table 1 and 2 indicates the obtained raw secondary data. Table 1 indicates the notified monthly dengue cases in the Colombo district from the 1st of January 2010 – the 31st of December 2019

These accessed secondary data are analyzed using time–series analysis using combined bar and line graphs.

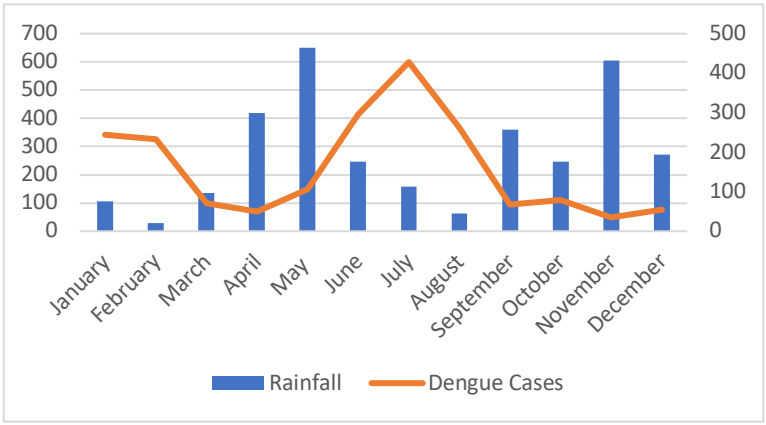

Figure 1 – Relationship between notified dengue cases and mean monthly rainfall in 2010.

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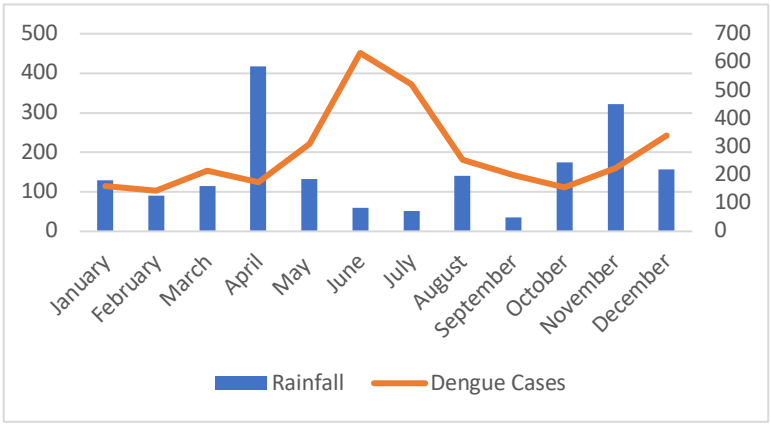

Figure 2 – Relationship between notified dengue cases and mean monthly rainfall in 2011.

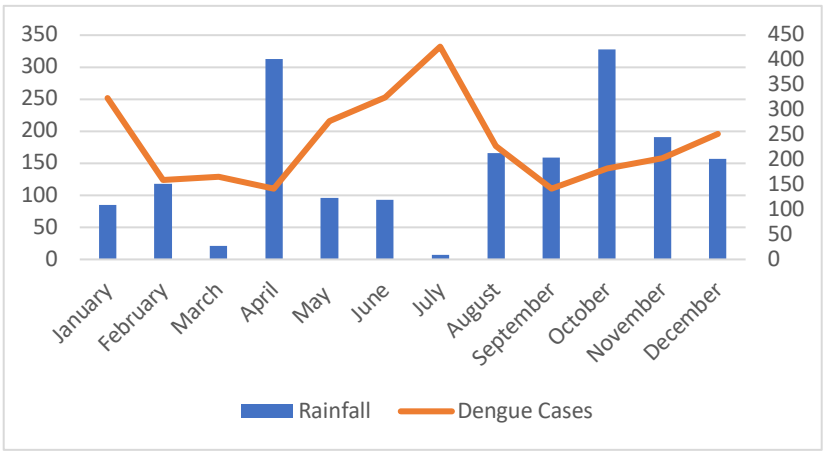

Figure 3 – Relationship between notified dengue cases and mean monthly rainfall in 2012.

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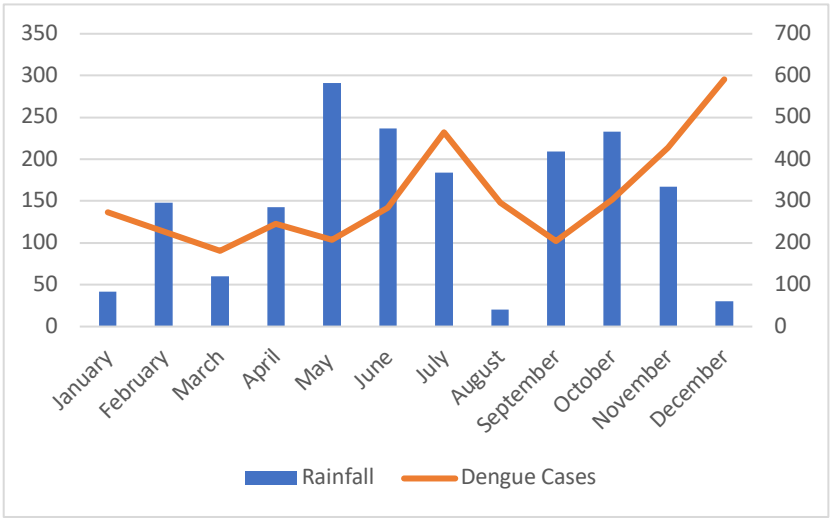

Figure 4 – Relationship between notified dengue cases and mean monthly rainfall in 2013.

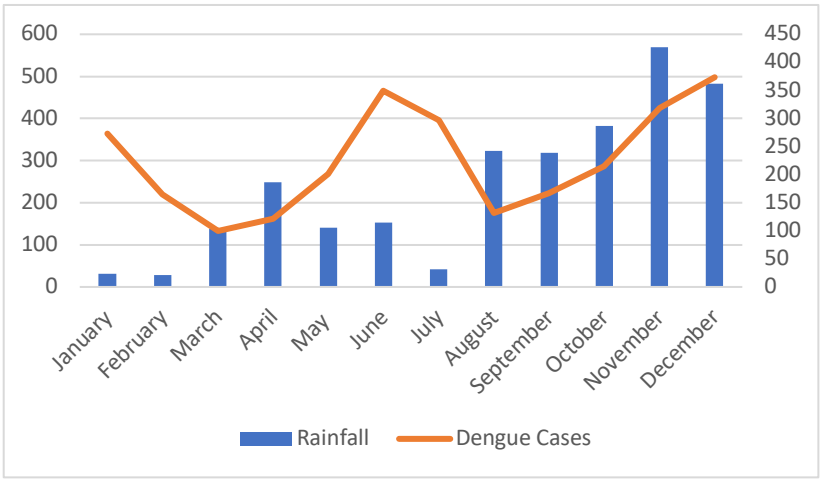

Figure 5 – Relationship between notified dengue cases and mean monthly rainfall in 2014.

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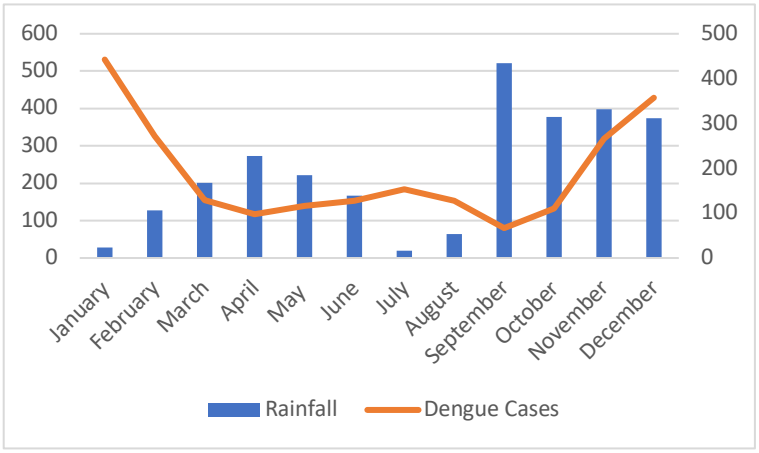

Figure 6 – Relationship between notified dengue cases and mean monthly rainfall in 2015.

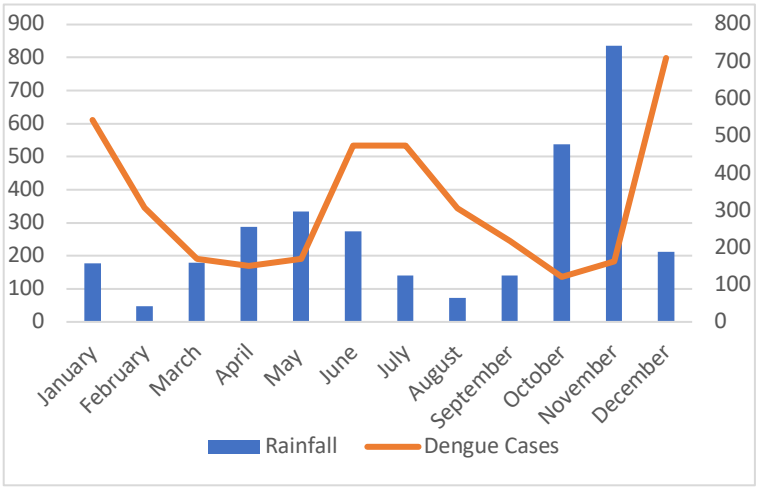

Figure 7 – Relationship between notified dengue cases and mean monthly rainfall in 2016.

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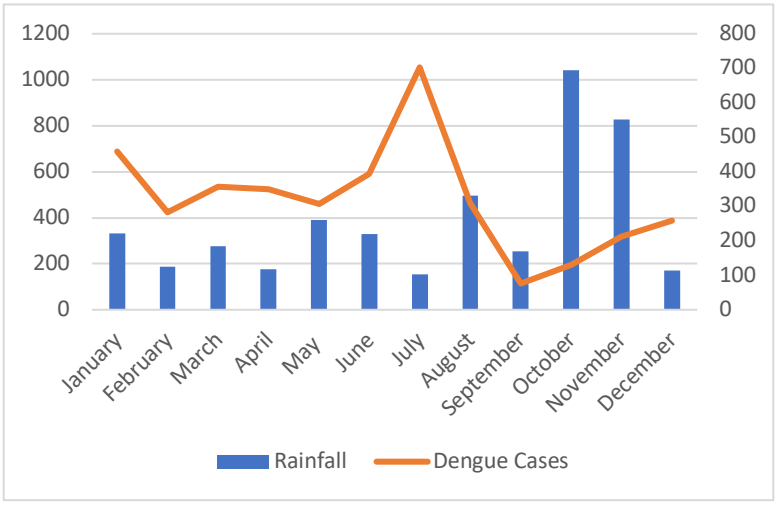

Figure 8 – Relationship between notified dengue cases and mean monthly rainfall in 2017.

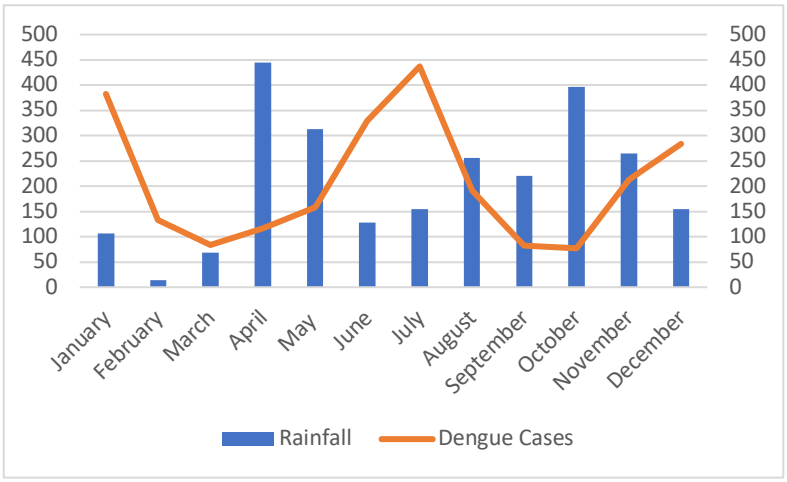

Figure 9 – Relationship between notified dengue cases and mean monthly rainfall in 2018.

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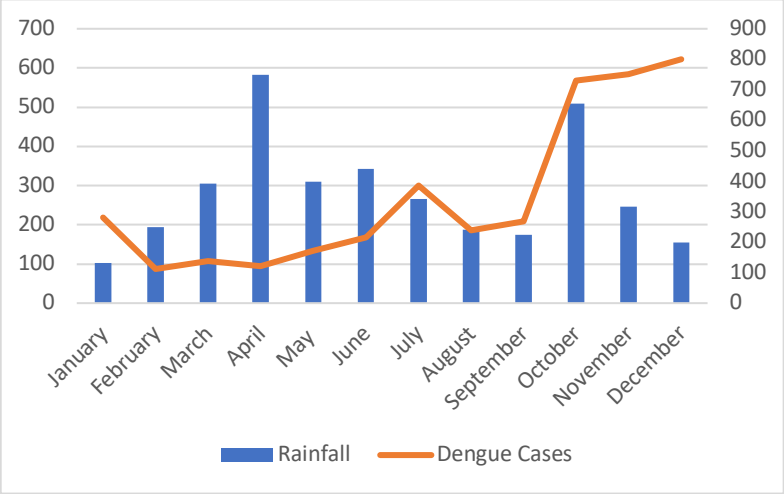

Figure 10 – Relationship between notified dengue cases and mean monthly rainfall in 2019.

Figure 1 – 10 indicates the pictorial presentation of the Relationship between monthly rainfall and dengue incidences in the Colombo district from 2010 – 2019. As the graphs demonstrate and according to literature, it is visible that the Colombo district gets more rainfall during April – June and October – December months. This is due to South West monsoon seasons and convectional rainfalls.

I took two correlations using SPSS–16 statistical analyses. The first correlation is associated with dengue incidences in the months with heavy rainfall, and the second correlation is associated with dengue incidences in the immediate next month of the heavy rainy season.

Interpretation of the correlation results

Table 1- Correlation of dengue incidences with the months of heavy rainfall

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		No_of_Dengue_Patients_monthly	Rain_in_mm_monthly
No_of_Dengue_Patients_monthly	Pearson Correlation	1	-.205*
	Sig. (2-tailed)		.025
	N	120	120
Rain_in_mm_monthly	Pearson Correlation	-.205*	1
	Sig. (2-tailed)	.025	
	N	120	120

Table 2 Correlation of dengue incidences with the immediate next month of heavy rainfall

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		No_of_Dengue_Patients_monthly	Rain_in_mm_monthly
No_of_Dengue_Patients_monthly	Pearson Correlation	1	.214*
	Sig. (2-tailed)		.019
	N	120	120
Rain_in_mm_monthly	Pearson Correlation	.214*	1
	Sig. (2-tailed)	.019	
	N	120	120

Discussion

According to Figure 1, the highest monthly rainfall in 2010 was in May, possibly due to South – West monsoon. Simultaneously, November and December months also appear to be with heavy rainfall. The highest number of dengue cases were reported in July, which is the following month of heavy rainfall. The graph shows the gradual increment of dengue cases from April to July, with an increase in rainfall from March to May. According to Figure 2, April produced the heaviest rainfall in 2011, and we can see the increment of dengue incidences in May, with the highest reporting in July. Even though there was heavy rainfall in November – December 2010, the dengue incidence was comparatively low in January and February of 2011. In October - December, the gradual increment of dengue cases is evident in accordance with the rainfall.

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Figure 3 demonstrates a high dengue incidence in January 2012, which can correlate with the high rainfall in November – December 2011. The highest rainfall of the year 2012 was in April and October. The Dengue incidence is in July and then sudden decrease followed by a gradual increase. Also, we can appreciate that the lowest rainfall of 2012 was reported in July. According to graph no 4, we can appreciate significant rainfall in the Colombo district in 2013 throughout the year. The lowest rainfall is reported in August, while the highest is in May. In 2013, it was visible that there were two dengue incidence peaks which are in July and December, while December was the highest. Also, it is important to note that the rainfall in December is very low compared to other months, only second to August by a small margin.

The Relationship between reported dengue cases and rainfall of the year 2014 can be appreciated in the graph indicated by Figure 5. In January 2014, there was a significant increase in dengue cases which can correlate with the heavy rainfall in November 2013 and the highest incidence of dengue in December 2013. In 2014 also, we can see two peaks of dengue incidences in June and December. The heaviest rainfall can be appreciated in November, with the highest dengue cases being reported in December 2014.

In figure 6, we can see a little deviation from the normal dengue incidence pattern of the Colombo district. All the above-mentioned graphs clearly demonstrated a high dengue incidence in the months of June – July, while in 2015, the two peaks of dengue were diverted to the beginning and end of the year. The highest number of dengue cases were reported in January, which can correlate with the heavy rainfall of October – December in the previous year. The highest rainfall of 2015 was in September, with a simultaneous increment of dengue cases from

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the immediate next month and a gradual increment. In 2016, the year started with a high dengue incidence and then gradually dropped in May. There was a significant amount of rainfall in May, and new dengue cases suddenly increased in June – July. The highest rainfall was reported in November, with a significant increase in new dengue cases in December, the highest in the year.

Figure 8 represents the Relationship between rainfall and dengue incidence in the year 2017. This year we can appreciate a typical dengue incidence pattern with relatively high in the first two months of the year and then gradually decreasing, relatively high rainfall in May, and a sudden increment of new dengue cases in June and July. Appreciating the low rainfall in July with a high dengue incidence here is also important. Figure 9 is also compatible with figure 8; the high first two-month dengue cases can correlate with the high rainfall in October – December 2017. According to Figure 10, rainfall and newly reported dengue cases were high in 2019. There are two peaks of heavy rainfall in April and October, and the highest dengue incidence can be seen in December.

By analyzing data from ten consecutive years, we can appreciate a pattern of dengue fever transmission in the Colombo district of Sri Lanka. December 2019 rainfall is analyzed with dengue incidence of January 2020) In most of the years, there is a high dengue incidence in June – July months and a high rainfall in April – May and October – November months. Again, there is a high dengue incidence rate at the beginning of the next year. The lag period between rainfall and symptomatic dengue patients reporting is about one month. In Dhaka, Bangladesh, this lag period is about two months. (Rahman et al., 2020)

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This analysis clearly shows that the new dengue cases rise right after the next month of heavy rainfall. Simultaneously, it is significant to mention that the highest dengue new dengue cases are reported he months of low rainfall, which are dry. Especially n the month of July is mostly with low rainfall and with high humidity, which provides a good environment for the transmission of vectors. In Thailand, a substantial correlation between cumulative rainfall over two months and dengue infection was discovered at temperatures higher than 23.2 °C. (Sriprom et al, 2010) In Singapore also, it is reported to have a linear relationship between dengue and cumulative rainfall with a lag period of 5 – 20 weeks. (Ling Hii et al.,2009)

HPSS – 16 gives a negative Pearson correlation with the rainfall and dengue incidence of the same month with a p-value of - 0.025. But it gives a positive Pearson correlation with the rainfall and dengue incidence of the immediate next month with a p-value of 0.019.

According to the literature, the rainy season provides a thriving setting for the growth and development of vector mosquitoes. The dry, humid season comes after the rainy season provides a thriving transmissive environment of grown mosquitoes. This gap period can be the lag between rainfall and high dengue incidences. Also, this period is associated with the dengue incubation period. (Chan M, Johansson A, 2012)

Conclusion

This study reveals a relationship between rainfall and dengue fever in the Colombo District of Sri Lanka. The correlation is positive between the rainfall and dengue incidences in the immediate next month. HPSS – 16 gives a positive correlation in these two variables with a

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p-value of 0.019. (Value is considered significant between 0.10 – 0.50) Therefore the correlation between rainfall and dengue fever in the Colombo district is strongly high.

This Relationship is primarily based on vector transmission. Healthy environments for vector transmission provides high dengue incidence rates. Therefore, this study aims to identify this Relationship to implement and strengthen dengue preventive measures. These preventive measures should be associated with vector control mechanisms and minimizing vector contacts. Vector control mechanisms should be carried out during the rainy season, and methods for minimizing vector contacts should be mainly carried out after rainfall. Even though mentioned separately, both measures should be carried out simultaneously to control dengue morbidity and mortality rates.

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