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Temporal Evolution of Dengue Incidence Rate in the Central Region of Peninsular Malaysia

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ABSTRACT

Dengue, a globally significant arthropod-borne viral disease that affects humans, is primarily transmitted by the Aedes aegypti mosquito and is caused by four viruses known as DENV-1 to DENV-4, which are classified as flaviviruses. In Malaysia, dengue has been a major public health concern with high incidence rates, particularly in the central region of Peninsular Malaysia. The year 2019 witnessed the highest number of reported cases globally, with severe outbreaks occurring in several Southeast Asian countries, including Malaysia. To better understand the temporal patterns of dengue incidence in the central region of Peninsular Malaysia, this study aimed to assess the temporal evolution of dengue incidence rates. Trend analysis was conducted using Dengue Incidence Rate (DIR) data from EW1-2013 to EW52-2019, calculated based on the number of dengue case notifications per week and district population estimates from the Malaysian census. The findings revealed that the temporal evolution of DIR in the central region exhibited a recurring pattern. The incidence rate tended to peak at the beginning of the year, followed by an increment in May (EW20) and another peak in November (EW45). Additional peaks were also detected in February, July, and December. These findings provide insights into the seasonal dynamics of dengue incidence in the central region of Peninsular Malaysia.

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1. Introduction

Dengue is a prevalent viral infection transmitted by Aedes mosquitoes, commonly found in tropical and subtropical countries. Aedes mosquitoes are easily recognizable by their distinctive black and white markings on the bodies and legs. In recent years, dengue has become a significant problem in urban areas, affecting many countries worldwide. Infection with dengue viruses typically presents with sudden onset fever, and in severe cases, it can progress to dengue hemorrhagic fever (DHF) and dengue shock syndrome (DSS), which can result in hospitalization and even death. However, early symptoms of dengue fever can resemble those of other febrile illnesses, leading to misdiagnosis and underestimation of its true incidence[1],[2]. According to WHO guideline, dengue fever is caused by any one of four types of dengue viruses known as DENV-1, DENV-2, DENV-3 and DENV-4. Therefore, a person can contract the disease up to four times, where the virus is transmitted through the bites of infected female mosquitoes. Nowadays, the latest infectious disease

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of COVID-19 has become the major public health focus of ASEAN countries. However, dengue disease still poses a risk to the populations of ASEAN countries, and the rate of dengue has continuously increased during the pandemic [3].

The World Health Organization (WHO) classifies dengue as one of the top ten threats to public health. The largest number of dengue cases ever reported globally was in 2019. All regions were affected, and the first-time transmission of dengue fever has been reported in Afghanistan. Furthermore, a high number of cases were reported in Asia including Bangladesh, Malaysia, Philippines and Vietnam about 101000, 131101, 420000 and 320000 respectively. Malaysia is among many Southeast Asian countries that are considered hyper endemic with a record of 668,802 cases of dengue, of which approximately 1,386 cases lead to death within the study period. In Malaysia, dengue was first reported in year 1902 in Penang [4].

Particularly, Ministry of Health Malaysia report in Health facts 2019 using reference data for 2018 indicated incidence rate and mortality rate of communicable disease 2018 (per 100,000 population) showed the highest under Vector Borne Disease was dengue fever recorded 244.07 (0), followed by dengue haemorrhagic fever recorded 1.23 (0.45) and Malaria recorded 14.09 (0.04). Next, Ministry of Health Malaysia report in Health facts 2020 using reference data for 2019 indicated incidence rate and mortality rate of communicable disease 2019 (per 100,000 population) still holds the highest under Vector Borne Disease; dengue fever recorded 397.71 (0), followed by dengue haemorrhagic fever 1.61 (0.56), Chikungunya 3.04 (0), Malaria 12.10 (0.02), Japanese Encephalitis 0.11 (0.01), Filariasis 1.53 (0) and Typhus 0.06 (0). Dengue fever is a serious threat to the population in Malaysia with 130,101 cases reported in 2019. During the year, Selangor (72,543 cases) is the most affected state, followed by Federal territories Kuala Lumpur and Putrajaya (15,424 cases) both are in central region with the largest number of reported cases of dengue fever, typically known as an urban disease.

Rapid urbanization environments create favorable conditions for dengue transmission in which people are increasingly densely in the area [5]. Well known as the most developed and populated area, this study focused on central region Malaysia consist of Selangor state with nine districts and two federal territories of Kuala Lumpur and Putrajaya. The geographical location in the centre of Peninsular Malaysia account for the majority of Malaysia's population about 25.8%, followed by northern region about 20.6%, southeast region about 17.9%, east coast region about 14.8% and east Malaysia (Sabah, Sarawak and Federal territory Labuan) about 20.9%.

This research aims to fill the gap in the current knowledge by conducting a comprehensive analysis of the temporal evolution of dengue incidence rate in the central region of Malaysia. The contribution of this paper lies in the use of the Dengue Incidence Rate (DIR) calculation, which has been adapted from a previous study [6]. By examining the trends and patterns of dengue transmission in this highly populated and urbanized area, this study seeks to provide valuable information that can contribute to a better understanding of dengue dynamics in Malaysia and help inform evidence-based strategies for dengue control and prevention.

2. Literature Review

Supported by previous studies, the dengue disease expands readily in urbans areas due to the increment of the human population [7]–[10]. Thus, there is a need to provide relevant information in the demographic data including the list the total population of Malaysia, population distribution by state, population density by state, level of urbanization of Malaysia from 1980 to 2010 and level of urbanization by state, Malaysia. According to Census 2010, the total population of Malaysia was 28.3 million compared with 23.3 million in 2000. This gives an average annual population growth rate of 2.0% for the period 2000 to 2010. Population distribution by state indicated that Selangor was the most populous state (5.46 million). Unlike the population distribution, the population density revealed a different picture. Among the most densely populated states were Federal territory Kuala Lumpur (6,891 persons), Penang (1,490 persons) and Federal territory Putrajaya (1,478 persons). Apart from Federal territory Kuala Lumpur and Federal territory Putrajaya with 100% level in urbanization, the other states with high level of urbanization were Selangor and Penang with 91.4% and 90.8% respectively.

The dengue expected to poses the greatest risk in highly populated regions with climate seasons where there are large populations of Aedes aegypti with a high tendency of contact between the mosquitoes and humans [6]. The dengue viruses have fully adapted in the large urban centers of the tropics, where crowded human populations were associated with huge mosquito populations.

Different levels of dengue disease have also occurred in Malaysia, especially in urban areas that having an excessively large population [11]. Thus, central region known as densely overpopulated area located in the heart of Peninsular Malaysia. Peninsular Malaysia historically known as Malaya also known as West Malaysia or the Malaysian Peninsula, is the part of Malaysia in southeast Asia. Its area totals 132,490 km2 (51,150 sq mi), which is nearly 40% of the total area of the country; the other 60% is in East Malaysia comprises the states of Sabah and Sarawak, as well as the federal territory of Labuan.

3. Methodology

3.1 The dataset

The data on dengue cases used in this study were obtained from the dengue surveillance database of the Vector Borne Disease sector, Ministry of Health (MOH) Malaysia. The term "dengue cases" refers to the total number of registered and confirmed cases of dengue fever in each epidemiological week (EW) for Selangor state and the two federal territories of Kuala Lumpur and Putrajaya in Malaysia, covering the period from 2013 to 2019. Ethical approval for this research was obtained from the National Medical Research Register (NMMR-19-1461-47865 (IIR)), MOH Malaysia.

3.2 Dengue Incidence Rate (DIR)

The study calculated the dengue incidence rate (DIR) for the central region of West Malaysia, specifically Selangor and the Federal territories of Kuala Lumpur and Putrajaya, using the number of notifications per epidemiological week and district level, based on population estimates from the 2010 Malaysian census. The DIR, which is defined as the weekly incidence per 100,000 persons at risk according to [6] , was determined using the formula provided in Equation 1.

$$\text{DIR} = \frac{y_{kt}}{p_{kj}} \times 100{,}000 \tag{1}$$

where y_{kt} is the number of cases, inspected in district *k(k = 1,2,3,…,11)* during *t(t = 1,2,3,…,365)* weeks and p_{kj} represents the total estimated population of district k for the year *j(j = 1,2,3,…,7)*, expressed in 100,000 persons, in which week *t* falls.

4. Results and Discussion

4.1 Yearly temporal evolution of DIR in Central region of Peninsular Malaysia

Figure 1 presents time series plots that depict the number of dengue cases by year from 2013 to 2019. The plots provide a visual representation of the temporal trend in dengue cases over the years, allowing for an examination of any patterns or changes in the incidence of dengue in the central region of Malaysia during the study period. The incidence of both dengue fever (DF) and dengue haemorrhagic fever (DHF) cases in the central region of Malaysia has shown an increasing trend. A total of 414,218 dengue cases were reported from January 2013 (Epidemiological Week 1) to December 2019 (Epidemiological Week 52), with the highest incidence recorded in 2015 and 2019. The total number of cases varied from 26,422 in 2013 to 87,967 in 2019. The number of dengue cases has continued to rise since 2013, with a notable upsurge in 2015, and further increase in 2019, surpassing three times the total cases reported in 2013. Similar trend in national level, Malaysia recorded dengue outbreaks in 2015 and 2019. There were 120,836 cases of dengue with 336 deaths reported in Malaysia for 2015 and 130,101 cases of dengue with 182 deaths for 2019.

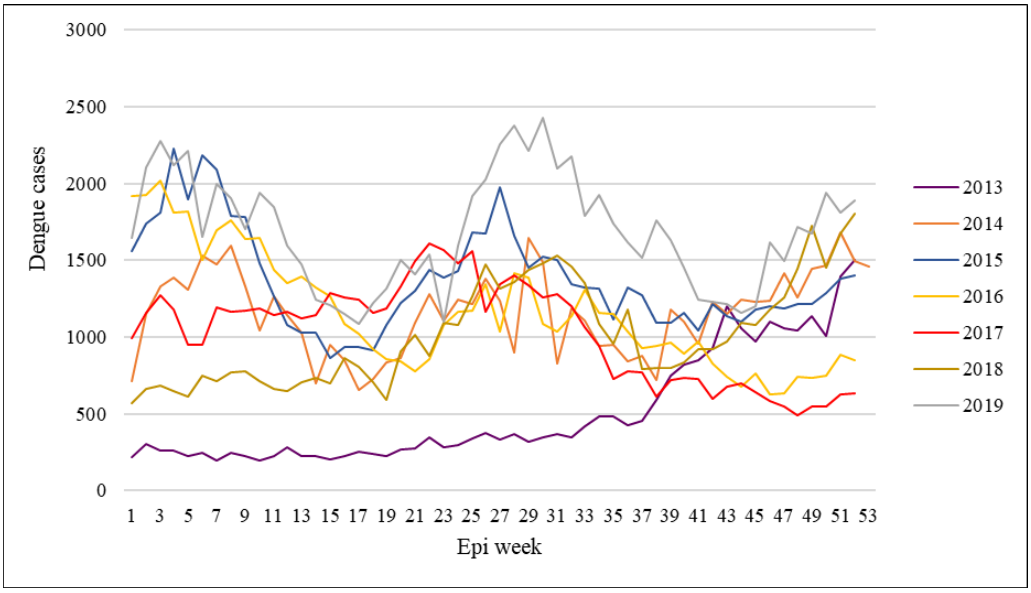

Figure 1. Time series plots of dengue cases by year

According to Figure 2, the mean annual dengue incidence rate (DIR) for the central region exhibited an increasing trend from 2013, with subsequent increments in 2014 and 2015. However, there were temporary decreases in DIR observed in 2016, 2017, and 2018. In contrast, the trend changed in 2019, with a sharp increase in dengue cases, reaching almost three times the number of cases reported in 2013 [11]. Throughout the study period from 2013 to 2019, the central region accounted for approximately 62% of the total cases, with 53% coming from Selangor and 9% from the Federal Territory of Kuala Lumpur and Putrajaya. This pattern is consistent with national records, as reported in https://idengue.mysa.gov.my/, which also showed a substantial increase in DIR between 2013 and 2015, peaking in 2015 at 394.4 cases per 100,000 population, followed by a decrease to 245.3 cases per 100,000 population in 2018. The highest occurrence was recorded in 2019, with 130,101 reported cases corresponding to a DIR of 390.4 cases per 100,000 population.

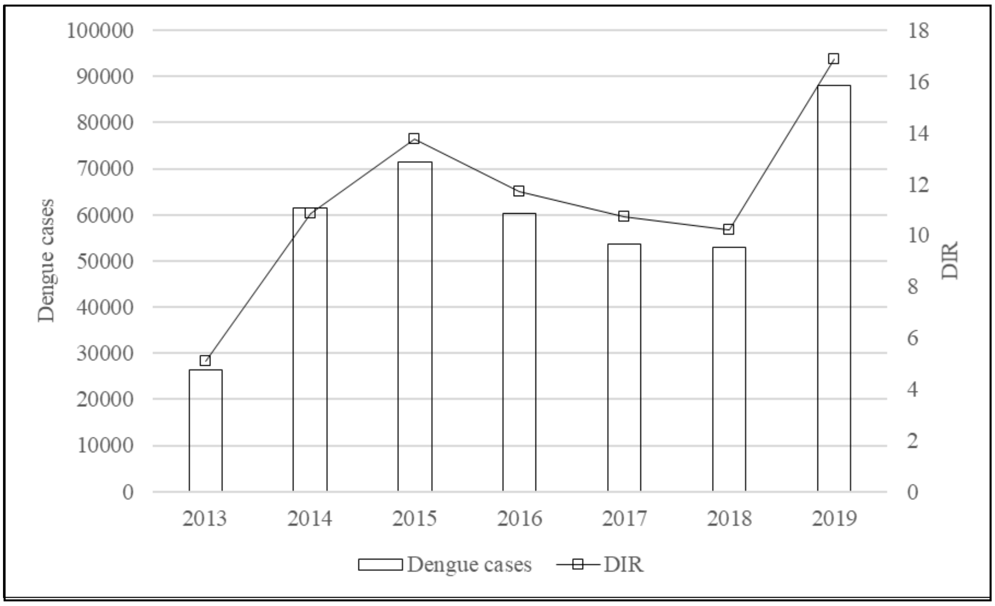

Figure 2. Dengue cases and mean annual DIR from 2013 to 2019 in Central region

The global incidence of dengue has experienced a dramatic increase in recent years, as reported to the World Health Organization in https://www.who.int/news-room/fact-sheets/detail/dengue-and-severe-dengue, with cases rising from 505,430 in 2000 to 5.2 million in 2019. In 2019, severe outbreaks were recorded in various countries, including Malaysia and other countries in Southeast Asia. Malaysia specifically witnessed higher dengue incidence in 2015 and 2019, particularly in the central region of Peninsular Malaysia, where cases showed an exceptional rise throughout the study period. The temporal evolution of the central region's mean annual dengue incidence rate (DIR) from 2013 to 2019 is depicted in Figure 3, illustrating the trend over time.

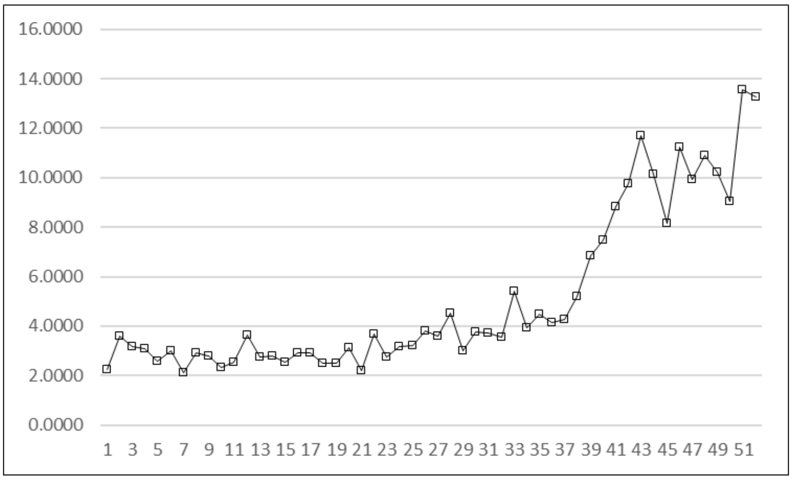

Figure 3. Temporal Evolution of DIR in Central Region, Averaged over the Period EW1-2013 – EW52-2013

According to MOH Malaysia, dengue cases decreased in 2011 and 2012 before steadily rising at the start of 2013. Figure 3 shows that the DIR increased significantly increased in September from epidemiological week 37. In 2013, the epidemic peak occurred in the latter half of the year from September until December. The peak was fully evident in December. This finding similar with [12] where the seasonal trend of dengue in Malaysia is changes in the pattern of epidemic peak could be the influence of global climate change in this region. Figure 4 shows a rise in dengue cases for the central region in 2014 from the previous year up to epidemiological week 8 in February after which they abruptly slid down for a few epidemiological weeks.

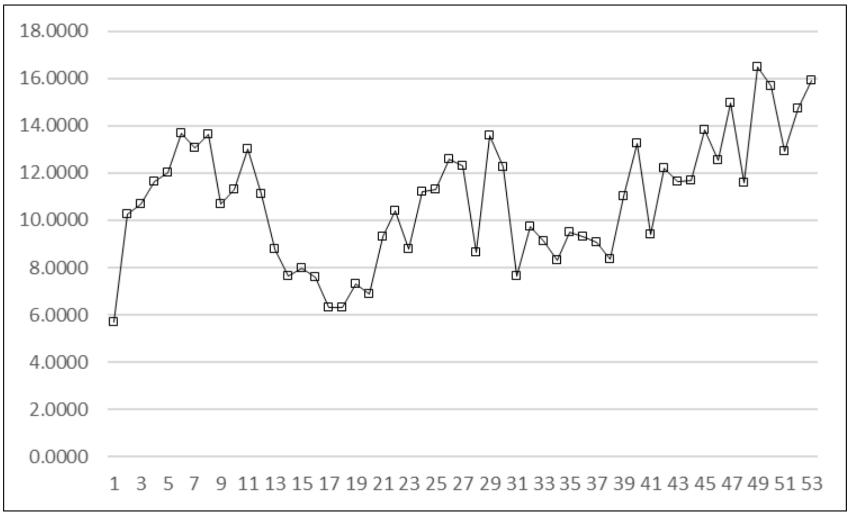

Figure 4. Temporal Evolution of DIR of Central Region, Averaged over the Period EW1-2014 – EW53-2014

Starting from epidemiological week 19 in May, a significant increase in the mean annual DIR can be observed. However, over the entire period, there is no clear trend of increasing or decreasing tendency, as the series appears to fluctuate up and down. In 2014, several peaks were detected in February, July, and December, as supported by [12], which showed serotype surveillance findings indicating a shift from DEN 4 to DEN 2 in March 2013, followed by a surge in cases from September 2013 to January 2014. Malaysia experienced two more serotype shifts in March and June 2014, with subsequent epidemic peaks from July to September of that year. The incidence of dengue in 2014 increased towards the later part of the year, in line with these findings.

Figure 5 illustrates a decrease in the mean annual DIR at the beginning of the year, spanning multiple epidemiological weeks. However, a notable increase can be observed from epidemiological week 15 onwards in April, with another peak occurring from epidemiological week 41 to week 51 in October. Similarly, in 2015, there were several peaks in February, July, and December, as reported by the Ministry of Health (MOH) which recorded 120,836 cases of dengue fever that year. Of these cases, 71,530 were from the central region, accounting for more than half of the total dengue incidence. These findings are consistent with MOH's epidemiology surveillance, which showed that 4 to 6 months after serotype shifts, there is a higher likelihood of a surge in dengue cases. Changes in serotype shifts in the community can lead to an increase in dengue cases and deaths due to a reduction in herd immunity to the new virus serotypes, as supported by researchers in [12]. At the national level, it is yet to be confirmed which dengue virus serotype caused the highest deaths in 2015, but regional incidence data suggest a possible shift from DENV-1 to DENV-2, in line with [13] where all four dengue virus serotypes were co-circulating, with DENV-1 and DENV-2 dominating, as reported by [11].

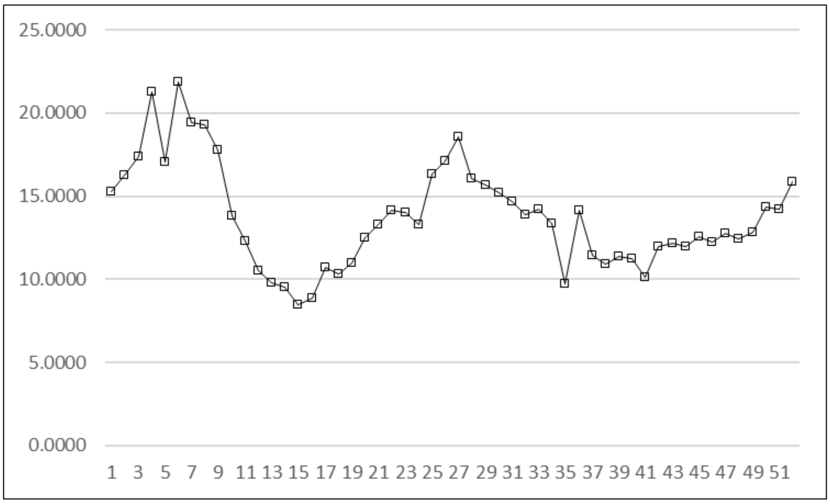

Figure 5. Temporal Evolution of DIR of Central Region, Averaged over the Period EW1-2015 – EW52-2015

In contrast to the trend observed in prior years, as depicted in Figure 6, the mean annual DIR sharply decreased in 2016, in comparison to the higher rates seen in 2014 and 2015. The highest peak in DIR was observed at the beginning of the year, continuing the trend from 2015. Consistent with 2016, Figure 7 depicts a declining trend, but the majority of cases occurred in the first half of 2017. However, throughout the course of the following six months, dengue cases appeared to be declining. Moreover, as evident from Figure 8, the dengue cases in 2018 followed a similar trend to previous years until May, when they began to peak (from epi-week 19 to epi-week 26), followed by a slight decrease, and then started to rise again from epi-week 37 in September. From that point onward, the trend showed a sharp increase, continuing through December.

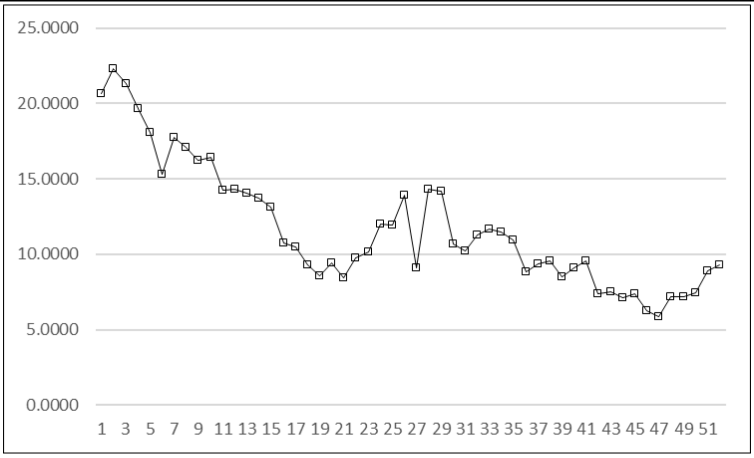

Figure 6. Temporal Evolution of DIR of Central Region, Averaged over the Period EW1-2016 – EW52-2016

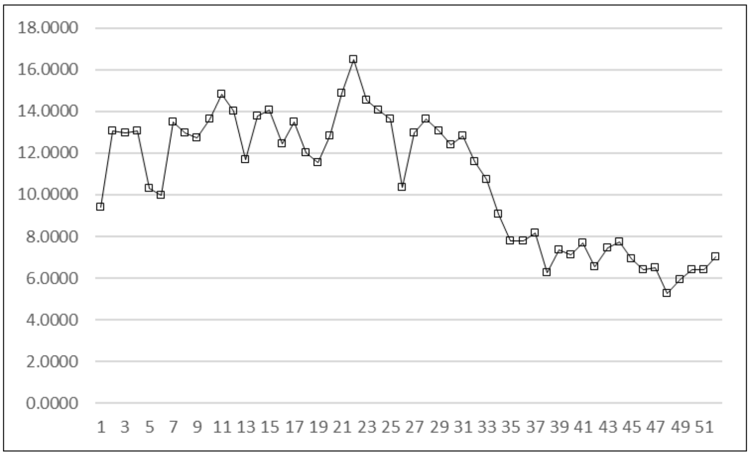

Figure 7. Temporal Evolution of DIR of Central Region, Averaged over the Period EW1-2017 – EW52-2017

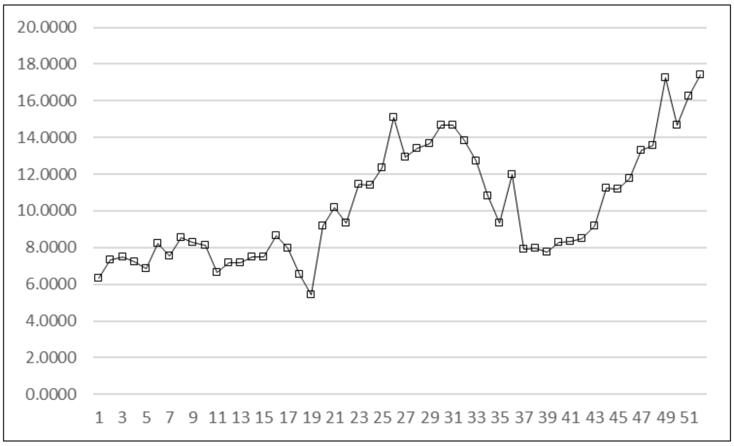

Figure 8. Temporal Evolution of DIR of Central Region, Averaged over the Period EW1-2018 – EW52-2018

The trend did not remain low compared to 2018, but instead rose in 2019. Figure 9 shows a decline that later took place across multiple epi-weeks at the start of the year. However, a notable increase in DIR can be detected from EW18 onwards. The highest DIR was recorded in EW30 and another peak was discovered in December, EW49. Overall, it is clearly seen the dengue outbreaks happened in 2015 and 2019. This finding supported the MOH Malaysia that reported the temporal incidence of dengue in 2015 and 2019 in country. The central Peninsular region, comprising mainly the Klang Valley (Selangor and Kuala Lumpur), was the most impacted by dengue. According to Ministry of health Malaysia, Health Indicators: 2017 to 2020, by locality, the incidence rates were highest in Selangor, followed by Kuala Lumpur-Putrajaya for dengue fever, whereas for dengue haemorrhagic fever, the highest incidence rates alternated between Selangor and Kuala Lumpur-Putrajaya in which both in central region.

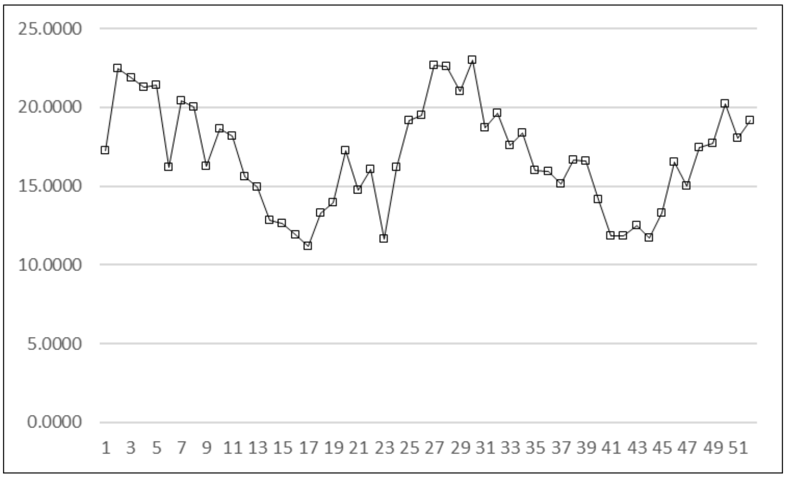

Figure 9. Temporal Evolution of DIR of Central Region, Averaged over the Period EW1-2019 – EW52-2019

4.2 Overall temporal evolution of DIR in Central region of Peninsular Malaysia

Figure 10 depicts the temporal evolution of dengue incidence rate (DIR) in the Central region, which may not be as conspicuous as in other geographical regions studied, such as Thailand [16]. However, the trend does show periodic fluctuations. When examining the temporal evolution of DIR for the 11 districts within the central region, averaged over the period from epi-week 1 in 2013 to epi-week 52 in 2019, a gradual decrease can be observed, followed by a notable increase within several epi-weeks at the beginning of the year. Additionally, a significant increment in DIR can be seen from May onwards (epi-week 20), with another peak observed from November onwards (epi-week 45). In conclusion, dengue fever poses a year-round threat across Malaysia with several peaks detected in February, July, and December. This study also found that the incidence of dengue tends to be higher in the later part of the year, particularly during November to February, when environmental conditions are conducive for mosquito breeding. Previous studies have indicated that dengue incidence may be influenced by climatic factors such as temperature, rainfall, and El Nino-Southern Oscillation [6], [11], [14]–[17].

Moreover, the climate of Selangor, Kuala Lumpur, and Putrajaya is influenced by two monsoonal winds. The northeast monsoon occurs between October and February, while the southwest monsoon prevails from May to September, with the transition phase known as the inter-monsoon period. From epi-week 9, there is a decreasing trend in dengue incidence rate until it reaches its minimum at epi-week 18, followed by a tendency to peak from epi-week 20 to epi-week 29 during the southwest monsoonal wind period. Subsequently, the incidence rate steadily increases until epi-week 29 and then declines from epi-week 30 to epi-week 41. Afterward, it tends to peak again from November (epi-week 45) until the beginning of the next year, coinciding with the northeast monsoonal wind period [18]. Studies have linked disease outbreaks, including dengue, to El Nino phenomena in various regions worldwide, such as Southeast Asia, Tanzania, western US, and Brazil, due to the profound impacts of El Nino Southern Oscillation (ENSO) on global climate[19]. Furthermore, global climate change has also been implicated in the spread of dengue, with countries in the Asia-Pacific region, such as Thailand, Vietnam, Laos, Singapore, and Malaysia, identified as potential hotspots for dengue transmission [20].

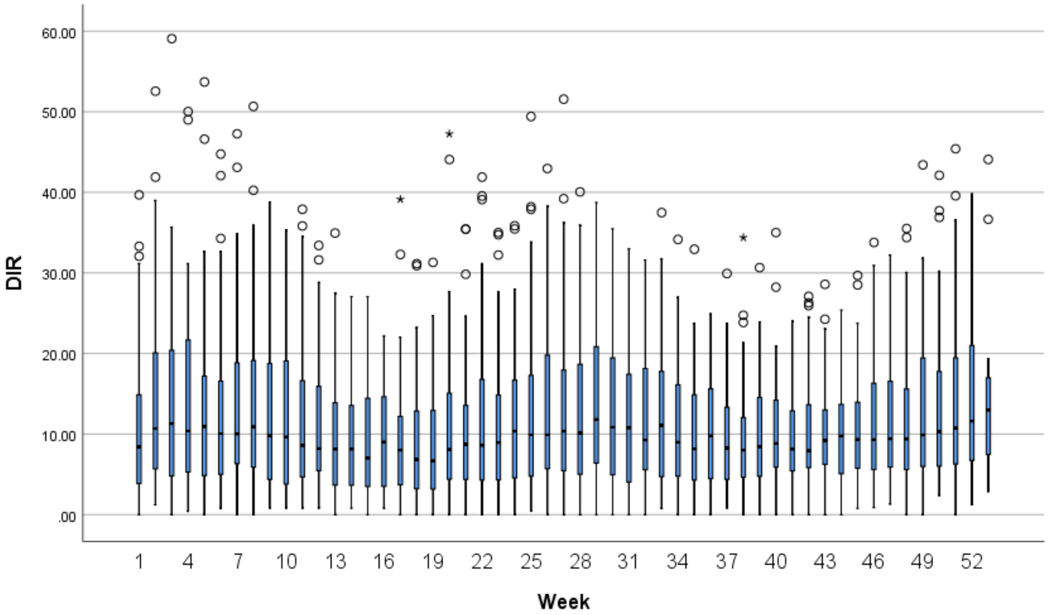

Figure 10. Temporal Evolution of DIR in Central Region, Averaged over the Period EW1-2013 – EW52-2019

5. Conclusion

This study is motivated by the urgent need to address the communicable disease burden caused by dengue fever, a mosquito-borne viral infection. Recognized as one of the top ten threats to global health by the World Health Organization, dengue fever remains hyper-endemic in many Southeast Asian countries, including Malaysia. Within the study period, Malaysia has reported a staggering 668,802 cases of dengue, with approximately 1,386 cases resulting in death. Notably, dengue fever has the highest incidence rate among communicable diseases at the national level in Malaysia, with peaks observed in 2015 and 2019, coinciding with the global spike in dengue cases in 2019. Moreover, the central region of Malaysia has consistently reported a significant number of dengue cases in 2019. This underscores the association between the rising number of dengue cases and increased urbanization levels, highlighting the need for policymakers to address the negative impact of urbanization on dengue incidence. Additionally, given that dengue is influenced by meteorological factors, future studies could incorporate a comprehensive analysis of meteorological and other relevant factors to better understand the dynamics of dengue transmission.

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Conflict of Interest

The authors declare no conflict of interest in the subject matter or materials discussed in this manuscript.

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