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RESEARCH ARTICLE

Spatial and Temporal Analysis of 2019 Novel Coronavirus (2019-Ncov) Cases in Selangor, Malaysia

Norezuan Abdul Gani[1], Nazri Che Dom[1,2], Rahmat Dapari[3], Nopadol Precha[4]

[1] Centre of Environmental Health and Safety, Faculty of Health Sciences, Universiti Teknologi MARA, UiTM Cawangan Selangor, 42300 Selangor, Malaysia

[2] Institute for Biodiversity and Sustainable Development (IBSD), Universiti Teknologi MARA, 40450, Shah Alam, Selangor, Malaysia

[3] Department of Community Health, Universiti Putra Malaysia, Serdang, Malaysia

[4] Department of Environmental Health Technology, School of Public Health, Walailak University, Thai Buri, Thailand.

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Correspondent email:
nazricd@uitm.edu.my

Abstract. The COVID-19 pandemic continues to wreak devastation on public health systems worldwide, particularly in Selangor, Malaysia, COVID-19 was reported from October 2020 to October 2021 at prevalent rate. In order to control and prevent the spread of this pandemic, which is already underway, there is need to comprehend the spatial dimension of this disease. Therefore, the purpose of this study was to describe the patterns of COVID-19 virus transmission in the state of Selangor. Methods: Using a Geographic Information System (GIS), and the Moran's Index (MI), spatial distribution of COVID-19 across the entire mukim was mapped and spatial statistical analysis was carried out with indications of local spatial correlations. Results: The finding revealed that the clusters were concentrated in the western and southern regions (Global Moran's I = 0.468, p = 0.05, Z = 7.01) of the state of Selangor, thus, this research provides important information on the regional distribution and temporal dynamics of COVID-19. Conclusion: An assessment of COVID-19's geographic spread can help enhance health care programs and resource allocation in Malaysia, specifically Selangor where the COVID-19 is pandemic.

1. Introduction

The novel coronavirus illness (COVID-19) has become a global health concern because of its high transmission rate and rapid spread. The COVID-19 pandemic has affected practically every country on World, wreaking havoc on our health system, economy, and culture (Sarkodie & Owusu, 2021). COVID-19, which first surfaced in December 2019 in Wuhan, China, has impacted millions of individuals. The World Health Organization (WHO) classified the outbreak as a pandemic due to its global impact (Alcantara et al., 2020). The WHO later classified the condition as a coronavirus disease in 2019 (COVID-19) (World Health Organization, WHO, 2020). The virus spreads quickly when individuals are gathered as it is transmitted mostly by airborne and direct interaction. Furthermore, the duration of the incubation period (Li et al., 2020) and the peak of transmissibility on or before the onset of symptoms (He et al., 2020) contribute to the disease's rapid spread throughout continents, resulting in an exponential rise in the number of infected people and millions of fatalities (Mackenzei & Smith, 2020).

Since July 2020, approximately 220 nations and regions worldwide have reported more than 17 million infections (WHO, 2020). As of January 1st, 2021, Malaysia had more than 115,078 confirmed cases of COVID-19 infection, with 474 deaths (Ministry of Health, MOH,2021). More than 33,169 instances have been confirmed in Selangor as of January 1, 2021(Rahim et al., 2021; Brohan et al., 2021). COVID 19 starts from asymptomatic to life-threatening respiratory problems. Fever, dry cough, dry cough, weariness, loss of taste or smell and dyspnoea are among the most commonly reported clinical signs of COVID-19. On average, symptoms begin to appear within 5–6 days of infection, although they might take as long as 14 days (Lauer et al., 2020; Yu et al., 2020). Acute respiratory distress syndrome (ARDS), pneumonia, bacterial superinfections, coagulation problems, sepsis, and mortality are all possible complications. Older age, diabetes, and cardiovascular disease have been related to poor results and an increased chance of mortality (Chen et al., 2020; Xu et al., 2020).

COVID-19 is due to SARS-CoV-2, an infection that is believed to have developed as a result of a bat spike mutation. This mutation enabled COVID-19 to infect humans (Angeletti et al., 2020). SARS-CoV-2 is classified into three strains: strain A, which strongly matches the bat coronavirus. Numerous epidemiological, ecological, and statistical models have been used to track the progression of the global COVID-19 pandemic, as well as to examine its spread and predict its future trends (Chu, 2021; Han et al., 2021). COVID-19 epidemiology and

Figure 1. Selangor map showing district.

clinical characteristics, transmission markers, and population distribution were the primary focus of most of this research. To allocate scarce resources effectively, it is vital to understand the temporal and geographical patterns of COVID-19 infection. Therefore, the aim of this study is to determine and analyse the trends of COVID-19 cases and their spatial distribution in Selangor, Malaysia. This research contributes to the effective control and decision-making process in the event of CIVID-19 outbreak in the future.

2. Methods

Study Areas

Malaysia is in Asia, with an equatorial climate of hot and humid for most of the year, the country has population of about 27.5 million population in 2020 (National census), (Department of Statistics Malaysia, 2020). Malaysia is divided into regions among are East Malaysia (hilly area) and West Malaysia (flat land area) regions that are separated by the South China Sea. Selangor is located on Peninsular Malaysia's western coast, north of Melaka's north shore and overlooks the Malacca Straits with population of about 5.3 million distributed in nine districts. Selangor has an area of about 8,000 km2, latitude 3° 46' 10.5636" N to 2° 41' 35.16" N and longitude 100° 59' 1.158" E to 101° 44' 59.28" E. The southwest and northeast monsoon seasons dominate Selangor's rainfall patterns of 5000 and 1750 mm, daily average temperature is between 25 and 28 OC as described by (Suhaila et al., 2010) Selangor has a tropical rainforest with 250,129 hectares of forest reserve and 82,890 hectares are peat swamp forests, and 18,998 hectares are mangrove forests along the shore. About 32% of the state's territory is reserved as a permanent reserve forest with 13.21 million hectares of land that covers approximately 43.6% of Peninsular Malaysia (Forestry Department) (Figure 1).

Data Collection

The laboratory confirmed positive COVID-19 ceases from October 2020 to October 2021 were aggregated from information provided by district health offices to state health departments through the scientist. These ceases were sorted, and each is included in this dataset, as well as the district in which it occurred. The demographic characteristics of COVID-19 cases were analysed using a state-level descriptive epidemiological study. SARS-CoV-2 (the virus that induces COVID-19) is mostly spread via respiratory droplets. The three primary methods of infection are as follows: (1) inhaling tiny respiratory secretion and aerosol particles, (2) splashing and spraying respiratory secretion and particles in their mouths and eyes, and (3) touching their mucous membranes with hands sullied by virus-containing respiratory fluids or by touching virus-infected surfaces (WHO, 2020). Furthermore, The open-source platform of the Department of Statistics Malaysia provided the population statistics for Peninsular Malaysia (Department of Statistics Malaysia).

Spatial Analysis of COVID-19 in Selangor

Between October 2020 and October 2021, a spatial analysis was carried out at the district level in Selangor. To account for the raw incidence rate's extreme skewness as a result of outliers and divergence from variance normality, the yearly square root transformed incidence rate (IR) per million people was determined for each district. We calculated the annual year population for each district from 2020 to 2021 (Department of Statistics Malaysia) using 2020 National Census data and yearly state population growth estimates from the Department of Statistics Malaysia, presuming that each district's rate of population growth was equal to the population growth rate of the state and a precise estimate of annual IRs was derived from the yearly population calculations.

When it comes to identifying disease hot spots and spatial autocorrelation, Moran's I statistics were used both globally and locally. It was decided to use the first order queen contiguity spatial weight matrix for the purpose of defining districts as neighbours for the sake of further analysis that share borders and vertices. Using the Global Moran's I test to discover COVID-19 infections' spatial autocorrelation. Index values can indicate random distribution (values close to zero), clustered distribution (close to +1.0) or dispersed but organised distribution (value close to -1.0) (Moran, 1948). The equation for Global Moran's I is as follows:

$$I = \frac{n \sum_{i=1}^{n} \sum_{j=1}^{n} w_{ij} (x_i - \bar{x})(x_j - \bar{x})}{(\sum_{i=1}^{n} \sum_{j=1}^{n} w_{ij}) \sum_{i=1}^{n} (x_i - \bar{x})^2}$$

where n is the number of observations, is the variable's mean, is the variable value at a particular location, is another location variable value, is a weight indexing location of i relative to j. The Local Indicators of Spatial Association (LISA) data is utilized to discover statistically significant infection spatial clusters (hot and cold spots) and identify outliers using Local Moran I. The following equation describes the local Moran I statistics:

$$I_i = z_i \sum_{j} w_{ij} z_j$$

Wth and are in deviations from the mean. LISA values are clustered into four groups: high-high, low-low, high-low, and low-high (Anselin, 2010). Clusters with a high IR intensity (hot spots) are related with high-high clusters, whereas clusters with a low IR intensity are connected with low-low clusters (cold spots). Outliers are classified as high-low and low-high. Monte Carlo simulation with 99,999 permutations was used to calculate the p-value for both tests. To minimise alpha risk (Type I error), the False Discovery Rate (FDR) correction was used, which resulted in p-value = 0.001 being determined as the significance cut-off. Moran's I tests were conducted globally and locally using Geo Da 1.18.0. (University of Chicago, Chicago, IL, USA). COVID-19 geographical and temporal patterns in Selangor from October 2020 to October 2021 were visualized using ARCGIS 10.6.1.

3. Result and Discussion

In Selangor, 705,256 cases were reported during October 2020 to October 2021. Petaling district had the highest percentage of cases, with 208973 (29.63 percent), followed by Hulu Langat district (20.22 percent) and Klang district (19.94 percent) (Table 1). From October 2020 to October 2021, the largest number of cases was reported in August 2021 at 196,000 COVID-19 cases.

Spatial Temporal Demographic Characteristics of COVID-19 from October 2020- October 2021

The result of spatial temporal demographic characteristics of COVID-19 from October 2020- October 2021 is detailed in (Figure 2). From the result, temporal COVID-19 disease distributions in Selangor, a few significant patterns revealed that the number of COVID-19 disease cases in Selangor has increased significantly in recent months. The scheme of monthly cases showed an increasing trend from October 2020 to January 2021. The worst COVID-19 disease cases were recorded in August 2021 in Selangor, with an average of more than 196,000 cases reported. By referring to both sets of distribution trends for each month (Figure 2), the pattern is quite similar for the entirety of Selangor state; it revealed a consistently different movement control order pattern of COVID-19 disease throughout the year from 2020 to 2021.

Determination of spatial autocorrelation of COVID-19

COVID-19's geographical autocorrelation was calculated using sampled data from October 2020 to October 2021. The Global Moran's I test found a positive and significant spatial autocorrelation in the research region (Global Moran's I = 0.468, p = 0.05, Z = 7.01) (Figures 3). This indicated that the incidence of COVID-19 was geographically dependent and concentrated in Selangor.

Then, a local Moran's I test were used in order to identify the primary hotspots (high-high spatial groupings) in five districts (Figure 4). A cold spot (low–low spatial clusters) including three districts was identified near big cities. All hotspots were concentrated in high-density areas (1,305 persons per square kilometer on average), whereas cold spots were concentrated in low-density areas (average of 34 people per square km) (Table 2). High-high spatial cluster were identified in 9 mukims. The highest mukim was recorded in Klang (LISA; 4.04), followed by Petaling (LISA; 2.77) and Damansara (LISA; 2.65). Low-low spatial cluster were identified mostly in northern part of Selangor. These mukims had low incidence of COVID-19 and had low population density.

Table 1. Incidence rate of COVID-19 cases reported in Selangor

District	Number of Cases	Population	IR
Sabak Bernam	4196	103709	4045.94
Kuala Selangor	23225	205257	11315.08
Klang	140631	831701	16908.84
Kuala Langat	38497	220214	17481.63
Petaling	208973	1765495	11836.51
Sepang	39822	207354	19204.84
Hulu Langat	142631	1138198	12531.30
Gombak	87256	668694	13048.72
Hulu Selangor	20025	194387	10301.61
Total	705256	5335009	13219.40

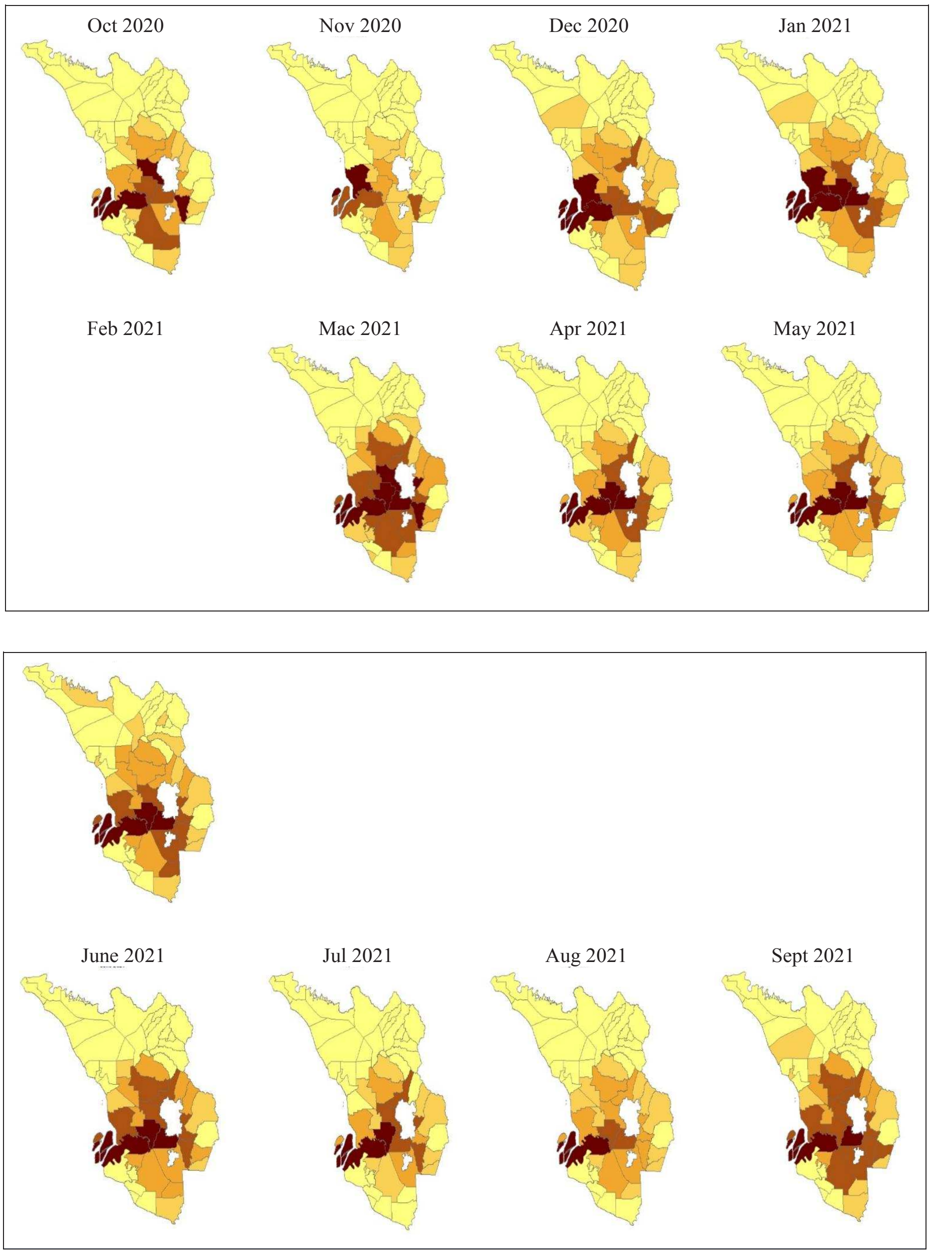

Figure 2. The temporal distribution of COVID-19 diseases for a continual period from October 2010 to September 2021

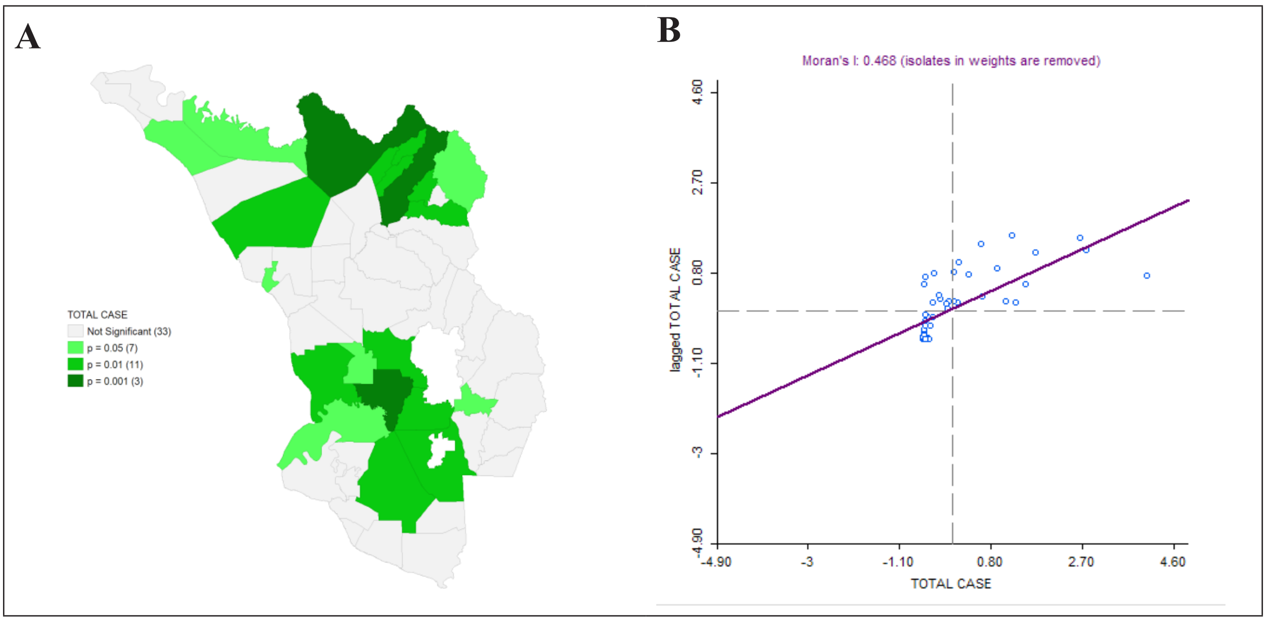

Figure 3 (A) LISA significant map and (B) Moran's Index of COVID-19 cases.

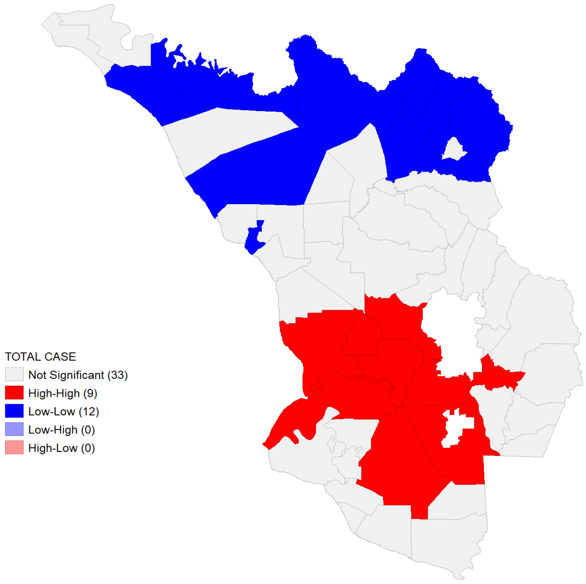

Figure 4. (A) District-level hotspot and cold spatial clusters of COVID-19

Table 2: Statistically significant mukim level spatial clusters of COVID-19 based on IR

Cluster Type	Mukim	Total Cases	IR	LISA Index	*p* -Value
High-High	Sg Buloh	50303	10790.86	1.73	0.01
	Bukit Raja	15723	13339.39	0.12	0.05
	Kapar	39590	15053.58	1.23	0.01
	Cheras	32952	13473.83	0.92	0.05
	Petaling	72781	12061.22	2.77	0.01
	Klang	101041	17766.79	4.04	0.05
	Dengkil	25684	15069.06	0.59	0.01
	Tanjung 12	20069	20444.36	0.33	0.01
	Damansara	70166	13580.53	2.65	0.001
Low-low	Sg Bedena (A)	626	7306.26	0.55	0.05
	Pancang Bedena (B)	1584	4055.82	0.53	0.05
	Kerling (C)	253	6804.73	0.58	0.001
	Kalumpang (D)	538	22013.09	0.61	0.01
	K. Kalumpang (E)	1	27.74	0.61	0.01
	Sg Gumut (F)	1	58.72	0.58	0.01
	Ampang Pecah (G)	1144	10830.93	0.53	0.01
	Tg Karang (H)	2201	7187.17	0.50	0.01
	Rasa (I)	695	23174.39	0.58	0.01
	Kuala Selangor (J)	2261	19409.39	0.50	0.05
	Hulu Bernam (K)	755	2830.79	0.58	0.001
	Pertak (L)	50	3526.09	0.59	0.05

Note: IR: Incidence rate

Discussion

This study demonstrated the fundamental epidemiology of dengue cases infection across all district in Selangor, Malaysia with a high prevalence location of COVID-19 were located in southern part of Selangor, specifically in Petaling district. These locations were identified as high number of incidence of COVID-19 due to many factors which related to environmental factors, high population density, movement of the population and urbanization (Abd Rashid et al., 2021; Rocklov & Sjodin, 2020; Neidderud, 2015). This is because it is more challenging to manage the movement of individuals in areas with a high population density, which in turn leads to a more uneven distribution of cases. For infectious disease to spread rapidly, human interaction rates are crucial, and super-connected incubators like dense populations and expansive cities in megaregions or megacities play a role in this.

The substantial increase in COVID-19 cases in these districts is attributed to workplace-related cases and the workforce. How workers live, how clean they are, and their home and work environments might make them sick. COVID-19 transmission among non-citizen labour is a concern. Employers can educate workers on personal hygiene, the work and home environment, and prevention. In addition to maintaining physical distance, staff in the workplace and lodging must follow infection control practices. Physical distance measures and resident compliance can reduce disease spread, although the time it takes varies by policy (Chung & Chan, 2021; Bischoff et al., 2013). In August 2021, daily COVID-19 incidences increased due to active detection and screening testing in the EMCO area. EMCO conducts intensive detection and screening testing to control COVID-19 (Ting et al., 2021). During the screening test, positive individuals will be segregated and treated according to infection category, while category four and five patients will be referred to hospital for intensive care. These detection activities should identify asymptomatic people so they can be separated and transmission stopped.

The rise in daily cases in Selangor is attributable to the dissemination of COVID-19, which is larger than the number of daily positive cases. Patients who are asymptomatic or pre-symptomatic can potentially transfer the infection. Some infected people have no symptoms, and 80% recover without therapy (WHO, 2020). There have been cases of COVID-19 infections from one person to another before the person was aware they were unwell, or the symptoms were so minor. The vaccine is effective two weeks after inoculation. The spread of novel variations with higher infection rates also increased cases. Our study examined COVID-19 in Selangor. During the epidemic's primary development stage (August), many regions had more than 1000 cumulative cases, indicating that most infected people were undetectable due to the virus's incubation time. The rise in incidence from March to May 2021 shows that the infections are spreading. Population cross-migration assisted this fast spread. An infectious disease spreads when a pathogen infects a new host (Leung, 2021). Due to increasing population migration in Klang district, the spatial distribution of cumulative COVID-19 cases has widened. In the research region, cumulative occurrences are distributed randomly. The government's social punishment scheme clusters accumulated incidences.

According to a spatial study, the high IR of COVID-19 was concentrated in the southwest region of Selangor. When compared to the other districts in this area, Klang and Sepang had the highest IR levels. Because the majority of infected people work in industry, there are likely to be frequent workplace hazards in these two industries. As a result, the likelihood of coming into contact with COVID-19 rises in tandem with population density. According to the 2020 census on population density covering all counties, manufacturing has the highest population density, followed by construction and agriculture, most likely due to abundant employment resources. According to Murti et al. (2021), 199 outbreaks occurred at work in Ontario, with manufacturing accounting for 45%, agriculture, forestry, fishing, and hunting accounting for 13%, and transportation and warehousing accounting for 11%. These three industries were responsible for 56%, 16%, and 8% of all epidemic cases, respectively. In this study, COVID-19 hotspots were discovered in several districts throughout the state of Selangor. As a result of these findings, the COVID-19 control programme will be able to develop more effective COVID-19 intervention strategies, especially in the districts of Klang, Petaling, and Hulu Langat. Furthermore, monitoring clustered districts as hotspots is critical because virus spreading across districts can occur as a result of cross-district human mobility carrying the virus or long-distance transmission from home to office. According to research conducted in Africa, the virus is frequently detected in the workplace (Nwagbara et al., 2021). Until now, the transmission behaviour of the COVID-19 virus in Malaysia has not been thoroughly investigated. This points to a knowledge gap that must be filled in order to comprehend the relationship between the environment and the occurrence of cases. This study also presents the current state of the art of how GIS science plays a role in achieving the Sustainable Development Goals (SDGs). The study not only presents the current state of research, but also shows how GIScience can help accelerate the issues to achieve the ultimate goal of sustainability.

4. Conclusion

This research focuses on the spatial temporal pattern of COVID-19 in Selangor, Malaysia, at the district scale. Modern GIS technologies are capable of improving data sharing and supporting critical decision making. Map-based communications provide people with accessible information to protect themselves and their communities. This tool can improve data transparency and help policymakers disseminate information and focus their intervention efforts in combating this disease.

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Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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