ORIGINAL ARTICLE

Spatial and Temporal Analysis of Covid-19 in Sibu, Sarawak

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ABSTRACT

Introduction: The high incidence of COVID-19 highlights the need for better understanding of the factors that contribute to disease transmission and its geographic distribution, which could help predict global outbreaks and enhance public health initiatives. The aim of this study was to analyse the spatio-temporal pattern based on the weekly COVID-19 surveillance data in Sibu, Sarawak. **Methods:** This is a retrospective study involving secondary COVID-19 data obtained from Sarawak State Health Department report of cases in Sibu division from weeks 1-26 in 2021. Data were analyzed using IBM SPSS and ArgGIS (Kernel Density Analysis and Average Nearest Neighbour Analysis). **Results:** According to the summary report of Average Nearest Neighbour Analysis, the nearest neighbour ratio is equal to 0.020554, with a z-score of -229.845638 and a p-value of 0.00000. The pattern displays clustering because the average nearest neighbour ratio, or index, is smaller than 1. With a z-score of -229.845638, the chances that this clustered pattern is the result of random chance is less than 1%. Analysis also revealed that all districts had a clustered pattern. **Conclusion:** Spatial and temporal analysis can also offer an evidence-based approach for prevention and control activities, not just for COVID-19 but also for other infectious diseases. In this study, district level maps of the COVID-19 distribution were created to provide detailed information to the local public health authorities so they may create appropriate SOPs or interventions to control the COVID-19 outbreak.

Keywords: Spatial analysis; Temporal analysis; COVID-19; Public health

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INTRODUCTION

As the most recent pandemic in human memory, it stands to reason that COVID-19 will remain fresh in the minds of the global population for the next several years. Most would still remember how it started, with only several cases initially found in Wuhan, China. In December 2019, China notified the outbreak of the COVID-19 to the World Health Organization, prompting officials to take actions by closing down the market that was believed to be the source of the outbreak. However, cases spread rapidly, first throughout China, before finally entering the international community. Globally, the number of infected people with COVID-19 is 17 times that of he SARS-CoV outbreak in Guandong, China, in 2003 and 50 times that of the MERS-CoV outbreak in 2012, which had also become a global public health concern (1).

Although data on COVID-19 is now widely accessible, there is still much to be learned. Additionally, given that COVID-19 is now in its endemic phase, the global health community needs to have the understanding and resources necessary for better monitoring of this disease, particularly for public health workers. To that end, numerous studies on spatial and temporal analysis have been conducted. For instance, a COVID-19 study was conducted in Nepal, and the findings of the spatial analysis were beneficial to the relevant authorities in helping them make appropriate decisions and carry out a comprehensive assessment and management that included the implementation of efficient public health measures in the various provinces of Nepal (2). Meanwhile, in the United States, a study employing spatial transmission showed the main regions that will be the focus of public health efforts to reduce COVID-19 outbreaks (3). A case study in Iraq used GIS spatial analysis to illustrate the spread risk of COVID-19 across the entire country, through a comparison of maps between the distribution of actual and predicted infected individuals across all of the provinces (4). These maps allow decision-makers in the health and government sectors to anticipate events in order to develop proactive plans to combat the disease. In addition, a study of GIS-based review for monitoring spatial distribution of COVID-19 in Haryana has been carried out to map the real-time mapping of infected area at a variety of zones since it was so beneficial in making cooperation among other supporting agencies easier (5).

The examples given make it evident that GIS is a great tool since it aids in better planning, decision-making, and mobilization, particularly by offering more tools for the dynamics of spatial transmission, and it helps to improve infection count estimations. The usage of this technique is also possible for identifying potential new outbreaks, enhancing the location of health care facilities and controls, comprehending and mapping people mobility, and other related tasks (6). In fact, the use of temporal and spatial analysis will increase precision public health through possibilities for targeted surveillance and intervention, thus allowing for better pandemic management (7). With the aim of providing the right intervention at the right time, precision public health makes use of a combination of already accessible technology to enable a more precise description and analysis of people and their surroundings over the course of a person's life. This improves population health overall and enables customization of preventative actions for at-risk populations.

In Malaysia, COVID-19 was confirmed to have reached the country in January 2020, following the first outbreak in Hubei Province, China (8). Within a few weeks, Malaysia had recorded the largest cumulative number of confirmed COVID-19 infections in Southeast Asia, breaching the number of 2000 active cases by the end of March 2020 (9). Since then, various study has been conducted to better understand the spatial and temporal analysis of COVID-19 in this country; and this particular study is one of the effort made towards better management of COVID-19. To note, this study concentrated primarily on a central division in Sarawak, Malaysia, rather than the whole country. Unlike other regions of Malaysia, Sarawak's population is distributed uniquely, which is why is it used as a case study for this research. Even though the government had offered a variety of resources to help the state manage the rising number of cases, the high rise of COVID-19 cases in 2021 put a pressure on Sarawak's public health system (10). As most of the COVID-19 cases in Sibu were from longhouse, this made the study location more unique. In longhouse's structure, the veranda area, also referred to as the "ruai," was connected to each other, and made it difficult to control how people moved inside the longhouse (11). Before Malaysia's ban on interstate travel on January 13, 2021, COVID-19 clusters had already started in Sibu (12). Sibu, a district in Sarawak, had reported 37 COVID-19 positive cases on 9th January, 2021, which kickstarts the emergence of the first cluster in Sibu, known as Cluster Passai (13).

For the record, no spatial temporal analysis of COVID-19 had been done in Sarawak nor Sibu, and this study can pave the way for further study on epidemiology towards precision public health. This study may be useful for the management of other infectious diseases as well as the early case detection of future outbreaks and pandemics. Understanding the geographic distribution of the infections is crucial for forecasting local epidemics and developing public health interventions. The spatial distribution and clustering pattern of COVID-19 cases from January to June 2021 were mapped using temporal and spatial analysis, which will assist in identifying potential high-risk regions. Undoubtedly, more precise disease surveillance can also reveal disease causes for improved prevention methods. Understanding the spatial and temporal dynamics of COVID-19 is essential for mitigation as it facilitates planning, decision-making, and community action.

MATERIALS AND METHODS

Data collection

This is a retrospective study using COVID-19 data obtained from reports of cases in Sibu from weeks 1-26 in 2021. The cases were from Sibu Division, which consist of Sibu, Kanowit and Selangau. The data used is the cumulative cases of COVID-19 that are registered in the Sarawak State Health Department, from the Ministry of Health. All confirmed cases were downloaded from e-notification (CDCIS) system and imported into Microsoft Excel 2007. The information from the downloaded data only included basic information of patients, such as name, age, occupation, and case's location coordinates.

Statistical Analysis

Data were analyzed using IBM SPSS Statistical software version 21 (IBM SPSS Statistics) and ArgGIS software version 10.8.2 (Kernel Density Analysis and Average Nearest Neighbor Analysis). The following formulas define how the kernel density for points is calculated and how the default search radius is determined within the kernel density formula.

Predicting the density for points;

The predicted density at a new (x,y) location is determined by the following formula:

$$Density = \frac{1}{(radius)^2} \sum_{i=1}^{n} \left[\frac{3}{\pi} \cdot pop_i \left(1 - \left(\frac{dist_i}{radius} \right)^2 \right)^2 \right]$$

For $dist_i < radius$

where:

- i = 1,…,n are the input points. Only include points in the sum if they are within the radius distance of the (x,y) location.
- op_i is the population field value of point i, which is an optional parameter.
- $dist_i$ is the distance between point i and the (x,y) location.

The calculated density is multiplied by the number of points or the total population field. With this adjustment, the spatial integral will no longer always equal 1, but will instead equal the number of points (or sum, or population field). This implementation makes use of a Quartic kernel (14). Every location's density has been calculated using the formula. The calculations are applied to the centre of each cell in the output raster since a raster is being generated. For distance analysis, the Average Nearest Neighbour (ANN) method is used. The results of the ANN analysis give the p-value and z-scores of the COVID-19 cases. As a result, the distribution's pattern can be divided into three categories: clustered, dispersed, and random.

RESULTS

Fig. 1 displays the COVID-19 cluster's within the Sibu division. From the figure, more than 15 different clusters emerged in the first half of 2021 with the biggest being the Passai cluster located in Sibu district. Meanwhile, the epidemic curve of COVID-19 cases in the Sibu division for the first half of 2021 is depicted in Fig. 2. Epidemic curves, or epid curves, are helpful because it can reveal details about the pattern of spread, magnitude, outliers, time trend, and the duration of exposure to the disease or its incubation period (15). Although the graph only displayed the overall number of COVID-19 cases for the first half of 2021, it is obvious that since the start of Passai cluster near Sibu/Selangau border (Fig. 1) in second week of January, there were daily records of more than 5 cases. The most cases ever reported were on May 7, 2021, at 245 cases. Table I displays the incidence rate, infection rate, and mortality rates for Sibu from January to June 2021. Sibu district had a total incidence rate of 5029.56, followed by Kanowit with 5443.12 and Selangau with 5775.89, with Sibu district having a rate of 4912.60. Selangau district had the highest Infected Rate (IR) (57.75888514%), Kanowit district came in second (54.43116668%), and Sibu district came in third (49.12599044%). In the first half of 2021, the COVID-19 death rate was over 1.0% in both the Sibu and Selangau districts. All population data were obtained from the Sarawak Government's official website (16).

Fig. 3 displayed the COVID-19's overall trend broken down by district and epidemiological week (EW) starting from January until June 2021, while Fig. 4 presents visualization of the same data. As seen in Fig. 3, Sibu district had the highest overall number of cases with 12,207 cases reported for the first half of 2021. Since the Passai cluster, more cases were reported with EW7 recording the highest number at 718 cases. In contrast, the overall number of cases in the Kanowit area increased in EW3 (134 cases)

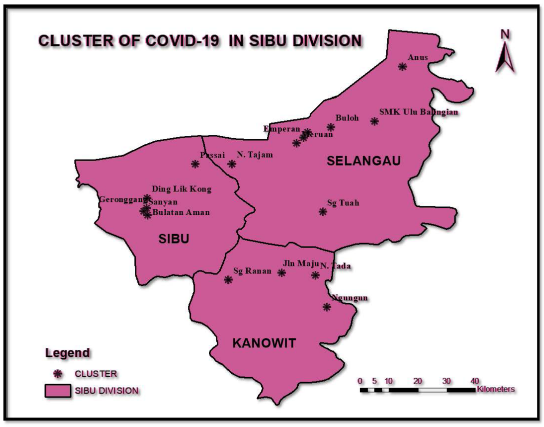


Fig. 1 : Clusters of Covid-19 in Sibu Division.

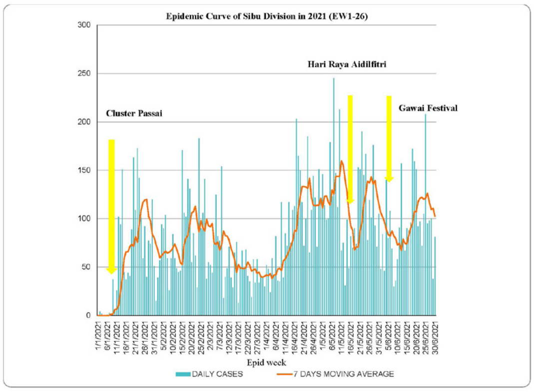
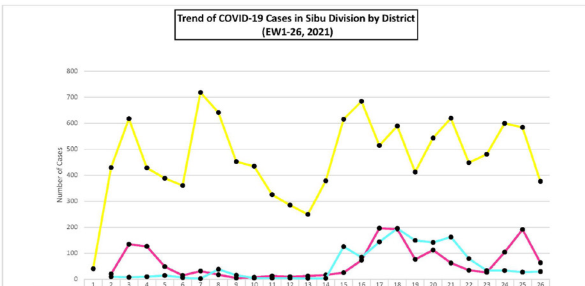


Fig. 2 : Epidemic Curve of Sibu Division (Half year of 2021).



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
KANOWIT		20	134	126	48	14	31	17	4	7	12	9	12	16	25	73	196	192	76	112	62	34	26	104	191	63
SELANGAU		9	7	9	14	6	2	38	15	4	4	4	3	3	125	84	143	195	149	141	162	79	33	33	27	29
SIBU	40	429	617	428	388	360	718	641	452	434	325	285	249	378	615	684	514	589	412	543	619	448	480	599	584	376

Fig. 3 : Trend of COVID-19 Cases according to Districts (Half year of 2021).

Table I : Summary of Descriptive Statistic of COVID-19 in Sibu (Jan-June, 2021)

Districts	Total Cases	Population	Incidence Rate per 100,000	Infected Rate (IR) per 100	Death Rate (DR) per 100
Sibu	12,183	247,995	4912.60	49.12599044	1.05064434
Kanowit	1,576	28,954	5443.12	54.43116668	0.697969543
Selangau	1,318	22,819	5775.89	57.75888514	1.062215478
Total for Sibu division	15,077	299,768	5029.56	50.2955619	1.014790741

and EW4 (126 cases). Following a somewhat stable number of cases, EW17 recorded a jump in the number of cases (196 cases) in Kanowit. Overall, in Kanowit with 1,604 number of cases were reported during the first half of 2021. Unlike Sibu and Kanowit, however, the trend in the Selangau were flat initially. Cases increased starting from EW15 with Selangau recording 1,318 cases overall for the first half of 2021.

Fig. 5 displays the hotspots that was calculated using Kernel Density Estimation (KDE). The map displayed the spatial distribution of COVID-19 cases over a six-month period. Red indicated high, yellow indicated low, and green indicated no cases. The figures are organized according to the months, starting with January (A), February (B), March (C), April (D), May (E), and ultimately June (F). Based on these figures, it is evident that between January and March 2021, Sibu district exhibited the majority of the cases. For Kanowit and Selangau, however, a lot of changes at the division level were observed after April, although still lower than Sibu district. Even though clusters had developed in all of Sibu's divisions, only Sibu district presented bigger clusters (as evidenced based on the colour red) compared to the other two districts. Within the six months, the pattern began to gradually spread from Sibu districts to other districts, affecting not only Sibu division but the entire state of Sarawak. The clusters in the Sibu division mainly emerged after the Passai cluster, which is the largest cluster.

Fig. 6 depicts the COVID-19 Average Nearest Neighbour (ANN) Summary for the Sibu division. Almost similar to the KDE result in Fig. 5, the ANN test is appropriate for infectious diseases like COVID-19 because it not only graphically displays the hotspot pattern but also displays the significance level of the data under test. ANN provides a detailed explanation of what had occurred in the Sibu division between January and June of 2021. The Sibu division map polygon in shapefile was also used to execute this test, along with the data that was evaluated using the coordinates of each COVID-19 case. Fig. 6

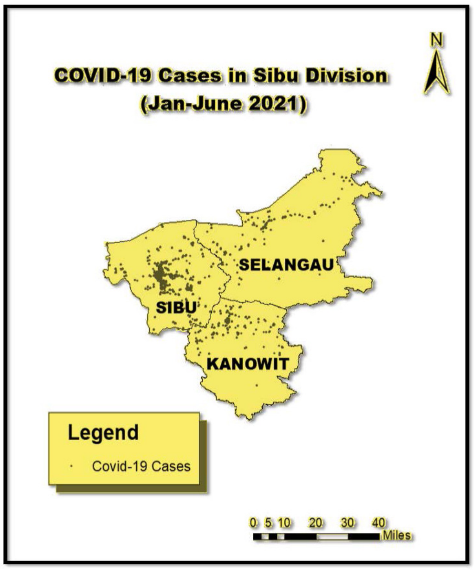


Fig. 4 : Spatial Distribution of COVID-19 in Sibu Division in 2021 (Jan-June).

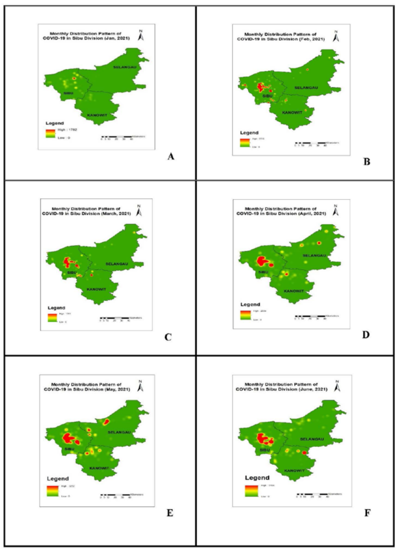


Fig. 5 : Hotspot Identification of COVID-19 in Sibu Division.

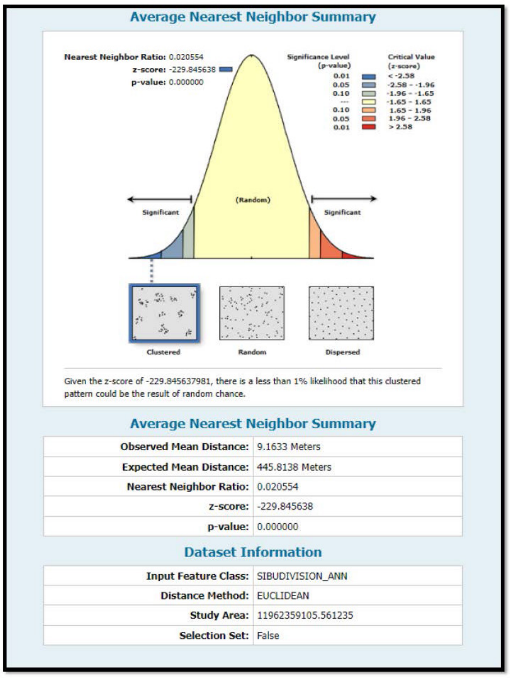


Fig. 6 : Average Nearest Neighbour Summary of COVID-19 in Sibu Division.

indicates the summary report. According to the figure, the nearest neighbour ratio is equal to 0.020554, with a z-score of -229.845638 and a p-value of 0.00000. The pattern displays clustering because the average nearest neighbour ratio, or index, is smaller than 1. This is expected, as COVID-19 is an infectious disease, therefore easily transmitted. In fact, with a z-score of -229.845638, the chances that this clustered pattern is the result of random chance is less than 1%. The result of the ANN highlights the need to strengthen prevention measures as well as to better understand the risk behaviours associated with the spread of COVID-19. Since COVID-19 infections can spread from one person to another via airborne or airdrops, clusters emerged rapidly. This puts not only additional burden on public health officers to maintain stringent prevention measures, but also to the public, as close contact carries high risk of transmission.

DISCUSSION

The study's findings revealed a significant variation in the spatial distribution of COVID-19 incidence in Sibu division, as well as the fact that the geographic range of confirmed cases has expanded over time in other districts: Kanowit and Selangau. There were certain reasons why there were high number of cases in certain period. For example, the Hari Raya and Gawai festival that falls on 13 and 14 May 2021 (EW19) and 1 and 2 June 2021 (EW22) meant that high rate of samples collected before Sarawakians celebrated Aidilfitri (Muslim holiday celebrated after Ramadhan) and Gawai Festival (holiday celebrated by Dayak ethnic in Sarawak) is mostly to blame for the high number of occurrences, as travelers were required to take tests prior to their journey, even when moving between districts. Despite the mass testing and the application of other Standard Operating Procedures (SOP) for the Gawai and Aidilfitri festivals, all failed in flattening the epid curve. Not only that, The Health Ministry of Malaysia also suggested keeping the prohibition on interstate travel throughout the Eid holiday season, yet the number of COVID-19 cases was still increasing (17). Following the increase of the number of cases during Eid season, claims were made that numerous Muslims disregarded the COVID-19 safety regulations that forbade them from seeing one another, bringing the Malaysia's overall cases to 549,514 with 2,552 fatalities. Additionally, about 40% of COVID-19-related deaths in Malaysia had taken place during that festive month (18). Not only that, although measures were in place to reduce movement during the following Gawai Festival, the epid curve still did not flatten (19). The epid curve highlights that despite measures, it is difficult to restrict the number of cases at times of high population density, such as Cluster Passai or any cluster that occurred after Aidilfitri and Gawai. Regardless, the epid curve highlights the potential to anticipate a high number of new clusters following a specific time or period, such as a huge gathering or any celebrations. Therefore, this can be used as a monitoring tool to increase public health vigilance.

Additionally, in contrast to Sibu district, the other two districts do not have nearly as many cases, despite having a few clusters. The significant number of cases that were registered in Sibu districts was also largely due to the highly convenient facility that Sibu offered for handling COVID-19 cases. As COVID-19 cases were reported under the district where the patients were tested, this undoubtedly had an impact on Sibu's COVID-19 statistics and indicates the need to organize the COVID-19 outbreak response better.

Not only that, Sibu district also serves as the geographic centre of Sarawak state as well as the centre of Sibu division. People who drive or relocate to another division for work tend to stay in the Sibu district before moving to another districts. Due to its localized position between other divisions such as Bintulu, Sarikei, Kapit and Mukah, Sibu is a convenient address to reside in. In fact, during the first two years of the pandemic, anyone entering the Bintulu division was required to submit to a COVID-19 test, and since Sibu division was where most individuals were tested, it is thus where the cases were registered. All of this contributed to the high number of cases in the district.

The findings of this study, which provide details on the epidemiological distribution of COVID-19 in Sibu division, can be used to help develop more precise public health measures that will lessen the effects of viral transmission. Overall, KDE was used to portray the overall condition that existed in the Sibu division and to visualise the COVID-19 cases, while ANN was crucial in identifying whether the pattern of distribution was clustered, dispersed, or random. It also lays the foundation for future studies on socio-demographic factors that affect changing disease patterns. The results can also be used to identify hotspots, or areas that require more organized surveillance and public health measures.

CONCLUSION

By utilising GIS technologies, this study was able to visualize the COVID-19 distribution. The study's findings revealed the spread of COVID-19 in the Sibu division for six consecutive months in the first half of 2021 by using KDE and ANN. By illustrating the spatial spread of the disease, health authorities can develop a more precise surveillance system that is more capable in predicting COVID-19 clusters. As a result, control measures can be carried out more effectively, without wasting unnecessary resources. Spatial and temporal analysis can also offer an evidence-based approach for prevention and control activities, not just for COVID-19 but also for other infectious diseases. In this research, district level maps of the COVID-19 distribution were created. In contrast to other studies that use the mapping method at the national level, the focus of this study is more on the division level to provide detailed information to the local public health authorities so they may create appropriate SOPs or interventions to control the COVID-19 outbreak. In light of this, the researcher believes that the Ministry of Health should prioritize spatial and temporal analysis in order to manage infectious diseases especially COVID-19. Lessons learnt from managing COVID-19 will also be essential for future references largely due to the threat of future pandemics as the result of climate change.

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REFERENCES

1. Shariati M, Mesgari T, Kasraee M, Jahangiri-Rad M. Spatiotemporal analysis and hotspots detection of COVID-19 using geographic information system (March and April, 2020). Available from: https://doi.org/10.1007/s40201-020-00565-x
2. Basnet BB, Pant RR, Bishwakarma K, Paudel S, Pandey N, Adhikari SK, et al. A Year Trend Analysis and Spatial Distribution of COVID-19 Cases in Nepal. Asia Pac J Public Health. 2021;33(5):641–4.
3. Andersen LM, Harden SR, Sugg MM, Runkle JD, Lundquist TE. Analyzing the spatial determinants of local Covid-19 transmission in the United States. Vol. 754, Science of the Total Environment. 2021.
4. Moneer Yahya B, Samier Yahya F, Ghazi Thannoun R. COVID-19 prediction analysis using artificial intelligence procedures and GIS spatial analyst: a case study for Iraq. 2021; Available from: https://doi.org/10.1007/s12518-021-00365-4
5. Kumar S, Singh R, Veer V, Jambheshwar Sr Sec School G, Professor A. GIS-Based Review for Monitoring the Spatial Distribution of Covid-19: A Case Study of Haryana. 2022;10.
6. Franch-Pardo I, Napoletano BM, Rosete-Verges F, Billa L. Spatial analysis and GIS in the study of COVID-19. A review. Science of the Total Environment. 2020;739.
7. Curtis AJ, Ajayakumar J, Curtis J, Brown S. Spatial Syndromic Surveillance and COVID-19 in the U.S.: Local Cluster Mapping for Pandemic Preparedness. Int J Environ Res Public Health. 2022 Aug 1;19(15).
8. Edinur HA, Safuan S. Sri petaling COVID-19 cluster in malaysia: Challenges and the mitigation strategies. Acta Biomedica. 2020;91(4):1–4.
9. The Straits Times. Malaysia reports new daily high of 15,573 Covid-19 cases. The Straits Times [Internet]. 2021 Jul 24; Available from: https://www.straitstimes.com/asia/se-asia/record-high-of-15573-new-covid-19-cases-in-malaysia-more-variants-of-concern-identified
10. Md Hamzah N, Yu MM, Fong See K. Assessing the efficiency of Malaysia health system in COVID-19 prevention and treatment response. Available from: https://doi.org/10.1007/s10729-020-09539-9
11. Mahayuddin SA, Harun SN, Mahat N. Sustainability Of Building Elements in Bidayuh Traditional Longhouse Construction Behavioural on Built Environment Sustainability (Volume 2) View Project Documenting Building Typology, Construction Method And Environmental Performance Of Traditional Longh [Internet]. 2015. Available from: https://www.researchgate.net/publication/313629690
12. Hazlin Hassan. Malaysia bans interstate, inter-district travel from May 10 to June 6 to curb Covid-19. New Straits Times. 2021 May 10;
13. Phillip Wong. Major Covid-19 outbreak in Pasai Siong, Sibu; 37 cases confirmed, eight longhouses under lockdown. Borneo Post Online. 2021 Jan 9;

14. Gesler W. The uses of spatial analysis in medical geography: A review. Soc Sci Med. 1986 Jan 1;23(10):963–73.
15. Torok M. Epidemic Curves Ahead. 2021.
16. Sarawak Government. Sarawak Population. Sarawak Government [Internet]. 2014;7–10. Available from: http://www.sarawak.gov.my/web/home/article_view/240/175/
17. Malaysia's health ministry calls for ban on Eid travel amid surge in COVID-19 cases. Reuters. 2021;1–9.
18. Gile M. 850 COVID-19 Cases in Malaysia Linked to Eid Festival. 2021;1–17.
19. Bernama. "Please don't come back for Gawai." 2021;2021–4.