Human leptospirosis distribution pattern analysis in Hulu Langat, Selangor

Zuhafiza Zulkifli¹, Abdul Rashid Mohamed Shariff¹, Zakri M. Tarmidi¹²

¹Faculty of Engineering, Universiti Putra Malaysia, 43400 UPM Serdang, Malaysia
²Department of Geoinformation, Faculty of Geoinformation and Real Estate, Universiti Teknologi Malaysia, 81310, Johor Bahru, Malaysia.

Corresponding Authors: zakritarmidi@gmail.com

Abstract. This paper discussed the distribution pattern of human leptospirosis in the Hulu Langat District, Selangor, Malaysia. The data used in this study is leptospirosis cases’ report, and spatial boundaries. Leptospirosis cases, data were collected from Health Office of Hulu Langat and spatial boundaries, including lot and district boundaries was collected from the Department of Mapping and Surveying Malaysia (JUPEM). A total of 599 leptospirosis cases were reported in 2013, and this data was mapped based on the addresses provided in the leptospirosis cases’ report. This study uses three statistical methods to analyze the distribution pattern; Moran’s I, average nearest neighborhood (ANN) and kernel density estimation. The analysis was used to determine the spatial distribution and the average distance of leptospirosis cases and located the hotspot locations. Using Moran’s I analysis, results indicated the cases were random, with a value of -0.202816 which show negative spatial autocorrelation exist among leptospirosis cases. The ANN analysis result, indicated the cases are in cluster pattern, with value of the average nearest neighbor ratio is -21.80. And results also show the hotspots are has been identified and mapped in the Hulu Langat District.

1. Introduction

Ministries of Health, under the Planning and Development Divisions has reported the increasing number of leptospirosis cases from 263 in 2000 to 1418 in 2009, as shown in Table 1 [1]. To reduce the disease spreading, prevention plan of case morbidity and mortality of leptospirosis disease was needed, and control plan using Prevention and Control of Infectious Diseases Act 1988 leptospirosis has been gazetted as a notifiable disease on 9 December 2010.

The locations of leptospirosis disease were needed to answer the questions related to leptospirosis cases such as where the case happened. When the case happened? How the case happened? What are the action that have been taken to prevent this case and other questions have to be answered as soon as possible in order to make other people in the area affected felt they are in a safe condition [1]. This question can be answered using spatial pattern distribution, where the locations of leptospirosis can be collected, stored and analyze to determine the disease spreading pattern, hotspot area and prevention plan to reduce the cases.
This paper focuses on the spatial analysis to determine the distribution pattern of leptospirosis cases in the Hulu Langat District, Selangor. The main aim of the study is to facilitate Health Department of Malaysia in utilizing modern technology to analyze and act on identifying environmental risk factors for human leptospirosis in order to arrange strategies for disease control and prevention of case morbidity and mortality.

2. Background
Leptospirosis is a bacterial infection caused by a species of pathogenic Leptospira genus called Spirochetes, which can be found in fresh water contaminated by animal urine [2-4]. This disease is known worldwide as the most common re-emerging zoonotic disease, and infectious with a broad range of clinical manifestations, ranging from mild flu-like illness to very severe disease with hemorrhagic manifestations and multiorgan failures [1, 5, 6]. Leptospirosis also known as weil disease, icterohemorrhagic fever, swineherd’s disease, rice-field fever, cane-cutter fever, swamp fever, mud fever, hemorrhagic jaundice Stuttgart disease and canicola fever [3]. Annually, approximately 500,000 severe cases occur worldwide, with a mortality rate of 5–20% [7].

In Malaysia, the first fatal case was reported by Fletcher in 1925, where he able to identify the disease from twenty one patient [1]. From 2004 to 2009, the leptospirosis case report is increasing and can be mapped, and the trend of the disease spreading can be predicted and control program can be implemented in this area.

Table 1: Leptospirosis cases in Malaysia from 2004 to 2009 [1].

| N | State | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|
| | | Cases | Cases | Cases | Cases | Cases | Cases |
| | | Death | Death | Death | Death | Death | Death |
| 1 | Perak | 29 | 4 | 71 | 4 | 93 | 3 | 149 | 3 | 289 | 16 | 280 | 19 |
| 2 | Selangor | 16 | 5 | 20 | 3 | 37 | 0 | 93 | 0 | 97 | 2 | 208 | 7 |
| 3 | Pahang | 29 | 1 | 24 | 0 | 51 | 3 | 184 | 3 | 198 | 7 | 184 | 5 |
| 4 | Kelantan | 15 | 1 | 38 | 1 | 17 | 1 | 81 | 1 | 180 | 4 | 138 | 4 |
| 5 | Terengganu | 7 | 1 | 17 | 0 | 42 | 1 | 55 | 3 | 107 | 4 | 126 | 9 |
| 6 | Kedah | 15 | 1 | 27 | 0 | 31 | 0 | 28 | 1 | 52 | 2 | 106 | 9 |
| 7 | N. Sembilan | 27 | 1 | 41 | 0 | 24 | 0 | 49 | 0 | 59 | 0 | 91 | 0 |
| 8 | Sarawak | 32 | 2 | 42 | 2 | 37 | 3 | 46 | 1 | 58 | 5 | 70 | 4 |
| 9 | Johor | 30 | 1 | 29 | 6 | 31 | 2 | 115 | 2 | 87 | 3 | 59 | 3 |
| 10 | WP KL | 31 | 0 | 20 | 1 | 27 | 1 | 31 | 0 | 45 | 0 | 54 | 0 |
| 11 | Sabah | 13 | 1 | 12 | 1 | 19 | 0 | 41 | 2 | 34 | 2 | 35 | 1 |
| 12 | P. Pinang | 9 | 0 | 25 | 1 | 28 | 0 | 37 | 0 | 25 | 2 | 32 | 0 |
| 13 | Melaka | 7 | 1 | 9 | 1 | 79 | 2 | 32 | 1 | 25 | 0 | 20 | 1 |
| 14 | WP Petrajaya | 1 | 0 | 1 | 0 | 3 | 0 | 3 | 0 | 1 | 0 | 14 | 0 |
| 15 | Perlis | 2 | 1 | 2 | 0 | 5 | 0 | 5 | 0 | 6 | 0 | 1 | 0 |
| 16 | WP Labuan | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

To help in reducing the leptospirosis cases, it is important to map the area of leptospirosis cases to implement the prevention and control program [9, 13]. Using spatial analysis, the distribution pattern can be mapped, and the trend of the disease spreading can be predicted and control program can be implemented in this area.

A research study by Soares (2010) shown the leptospirosis incidence and lethality rates correlated with the population’s socioeconomic conditions, independent of the period in Sao Paulo, Southeastern Brazil [3]. The variables were analyzed using the global and local Moran indices to identify the spatial
pattern (dispersed, clustered or random). Spearman’s correlation coefficient was used to test the associations between variables with clustered spatial patterns.

Another study by Yimsamran and Dasananda, (2011) used to apply Geoinformatics technology and spatial statistic to analyze the leptospirosis cases in Thailand during 2003 until 2009 [4]. Exploratory spatial data analysis (ESDA) was done to demonstrate the geographical distribution of the disease, and Kulldorff’s scan statistic was used to detect significant area using spatial clusters, temporal clusters and spatiotemporal clusters of leptospirosis in Thailand provinces. Result from this study shown the most highly transmission of leptospirosis is in the northeast area of Thailand, which will need closer surveillance and monitoring.

3. Research methodology
This study involves three phases; background study, data acquisition and data analysis. The first phase was to identify the research topics, scope and objectives, where the study has identified the leptospirosis spreading cases locations, based on the epidemiology of leptospirosis cases, factors for emergence of leptospirosis, prevention and control, and spatial distribution pattern of leptospirosis. The second phase is data collection, data mining process, database design and development and database integration. Data was collected in the Hulu Langat District, Selangor Malaysia, and data mining was used to locate the leptospirosis cases, and make it spatially enable for the data analysis process. Figure 1 show the study area for this research. The third phase was to analyze the pattern distribution of leptospirosis cases; Global Moran’s I was applied to determine the spatial autocorrelation based on both feature locations and values, Average Nearest Neighbors was applied to analyze the leptospirosis spatial distribution and Kernel density estimation was applied to locate the hot spot location for leptospirosis cases.

![Figure 1: The location of Hulu Langat District in Selangor State.](image-url)
4. Results
To obtain the results in this study, the analysis was conducted into descriptive and inferential analysis. The descriptive analysis purpose is to obtain the statistical result of leptospirosis cases based on time (month) and location. The inferential analysis was conducted to identify the distribution pattern of the leptospirosis cases, whether it’s cluster, random or dispersed.

4.1. Descriptive analysis
The first analysis was to identify the distribution pattern of leptospirosis cases based on time and location. The data used was recorded in 2013, in the Hulu Langat District, which consists of seven mukim, including Ampang, Beranang, Cheras, Kajang, Semenyih, Ulu Langat and Ulu Semenyih. Leptospirosis cases in the Hulu Langat district show there is 599 cases was reported in 2013, with Ampang has highest leptospirosis cases (316), followed by Kajang (115), Cheras (55), Ulu Langat (46), Semenyih (44), Beranang (20) and Ulu Semenyih (3). From the analysis, it shows the distribution of human leptospirosis is random in Ulu Semenyih, clustered pattern in Ampang, Cheras, Kajang and certain area in Ulu Langat, Semenyih and Beranang. Figure 2 shows the leptospirosis distribution pattern of the Hulu Langat District. From the analysis, it is also shown the leptospirosis cases highest number in July (77), October (64) and November (62) as shown in figure 3.

Figure 2: Distribution map of human leptospirosis cases in Hulu Langat District (2013).
4.2. Inferential analysis

The aim of the inferential analysis is to identify the distribution pattern of leptospirosis cases in the Hulu Langat District. To get the results, three analysis methods were conducted; Global Moran’s I, Average Nearest Neighbor, and Kernel Density. Global Moran’s I analysis was selected to identify the spatial correlation of the leptospirosis cases area; either it’s dispersed, random or clustered. Global Moran’s I were based on locations and data values, with simultaneous analysis. The null hypothesis for Global Moran’s I was the distribution values were randomly distributed among features in the dataset. The results show there were a negative spatial correlation exist among leptospirosis cases within the Hulu Langat District, with result of cases is -0.202816, while z-score is -0.184058 with a p value of 0.853968. From the result, the null hypothesis was accepted; it shows the spatial distribution of the leptospirosis cases in the Hulu Langat District is spatially random.

The second analysis to analyze the leptospirosis cases spatial distribution using Average Nearest Neighbors analysis. The null hypothesis for this analysis is the leptospirosis cases are randomly distributed in the Hulu Langat District. The result shows the average nearest neighbor ratio is 0.534353 with p: 0.0000. With the value of z-score of -21.80, there is less than 1% likelihood that this clustered pattern could be the result of random chance, so the null hypothesis is rejected, and from the result, it can conclude the leptospirosis cases pattern in the Hulu Langat District is exhibiting a cluster pattern.

The last analysis is to locate the leptospirosis cases hot spot area in the Hulu Langat District, using Kernel density estimation analysis and the result of this analysis is the density map of the leptospirosis cases. Figure 4 shows the leptospirosis density map, with the dark red color area is the maximum leptospirosis incidence density, and the lighter color is the area with lower cases of leptospirosis. From the result, the most affected area was located in Ampang, with hot spot area including Taman Kosas, Kampung Tasik Tambahan, Jalan Pandan Indah and Taman Cempaka. Besides that, Sungai Chua in Kajang also detected as one of the high density area of leptospirosis cases.
5. Discussion
Several analyses were conducted to identify the distribution pattern of leptospirosis cases in the Hulu Langat district, including descriptive and inferential analysis. Analysis based on location show the distribution pattern of leptospirosis cases is clustered in Ampang, Kajang, Cheras and Semenyih, and random in Beranang, Ulu Langat and Ulu Semenyih. Analysis based on month, show the highest number of cases is on July 2013; with mukim Ampang contributes the highest number of leptospirosis cases.

From the inferential analysis, from Moran’s I analysis, it indicated the negative spatial autocorrelation exist among leptospirosis cases within the district, and thus the null hypothesis is accepted where the leptospirosis cases in the district distribute spatially random. However, result from
ANN analysis showed the average nearest neighbor ratio is less than 1 (0.534353 with p = 0.00), which conclude the leptospirosis cases in the Hulu Langat district is exhibiting a cluster pattern, where it indicates the each case happened were near between each other, and most the hot spot locations of leptospirosis cases were located in a residential area in Ampang and Kajang.

To improve the results of the analysis, a recommendation for future research is; to include data of leptospirosis cases for five or more years, integrating the analysis of leptospirosis cases with other disease cases, especially dengue, to identify the relationship between different diseases, and included other spatial data, such as land use, demographic data, and water body, to see the relationship between these data with increasing number of leptospirosis cases. Besides that, a larger area of leptospirosis cases can also be added, to see other district pattern, and how to plan a prevention action in the Health Department of Malaysia.

6. Conclusion
This study has identified the distribution pattern of leptospirosis cases in the Hulu Langat District, Selangor Malaysia. This study is significant in identify the distribution pattern, and it can help Malaysia’s Health Department to plan for preventing the spreading of the disease.

7. Acknowledgment
A special thanks to Pejabat Kesihatan Daerah Hulu Langat and member of Faculty of Engineering, Universiti Putra Malaysia.

References
[1] M. Ministry of Health. (2011). Guidelines for the Diagnosis, Management, Prevention and Control of Leptospirosis in Malaysia. Available: http://www.jknselangor.moh.gov.my/documents/pdf/sharingDoc/kawalan penyakit berjangkit/guidelines/Leptospirosis.pdf.
[2] C. H. Chang, M. Riazi, M. H. Yunus, S. Osman, and R. Noordin, "Limited diagnostic value of two commercial rapid tests for acute leptospirosis detection in Malaysia," Diagnostic Microbiology and Infectious Disease, vol. 80, pp. 278-281, 12/ 2014.
[3] T. S. M. Soares, M. d. R. d. Latorre, G. Z. Laporta, and M. R. Buzzar, "Spatial and seasonal analysis on leptospirosis in the municipality of São Paulo, Southeastern Brazil, 1998 to 2006," Revista de saude publica, vol. 44, pp. 283-291, 2010.
[4] S. Yimsamran and S. Dasananda, "Pattern of Leptospirosis Incidence in Thailand: A Spatiotemporal Analysis," Suranaree Journal of Science & Technology, vol. 18, 2011.