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The Investigation of Significant Leptospirosis Hotspots during the Initial COVID-19 Pandemic in the City of Jakarta, Indonesia

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Abstract

Leptospirosis is a common bacterial infection caused by pathogenic *Leptospira* spp.in tropical region, including in Indonesia. During the first year of COVID-19 pandemic, Jakarta reported a significant increase in leptospirosis cases. A study was conducted to analyze the distribution of leptospirosis and to identify hotspots of the leptospirosis. Leptospirosis notifications for the period of January to December 2020 were collected from the online surveillance database provided by the Provincial Health Office of Jakarta. Global and local spatial clustering at the village level across Jakarta was examined using Moran's *I* and local indicators for spatial association (LISA). In 2020, total of 207 people infected by *Leptospira* spp. The highest number was recorded in January (n=142), accounting for 68.5% of the total reports over the period studied. The incidence was geographically dissimilar at village-level with the highest rates was observed in the west of the city. Moran's *I* analysis demonstrates that leptospirosis incidence was significantly clustered (I = 0.191, *p*-value = 0.001). Total of 19 high-risk clusters in 9 sub-districts were identified and approximately 891,202 people were at higher risk of leptospirosis during the year of 2020. The findings suggest needs an improved disease surveillance to support spatially targeted interventions to control leptospirosis transmission.

Keywords: leptospirosis, spatial analysis, clustering, COVID-19, Jakarta

Introduction

Leptospirosis is a bacterial infection caused by pathogenic spirochetes Leptospira spp. The disease is commonly found in tropical and sub-tropical countries and can be found in both urban and rural areas.[1] Annually, more than one million people infected and up to 60,000 people died because of leptospirosis across the globe.[2] People can be infected through direct or indirect exposure to Leptospira infected animal tissues or contaminated water and soil. The bacteria enter human body through injured skin or mucous membranes.[1] Rodents are the most important animal responsible for shedding the bacteria into the environment although some domestic, livestock and wildlife animals can also play in the transmission of leptospirosis.[3] Leptospirosis have broad clinical manifestations including fever, chill and headache. and it is often misdiagnosed with other febrile illness such as dengue.[4]

In Indonesia, leptospirosis is also a public health problem, affecting both urban and rural population. Leptospirosis outbreaks have been reported in many

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places including Jakarta, Semarang, Demak and Banyumas. The largest leptospirosis outbreak has been recorded in Jakarta in 2002 after severe flooding Since then, the number of leptospirosis cases in Indonesia is continuously increasing with significant death rates.[5,6] Leptospirosis prevention and control is challenged by the low awareness and lack of knowledge on the epidemiology of leptospirosis. Identifying areas whereleptospirosis risk is higher is important as this would help understand patterns and potential factors facilitating the transmission. There is a need to improve preparedness and monitoring tools to prevent and control following leptospirosis outbreaks.

Geographic information system (GIS) and spatial statistics approaches have been used in broad fields, including health. The use of such tools in understanding disease transmission from the spatial perspective have been documented in many studies, including in the field of leptospirosis.[7-9] Yet, there is no study have used such tools exploring the spatial pattern of leptospirosis in Jakarta. GIS can be used to map pattern of disease, allowing to examine the geographical extent of disease of interest. In addition, the advancement of geospatial statistics tools provide opportunity to better explore the spatial autocorrelation in the data and help to generate and test hypotheses, which can help in shaping knowledge on disease epidemiology.[10]

An ecological study using GIS and spatial analysis was conducted, aimed at examining the presence of spatial autocorrelation of leptospirosis incidence and to further locate the high-risk areas for leptospirosis transmission in Jakarta during the first year of COVID-19 pandemic.

Materials and Methods

St*udy Site*

The study was performed in the metropolitan Jakarta, Indonesia in 2020. It has an area of 622.33 km^2 which is shared into six municipalities, 44 sub-district (*kecamatans*) and 267 villages (*kelurahans*). The city is inhabited by at least 9.6 million people. At the *kelurahan* level, the population density is ranging from 1013 persons per km^2 (Kamal Muara, North Jakarta) to 319,107 persons per km^2 (Jelambar Baru, West Jakarta). Jakarta has a tropical climate with mean temperature of 28.7°C and annual precipitation ranging from 1459 to 1600 mm with the highest precipitation rate is on February.[11]

Data Collection

The *kelurahan* level monthly human leptospirosis cases recorded in hospitals for the period of January to December 2020 wereobtained from the online surveillance website of Provincial Health Office (PHO) of Jakarta (https://surveilans-dinkesdki.net/). In Indonesia, leptospirosis is a notifiable disease which all health facilities are required to report all cases to the District Health Office (DHO) within 24 hours of diagnosis. Data for population at village level were collected from the Bureau of Statistics.[11]

Data Analysis

Incidence Mapping: The incidence rate per 10,000 people for each kelurahan was calculated by dividing number of cases with number people multipliedby 10,000. The data were then linked to village ID polygons and the choropleth map of incidence of leptospirosis was created using ArcMap v.10.5.1 software (ESRI, Redlands, CA, USA).

Spatial clustering and local clusters detection: Moran's I statistics was performed to measure the clustering of the incidence using the formula as follow:

$$I = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n}\omega_{ij}(z_i - \bar{z})(z_j - \bar{z})}{\sum_{i=1}^{n}(z_i - \bar{z})^2}$$

Where n is the number of areas (*kelurahans*), z_i the count or incidence of leptospirosis in *kelurahani*, z is the mean count or incidence of leptospirosis in the region of study and ω_{ij} is the spatial contiguity matrix. In this analysis, Queen contiguity style was built, meaning that the *kelurahan* polygon shares a common edge or vertex. Moran's *I* value ranging from −1 to 1 with a value close to 0 means no spatial autocorrelation (random). A positive value indicates positive autocorrelation and a negative value means negative autocorrelation.[12] The significance of Moran's *I* coefficient was examined using Monte-Carlo randomization with 999 permutations. Significance ($p < 0.05$) of the test statistic means that incidence is spatially clustered or dispersed.

Once the global spatial autocorrelation was detected, the local index of spatial association (LISA) was estimated by using the equation below:

$$I_i = \frac{z_i \sum_{j=1}^{n}\omega_{ij} z_j}{\sum_{i=1}^{n} z_j^2}$$

LISA analysis was used to detect significant local clusters (hotspots), providing evidence of clusters of *kelurahans* with high incidence (High-High, HH), low incidence (Low-Low, LL) and spatial outliers (High-Low, HL and Low-High, LH). The HH clusters mean that a high incidence *kelurahan* is adjacent to other high incidence *kelurahans* and so on.[13] All these spatial analyses were performed in open source GeoDA 1.18 software.[14]

Results

Geographical variation of incidence of leptospirosis

The incidence of leptospirosis was dissimilar at village level across the Jakarta metropolitan, ranged from 0 to 2.70 per 10,000 people. High rate villages were observed in west Jakarta and small number of villages in central and south. The highest rateof leptospirosis was identified in Rawa Barat in South Jakarta (2.70/10.000 people), followed by Karet Tengsin (2.62/10,000 people), Kedoya Utara (2.38/10,000 people), Kampung Melayu (2.32/10,000 people) and Kamal Muara (1.87/10,000 people).

Spatial Clustering and Local Clusters of Leptospirosis

Moran's *I* analysis indicated the rate of leptospirosis was statistically significantly clustered (Moran's *I* coefficient = 0.191; *p*-value = 0.001). LISA analysis identified significant spatial clusters of leptospirosis in Jakarta. Nineteen High-High clusters were identified with population at-risk was approximately 891,202 people (Table 1). These High-High clusters were primarily concentrated in northwest Jakarta. Small set of High-High clusters also detected in central and east Jakarta. The High-High clusters belong to 9 *Kecamatans* including Cengkareng (4 *kelurahans*), Palmerah (4), Kebon Jeruk (3), Tanah Abang (2), Grogol Petamburan (2), Jatinegara (1), Kebayoran Lama (1), Kembangan (1), and Tebet 1.

Thirty-six Low-Low clusters were identified during period studied, which mainly clustered innortheast Jakarta. Additionally, fourteen significant spatial outliers (7 Low-High dan 7 High-Low clusters) were detected.

Table 1: Summary statistics of local spatial clusters of leptospirosis in Jakarta, 2020

Type of Cluster	No. of Cases	Mean Incidence (Per 10,000 Persons)	No. of Villages	Population at risk	Mean Population Density (per Km^2)
H-H	60	0.62	19	891,202	24,447
L-L	0	0	36	1,575,997	16,590
L-H	1	0.03	7	164,796	13,594
H-L	8	0.28	7	302,694	30,313

Discussion

Using the GIS and spatial statistics approach, this study was aimed to explore spatial heterogeneity of the incidence of human leptospirosis in Jakarta during 2020. This study demonstrated the presence of spatial clusters of leptospirosis in west Jakarta. Nineteen significant clusters involving 9 *kecamatans* were detected. This clustering patternsuggest that this was because factors (environmental or societal) might have influenced the spread of leptospirosis, which need further investigation.

Spatial autocorrelation test has also been used to investigate the spatial pattern in incidence of leptospirosis in different studies elsewhere [15-17], which also result similar finding with this present study. the emergence of leptospirosis is known to be associated with climate and environmental factors. Studies have shown that extreme climatic events such as heavy rainfall and flooding have been responsible for numbers of leptospirosis outbreak worldwide, including in Jakarta. Poor drainage system and disrupted access to safe drinking water and sanitation during flooding could magnify the probability of contact with bacterial contaminated environment. In addition, poor waste management (i.e., improper garbage disposal) maintains rodent population that could harbor pathogenic *Leptospira* spp. Such environmental conditions are common risk factors for the transmission of leptospirosis in urban setting.

Clustering in incidence of leptospirosis in northwest Jakarta might be partly explained by the variation in population density. *Kecamatans* in west Jakarta such as Cengkareng, Kebon Jeruk, Grogol Petamburan and Palmerah are areas known with high people density in Jakarta and frequently experience

severe flooding. This may explain why most High-High clusters for leptospirosis was found in west Jakarta. Population density and socioeconomic conditionhave been important demographical characteristicsassociated with the occurrence of leptospirosis in other studies [18,19]. Densely inhabited urban area, in which basic services and environmental health are lacking, could foster rat infestation and increase the transmission of leptospirosis. People living in slums and near the river are known at the highest risk of leptospirosis[20]. Further explorationis needed to investigate the role of individual and community level factors explaining the distribution of risk of leptospirosis in Jakarta.

The use of GIS and spatial statistics have been helpful in understanding the disease epidemiology including leptospirosis. This approach can be beneficial in assisting health officials or epidemiologist to zooming-in the factors that may have driven the occurrence and spread of the diseases. This study is an ecological study which is known to have several limitations including the inability to draw the causal link between infection and factors at individual or community level. In addition, the leptospirosis data used here were based on passive surveillance which may suffer from underreported number resulting in underestimation of actual number of infections in population. However, this study has provided important evidence about leptospirosis distribution in Jakarta, which has never been studied before.

Conclusions

Using GIS and spatial analysis, the study demonstrated the significant spatial clustering in the incidence of leptospirosis in 2020. More importantly, the study revealed 19 high-risk *kelurahans* for leptospirosis transmission across Jakarta, which mainly concentrated in the northwest of the city, suggesting the needs for further interventions to better control leptospirosis in these identified areas to prevent outbreak in the future.

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