Transmission elimination of lymphatic filariasis using spatial autocorrelation

E Surjadi¹,* and B S Wiwoho²

¹ Postgraduate Program, Universitas PGRI Kanjuruhan Malang, Jl. S. Supriyadi No. 48, Malang 65148, Indonesia
² Geography Department, State University of Malang, Jl. Semarang No 6 Malang, Indonesia

*surjadi@unikama.ac.id

Abstract. At present, spatial analysis has been used on epidemiology. Spatial analysis was used to determine the environmental risk that influence to transmission of Filariasis. The aim of the study was to identify, at industrial area, the environment determinant that are associated with Filariasis cases in Pekalongan City. The geocoding method was applied on the prevalence of cases to determine the pattern of spatial. Spatial autocorrelation was used to determine the effect of the environment on filariasis transmission. The kernel method was used to determine the density of filariasis cases. Based on the spatial analysis, the statistical values associated with the correlation between the risk of filariasis transmission and environmental factors were obtained. The correlation value of the influence of the environment on the transmission of Filariasis was statistically significant, this coefficient is 0.312. The value of R indicates that the spatial pattern of filariasis cases forms a cluster pattern. The Moran's index calculation obtained a positive spatial autocorrelation value of 0.44 with z-score is 16.05 and P-value is 0.00. Spatial autocorrelation was useful to determining the level of risk transmission of filariasis in Pekalongan City which may help to adopt effective control strategies in filariasis eradication programs in Pekalongan City.

1. Introduction

Spatial analysis has been widely used in various fields, one of which is in the field of epidemiology. The use of spatial analysis in the field of epidemiology is primarily to determine the relationship between environmental conditions and disease incidence. One method of analysing the relationship between environmental conditions and disease incidence is a spatial autocorrelation. The spatial pattern of objects, phenomena and events is determined by certain environmental variables. An understanding of the degree of spatial structure is often described based on the first law of geography, namely: "Everything is related to everything else, but near things are more related than distant things" (Tobler, 1970, in Liang [1]).

Filariasis is caused by filarial worms which are transmitted through the bite of an infected mosquito into the human body. The abundance of mosquitoes infected with filaria can be explained based on the mosquito habitat that supports them as a place to lay eggs and breed. A supportive environment as a place to lay eggs and breed as a factor in the presence of disease endemics in an area. Pekalongan is noticed as endemic for filariasis based on the microfilaria rate (mf rate) which reaches more than 1%.
Several studies have been conducted regarding the elimination strategy of filariasis transmission. The research approach was carried out using descriptive surveys to determine transmission risk factors such as the presence of shrubs and irrigation systems, residential environment [2]. Filaria diagnostic test to support transmission mapping and monitoring [3], mapping risk and visualization are used for filariasis endemic identification and filariasis monitoring of filariasis transmission using geo-climatic variables [4-6]. The development / poverty index (especially in urban areas) should be considered as a risk factor for LF transmission [7]. Pekalongan City as a filariasis endemic area is still very potential as an area of transmission and spread of filariasis [8]. Remote sensing and geographic information systems are also increasingly being carried out, especially for mapping the prevalence of disease and modelling the distribution of hosts [9,10]. At the stage of adult mosquitoes need water, which in this case still associated with wetlands as an ecology of mosquitoes and diseases caused by vectors [11]. Apart from the factors that influence filariasis cases, the spatial relationship between filariasis cases and attributes is also needed in the framework of strategies to break filariasis transmission. This research was conducted to determine the degree of dependency of filariasis cases on risk factors for filariasis transmission.

2. Methods

The data used in this study is 2016 lymphatic filariasis case registered data from the Pekalongan of Health Office, Central Java Province. Geocoding method is done by using GPS to plot the location of lymphatic filariasis cases. Disease mapping of lymphatic filariasis outbreaks used geocoding method, which is statistical data converted into georeferenced data. The register data were obtained from Health Office in the form of clinical and chronic cases of sufferers and the finger blood survey that had been carried out.

Mapping of filariasis incidents was carried out to pinpoint the location of the cases based on the address of the patients and their coordinates. The coordinates were recorded using Microsoft excel which were then imported into the ArcGIS software for further analysis.

Geographical information systems (GIS) and statistical analysis used to detect the clustering of cases and link the clustering dynamics with geographical locations that carry certain for the sources of infection (e.g., mosquito breeding sites) and for the spread of infection (e.g., vector exposure). Spatial autocorrelation refers to the degree of the association between the spatial location of a testing variable and its neighbors. There are spatial autocorrelations while the values of the variable are interrelated spatially, which also means there are spatial patterns to those correlations. In this study, we determined the spatial autocorrelations used Moran-I as a spatial risk index to identify significant spatial patterns, including clustering and outliers. The definition of a Moran’s Index is:

\[ I = \frac{N}{\sum_{i} \sum_{j} W_{ij} (X_i - \bar{X})(X_j - \bar{X})}{\left( \sum_{i} \sum_{j} W_{ij} \right) \sum (X_i - \bar{X})^2} \]  

where N is the sample size, X is the mean of the variable, Xi is the value of the variable at a particular location i, Xj is the variable value at location j, and Wij is a spatial weight indexing the location of i relative to j. The value of this statistic is scored between -1 and 1. A score close to 1 represents positive autocorrelation and townships that may be hot spots. A score near -1 shows negative autocorrelation, indicating that the values of neighboring areas are opposite that of the township being examined. The significance of Moran’s I is evaluated by using a Z score and p-value generated by random permutation. The null hypothesis states that there is no spatial autocorrelation for the variable within the geographic area.
3. Results and discussion

3.1. Spatial distribution of filariasis cases

Figure 1 and 2 illustrates the spatial distribution of the risk of lymphatic Filariasis transmission. The spread of risk of transmission lies between the City and Pekalongan Regency and spreads outward from the epidemic center of lymphatic Filariasis. Endemicity of lymphatic filariasis in Pekalongan has been demonstrated both qualitatively and quantitatively. Qualitatively it is based on the results of the finger blood survey conducted by the City Health Office and Pekalongan District which states that in some regions it is declared an endemic area because the microfilariae level (mF rate) reaches 1% or more. While quantitatively it has been proven that the prevalence of clinical and chronic cases of lymphatic filariasis has a spatial structure with cluster patterns.

Regions that are predicted to experience transmission risk increases for Pekalongan City, namely North Pekalongan District, Pekalongan Barat and Pekalongan Selatan. While for Pekalongan Regency are Wiradesa Subdistrict, Tirto, Kedungwuni, Kesesi, Bojong, Karangdadap, Sragi and Kajen. These areas are located in areas that are relatively flat and are urban areas.

Figure 1. Map of spatial distribution of filariasis cases.
Figure 2. Map of lymphatic filariasis risk.

3.2. Autocorrelation spatial

The results of statistical analysis using the nearest neighbourhood ratio method (Table 1) obtained an R value of 0.31, which means that the spatial distribution of filariasis cases in the study area forms a cluster pattern. The Z score shows a cluster pattern with a very significant statistical value. The Z score for the spatial pattern of lymphatic filariasis cases shows a very significant statistical value, namely -23.54.

| Rstatistic | Z-score | P-value | Robs | Rexp |
|------------|---------|---------|------|------|
| 0.31       | -23.54  | 0.00    | 233.92 | 749.14 |

Source: Spatial data analysis on 2019

The similarity in the characteristics of the locations is done by calculating the different attributes of spatially adjacent points. The index that is often used to measure spatial autocorrelation in point distributions is the Moran’s Index.
Table 2. Spatial statistic using Moran’s I.

| Moran’s I | Z-score | P-value |
|-----------|---------|---------|
| 0.44      | 16.05   | 0.00    |

Source: Statistical spatial data analysis on 2019.

The value of this statistic is scored between −1 and 1. A score close to 1 represents positive autocorrelation and townships that may be hot spots. A score near −1 shows negative autocorrelation, indicating that the values of neighboring areas are opposite that of the township being examined. The significance of Moran’s I is evaluated by using a Z score and p-value generated by random permutation. The null hypothesis states that there is no spatial autocorrelation for the variable within the geographic area.

Based on table 2, the Moran’s Index value was 0.44, which means that the spatial characteristics of filariasis cases are more represent positive spatial autocorrelation. This means that the incidence of filariasis cases forms clusters and can be distinguished from the surrounding area.

The model validation test was carried out by taking 40 sample point locations. 40 samples were considered because the risk classes used were 4 classes and 10 samples were taken for each class. Furthermore, the location of the sample points will be tested for validation to determine the accuracy of the model. The validation test was carried out by comparing the FL transmission risk classes in the model with the transmission risk classes calculated based on the distance to the FL case. Based on the calculation, the accuracy model is 89.77%

At the first step, a mapping stage needs to be done to determine the environmental conditions that influence and the spread of the disease. To determine environmental factors, Remote sensing technology is used. Some of the advantages of remote sensing are covering a large area, fast, relatively cheaper, and it can reach remote areas.

Identifying FL transmission requires an understanding of the distribution of disease incidence and environmental factors as causes. By knowing the environmental factors that influence the incidence of a disease, it can then be used to assist in the implementation of eradication and surveillance programs against infectious diseases caused by environmental factors.

Mapping is an alternative method in assisting the lymphatic filariasis elimination program and it shows areas with a high enough prevalence so that intervention is necessary. The risk factors for FL transmission have various factors and are influenced by several things, including land cover conditions, vegetation density, building density, and surface water conditions. The vegetation condition that affects is the presence of shrubs and forests. Shrubs are a great place to settle for mosquitoes. Meanwhile, the forest will provide a suitable environment for mosquito breeding. The building density condition is a representation of the population density condition. Occupation density is a risk factor for FL transmission. The denser the population, the possibility of FL transmission will also be very high. Soil moisture conditions also make it easier for water logging to occur where is a breeding ground for mosquito larvae.

The findings of this study show that Geographic information system and statistical spatial can be used to identify risk areas of filariasis more effectively.

4. Conclusion

The spatial structure of the filariasis case is influenced by its attribute as a result of the spatial dependence between variables. Spatial dependence is a case response to environmental conditions (spatial autocorrelation). A high Moran index value indicates a high level of spatial autocorrelation and a Z-score value indicates the strength of this relationship. Based on the spatial statistical analysis, the Moran's index value was 0.44. Filariasis spread even more over a wider area. Based on the description above, in general the research area is included in the category of positive spatial autocorrelation, this indicates that the cluster pattern of filariasis cases is influenced by environmental factors.
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