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SPATIAL ANALYSIS OF THE SPREAD OF TUBERCULOSIS USING LOCAL INDICATOR OF SPATIAL ASSOCIATION (LISA) IN MAKASSAR, INDONESIA

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ABSTRACT

Tuberculosis (TB) is one of the causes of death in developing countries. This disease is caused by mycobacteria. As one of the developing countries, Indonesia globally ranked fifth in terms of the number of TB cases. With a particular focus on Makassar as the capital of South Sulawesi province, this city with a population of approximately 1.3 million people is an area whose the highest number of tuberculosis patients among 23 districts in the region of South Sulawesi. This research aims to analyze the spread pattern of tuberculosis from 2010 to 2013 in Makassar. A spatial linkage in the spread of the disease is measured by spatial autocorrelation using the Local Indicator of Spatial Association (LISA). The results of the research revealed that sub-districts, where have a high number of TB cases, are Rappocini, Tamalate, Mamajang, Mariso, Tallo, Panakukang, and Tamalanrea. The test using LISA showed that the districts which have autocorrelation are Wajo and Manggala. Wajo is categorized as a safe area while Manggala is prone to be smitten by tuberculosis disease.

Keywords: Spatial autocorrelation, Moran Scatterplot, LISA, tuberculosis.

1. INTRODUCTION

Tuberculosis (TB) is one of the leading causes of death in developing countries caused by the bacteria mycobacterium WHO (2010). Tuberculosis or TB is currently still a major global health problem. As a developing country, Indonesia is now ranked fifth in the country with the highest TB burden in the world. Some researches related to TB disease have been conducted. Idianto and Kusumastuti (2013) measured the transmission level of strains of M. tuberculosis and indicated that the rate of spread of the disease can be inhibited with the effectiveness of Chemoprophylaxis and therapy. Fredlina et al (2012) used mathematical modeling and concluded that the spread of tuberculosis can be controlled from the incidence of the epidemic by making $R_0 < 0$ or lower rate transmission and increase the rate of healing.

The studies discuss tuberculosis using mathematical concepts which aim to tackle the problem of tuberculosis in terms of healing. Research on how the pattern of the spread of tuberculosis, especially in the city of Makassar has not been discussed. Knowledge of the pattern of the spread of tuberculosis is one of the crucial roles in tackling the spread of TB disease. Therefore, this research aims to investigate the pattern of spread of TB disease using spatial analysis especially Moran's I and Local Indicator of Spatial Association (LISA).

2. LITERATURE

2.1 Geography Information System

A geographic information system (GIS) is a computer-based information system that is used in digital to describe and analyze geographic characteristics described on the surface of the Earth. Spatial autocorrelation is a measure of the similarity of the objects in a space that is interconnected (Prahasta & Eddy, 2019).

The spatial pattern can be categorized as clustered, dispersed, or random. Positive spatial autocorrelation indicates a nearby location has similar values and tends to cluster. Negative Spatial autocorrelation indicates a nearby location has different values and tends to spread. No spatial autocorrelation indicates a pattern of random locations (Lee and Wong, 2001).

Spatial data is data that relates to location-based on geography that consists of latitude-longitude and the region. Measurement of spatial autocorrelation for the spatial data area can be calculated using the Moran's I, Geary's c, Tango's excess methods (Pfeiffer, 2008). However, this research will be restricted to the index method of Moran.

2.2 TBC

Tuberculosis is an infectious disease caused by the bacteria Mycobacterium tuberculosis. This rod-shaped bacteria and is resistant to acid, so also known as Acid-resistant Trunk (BTA).

2.3 Standardized Matrix

The spatial contiguity matrix is defined by using the binary adjacent matrix, that is, 1 if the areas are adjacent and 0 if the areas are not adjacent. This definition is also known as the non-standardized spatial matrix. A row-standardized matrix (w_{ij}) is defined as the ratio of the value on specific areas in the i^{th} row and column j^{th} (the non-standardized spatial matrix) (c_{ij}) to a total value of neighboring areas (a total value of the i^{th} row) (c_i). The formula is given as follows.

$$w_{ij} = \frac{c_{ij}}{c_i} \qquad 2.1$$

2.4 Spatial Autocorrelation

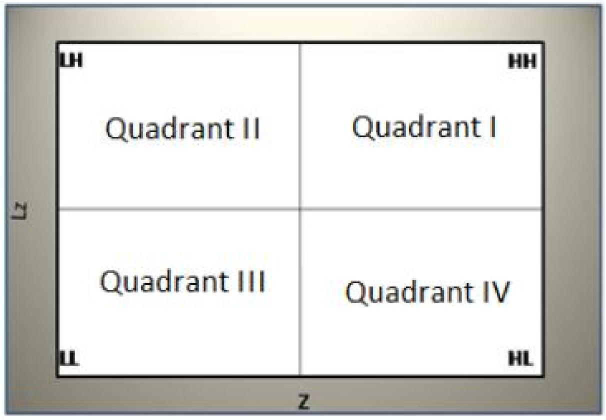
Spatial autocorrelation is a measure of the similarity of the objects in a space that is interconnected. Positive spatial autocorrelation indicates a location adjacent to have similar values and are likely to be in a group. Negative spatial autocorrelation indicates a nearby location has different values and tends to spread. No spatial autocorrelation indicates a pattern of random locations (Lee and Wong, 2001).

2.5 Moran's Index (Moran's I) and Moran's Scatterplot

The coefficient of Moran's I is used to test the spatial autocorrelation or dependencies between locations and it is defined as follows.

$$I = \frac{[x_j - \bar{x}]' w_{ij} [x_j - \bar{x}]}{[x_j - \bar{x}]' [x_j - \bar{x}]}$$

Lee and Wong (2001) mention that Moran's scatterplot is one way to interpret the statistics index of Moran. The visualization of the Moran Scatter plot shows the four categorizations of spatial autocorrelation which is classified into four quadrants. Quadrants I and III are the quadrants of High-High (HH) and Low-Low (LL) spatial dependence, respectively which correspond with positive spatial autocorrelation. Furthermore, quadrants II and IV are the quadrants of Low-High (LH) and High-Low (HL) spatial dependence, respectively which correspond with negative spatial autocorrelation.



Quadrant I called High-High (HH) shows the areas that have high observation value and are surrounded by an area that has a high value of observations. Quadrant II is called Low-High (LH) shows the region has low observations but is surrounded by an area that has a high value of observations. Quadrant III called the Low-Low (LL) shows the areas that have a low observation value and are surrounded by an area that has a low observation value. Quadrant IV is called High-Low (HL) shows the areas that have a high observation value are surrounded by an area that has a value of low observation (Arrowiyah, 2001).

Moran's Scatterplot which many put observations in quadrants and quadrant HH LL will likely have positive Spatial autocorrelation values (cluster). Whereas a Scatterplot Moran's many placing observations on quadrant HL and LH will tend to have a value of negative Spatial autocorrelation (Arrowiyah, 2001).

2.6 Local Indicators of Spatial Association (LISA)

Local Indicators of Spatial Association (LISA) can be used for identifying the coefficients of autocorrelation locally (local autocorrelation) or spatial correlation in each area.

3. RESEARCH METHODS

This research is applied research where spatial analysis method by using multiple theories, i.e. the spatial autocorrelation indexes, Moran's I, Moran Scatterplot's, Local Indicators of Spatial Association (LISA) was used. Based on the data obtained, a thematic map is created to see a concrete overview map of the research results. The procedure of implementation of research applied research are:

a. Identification of the problems associated with tuberculosis, then formulate problems and formulating the goals and benefits of the research obtained in this research.
b. Look for a reference that is related to the object of research.
c. The collection of data. In this stage, there are two kinds of data, namely the location data in the form of a map of Makassar city and TB cases data that occurred in the city of Makassar in a certain period.
d. Data processing.
   This data processing consists of several steps as follows
   1. Makassar city location data was processed to show the strength of the interaction between the locations by using a contiguity matrix that has a standardized so-called standardized matrix.
   2. A matrix of spatial data and standardized matrix of the number of TB cases are calculated using Moran's I as follows,

$$I = \frac{[x_j - \bar{x}]' w_{ij} [x_j - \bar{x}]}{[x_j - \bar{x}]' [x_j - \bar{x}]} \qquad 3.1$$

      and tested with a test statistic as follows,

$$Z_{hitung} = \frac{I - I_0}{\sqrt{Var\,(I)}} \sim N\,(0,1) \qquad 3.2$$

   3. Determining the Moran scatterplot.
   4. Testing of LISA to identify the relationship between a location's observations on the location of other observations.

$$I_i = \frac{[x_{ij} - \bar{x}] w_{ij} [x_j - \bar{x}]}{\frac{[x_j - \bar{x}]^2}{n}} \qquad 3.3$$

   5. Create a thematic map.

4. RESULTS

4.1 Research Data

This study uses two types of data namely locations or areas data and the number of TB cases in the city of Makassar from 2010 to 2013. Data location information was obtained from the administrative map of Makassar city.

Figure 4.1 Map of the administrative city of Makassar

The data on the number of TB cases in the city of Makassar from 2010 to 2013 was retrieved from Makassar City Health Office and it can be seen in Table 4.1.

Table 4.1 Data on the number of TB Cases in Makassar city 2010-2013

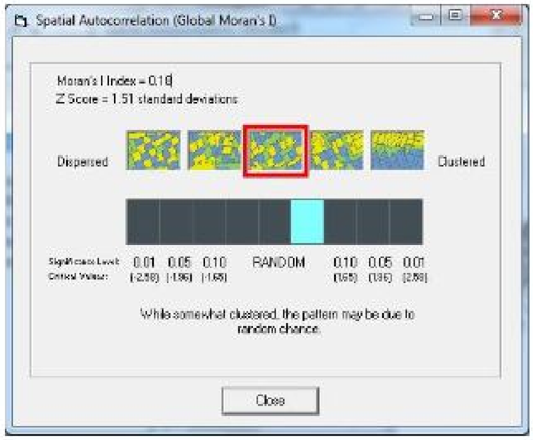
No.	Subdistrict	Year			
		2010	**2011**	**2012**	**2013**
1	Rappocini	209	235	268	213
2	Tamalate	201	215	185	254
3	Makassar	116	149	150	157
4	Mariso	144	132	159	152
5	Mamajang	228	156	171	130
6	Ujung Pandang	57	65	37	41
7	Tallo	184	158	179	157
8	Manggala	46	58	44	55
9	Panakukang	190	102	233	247
10	Wajo	27	20	26	22
11	Bontoala	58	63	59	52
12	Ujung Tanah	65	90	99	62
13	Tamalanrea	144	133	139	264
14	Biringkanayya	81	122	183	147
Sum		**1750**	**1698**	**1932**	**1953**

Source: Health Services City of Makassar

4.2 Analysis

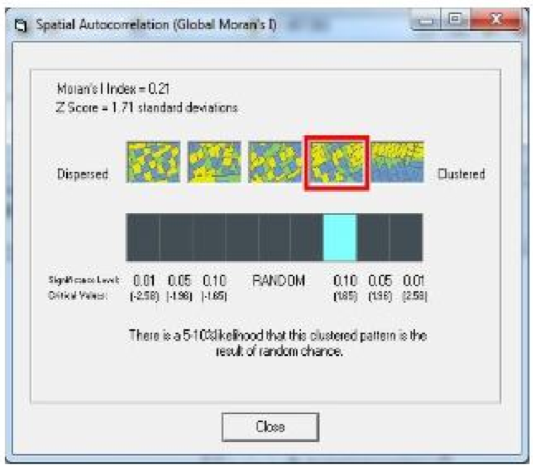
The results of Moran's Index from 2010-2013 are given as follow:

- In 2010



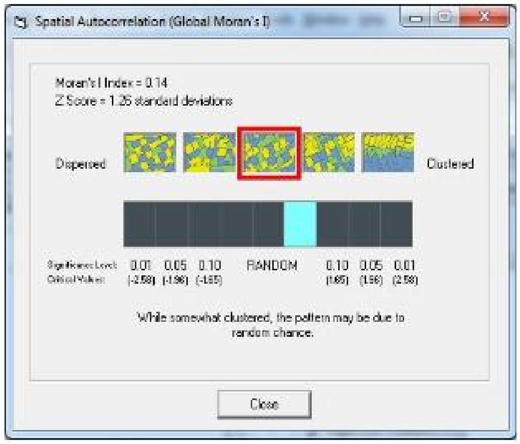
Z Score = 1.5 < Z table = 1.65 indicates that the null hypothesis fail to reject. It means that there is no spatial autocorrelation (random pattern) on TB data in 2010.

- In 2011



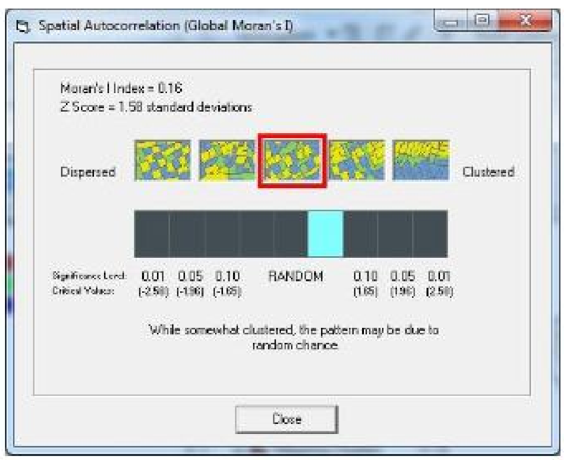
Z score = 1.71 > Z table = 1.65 indicates that the null hypothesis is rejected. It means that there is a positive spatial autocorrelation (cluster) on TB data in 2011.

- In 2012



Z Score = 1.26 < Z table = 1.65 indicates that the null hypothesis fail to reject. It means that there is no spatial autocorrelation (random pattern) on TB data in 2012.

- In 2013



Z score = 1.58 < Z table = 1.65 indicates that the null hypothesis fail to reject. It means that there is no spatial autocorrelation (random pattern) on TB data in 2013.

LISA analysis on the number of TB cases in Makassar city 2010-2013 can be seen in Table 4.2.

Table 4.2 LISA analysis on the number of TB Cases in Makassar city 2010-2013

Sub/Year	2010	2011	2012	2013
Rappocini	HH	HH	HH	HH
Tamalate	HH	HH	HH	HL
Makassar	LH	HH	HH	HL
Mariso	HH	HH	HL	HH
Mamajang	HH	HH	HH	LH
Ujung Pandang	LH	LH	LL	LL
Tallo	HL	HL	HL	HH
Manggala	LH	LH	LH	LH
Panakukang	HH	LH	HH	HH
Wajo	LL	LL	LL	LL
Bontoala	LL	LL	LL	LL
Ujung Tanah	LL	LL	LL	LL
Tamalanrea	HH	HL	HH	HH
Biringkanaya	LH	HH	HH	HH

The results indicate that based on the Moran scatter plot, the dominant areas in a category HH are Rappocini, Tamalate, Mamajang, Mariso, Panakukang, and Tamalanrea.

In 2010, only one area (Tallo district) is categorized HL and four areas are categorized LH (Makassar, Ujung Pandang, Manggala and Biringkanya districts). In 2011, two areas (Tallo, and Tamalanrea districts) are categorized HL and three areas are categorized LH (Ujung Pandang, Manggala, and Panakukang districts). In 2012, two areas (Mariso, and Tallo districts) are categorized HL and only one area is categorized LH (Manggala district). In 2013, two areas (Tamalate, and Makassar districts) are categorized HL, and two areas are categorized LH (Mamajang, and Manggala district).

5. CONCLUSION

Based on the results, it can be concluded as follows:

1. The spread of TB disease in 2010, 2012, and 2013 have random patterns while the spread of tuberculosis in 2011 have clusters patterns.
2. The dominant areas which have high number of TB cases from 2010 to 2013, are Rappocini, Tamalate, Mariso, Mamajang, Tallo, Panakukang and Tamalanrea.

3. Based on testing of LISA, an area that has a cluster pattern in 2010 is Wajo, and areas that have a pattern of spread (dispersed) is Manggala. In 2011 the area that has pattern clusters is Wajo. In 2012 the area that has the pattern of clusters is Wajo and areas that have a dispersed pattern is Manggala. In 2013 the area that has a pattern of clusters (clusters) is Wajo and the area that have a pattern of spread (dispersed) is Manggala.
4. Overall, from 2010 to 2013, an area that has a cluster pattern is Wajo. Wajo is grouped with areas that have a low number of TB cases indicating that Wajo was the most secure transmission of TB disease. On the other hand, Manggala district has had a significantly dispersed pattern for 3 years and is categorized Low-High. It indicates that Manggala adjoined directly to the areas that have a high rate of TB cases indicating that Manggala is a sub-district that is prone to contracting TB disease from the surrounding area.

It is suggested that researchers can consider the factors that affect the spread of tuberculosis incidence in Makassar city using Local Indicators of Spatial Association (LISA) or other methods for future work. Furthermore, it is recommended that researchers can apply a spatial analysis process in other fields, such as education.

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