Spatial Analysis of Diabetes Mellitus in Jambi Province: Methods Space-Time Scan Statistic and Spatial Autocorrelation

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Diabetes Mellitus (DM), Autocorrelation, Cluster, Space-Time Scan Statistics

ABSTRACT
Diabetes Mellitus (DM) is a chronic disease that threatens human health, the research aims to determine distribution, clusters, and spatial autocorrelation. The type of research is an exploratory study with an ecological design. Diabetes Mellitus using a Geographic Information System (GIS) is analyzed spatially. The research was conducted in the Jambi Province Region. The research sample was participants with a diagnosis of DM sourced from data from visits by the Social Security Administering Agency as name (BPJS) at FKTP in 2020 - 2022. The results of the space-time scan statistical analysis during the 2020-2022 period found 10 DM clusters with details of 3 most likely clusters and 7 secondary clusters. Spatial autocorrelation analysis with Moran's I index found that there was spatial autocorrelation of DM in Jambi Province during the three-year research period. The conclusion obtained is that there are clusters and autocorrelation of DM disease in Jambi Province, the need for intervention in prevention and control programs in cluster and hotspot areas.

1. Introduction

Diabetes Mellitus (DM), a chronic disease, occurs because the pancreas does not produce enough insulin or when the body does not effectively use the insulin produced [1] [2]. Diabetes is becoming an epidemic throughout the world, a common chronic disease that seriously threatens human health [3]. Continuously high blood glucose levels can cause damage to large blood vessels which affects the heart, eyes, kidneys, and nerves and result in complications [4] DM is also known as the silent killer [2]. The global prevalence of diabetes and impaired glucose tolerance in adults has increased over the last decades[5][6]. It is estimated that in 2017 there were 451 million (aged 18–99 years) diabetes sufferers worldwide. These figures are expected to increase to 693 million by 2045, accounting for nearly half of all people (49.7%) living with undiagnosed diabetes. There are 374 million people with impaired glucose tolerance (IGT), and nearly 21.3 million live births to women affected by some form of hyperglycemia in pregnancy [7]. The prevalence of DM in Indonesia based on Basic Health Research (Riskesdas) has increased from 1.56% in 2013 to 2.0% in 2018. The highest prevalence of DM by age group based on doctor's diagnosis is in East Java province at 4.2% followed by Yogyakarta at 3.86 %. The incidence of DM in Jambi Province in the 2007 Riskesdas was 5.2% and decreased in the 2013 Riskesdas results to 1.2% and then increased to 1.4% in 2018.[8][9]. DM is known as the "Mother of Disease" because it is the mother of other diseases such as hypertension, blood vessels, heart disease, stroke, kidney failure, and blindness [10]. Efforts to prevent the introduction of DM include education on healthy lifestyles, early detection, and risk socialization. DM. The success of the DM disease control process is determined by changes in community behavior and a holistic approach from all parties [10]

Research has found that the development of type 2 DM is caused by a complex interaction between genetics, environment, lifestyle, and other risk factors. [11][12] It has also been revealed that obesity and lack of physical activity are highly correlated with Type 2 DM [13][14]. Several existing studies have reported geographical variance in the burden of T2DM disease [15]. The use of small area maps to map chronic disease risk at a local level is relatively new. It provides information regarding the visualization of important social determinants of health. [16] The spatial distribution of T2DM incidence is significantly associated with the geographic prevalence of obesity and the level of physical inactivity[17]. The burden of DM in India is spatially clustered. Southern countries have the highest level of spatial clustering[18]. Research results show that the clustering areas of diabetes patients are mostly in the Beijing–Tianjin–Hebei region[19]

The prevalence of DM in Jambi Province has increased from 1.2% in 2013 to 1.4% in 2018. [8][9].

The age factor > 45 years is the dominant factor in the incidence of DM and the female age group is more dominant in the incidence of DM [20]. One strategy for preventing DM and hypertension control is to apply spatial analysis to find areas with a high risk of these diseases. [21] The importance of mapping and spatial analysis related to non-communicable diseases, especially DM, will contribute to the Non-Communicable Disease program.

2. Methodology

Research design

This research is an exploratory study with an ecological design that studies the distribution of Diabetes Mellitus and uses a Geographic Information System (GIS) application that analyzes data spatially.

Research area

This research was conducted in the regencies/cities of the BPJS Region II Jambi Province, namely Bungo, Tebo, Merangin, Sarolangun, Kerinci and Sungai Banyak regencies. The research sample was participants with a diagnosis of DM sourced from BPJS visit data at the FKTP for 2020 – 2022.

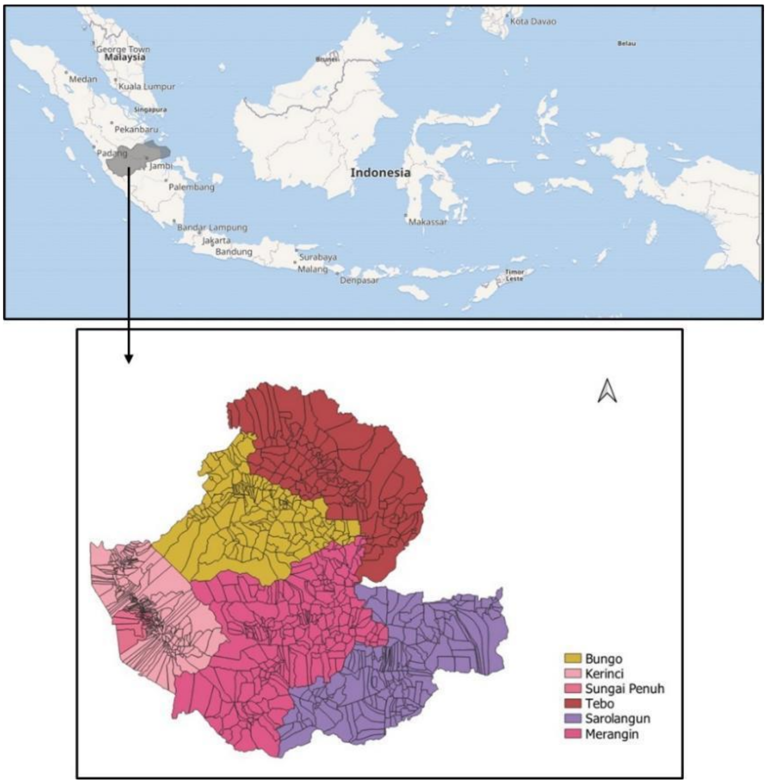

Figure 1. Research Area

Data

The data source was obtained from the Jambi Province BPJS Membership Recording Report for 2020 - 2022. The instrument in this research used the QGIS application (https://qgis.org/en/site/) whose function can produce output in the form of a map of the distribution of DM cases in Jambi Province, while the Geoda application (https://geodacenter.github.io/download_windows.html) was used to conduct cluster analysis of DM cases. Data analysis was carried out univariately to see the frequency distribution of DM cases and map the distribution of DM cases. Spatial analysis was used to see the pattern of grouping of DM cases.

Space-time scan statistic

Analysis space-time scan statistics use software SaTScan TM v9.4.4

(https://www.satscan.org/download_satscan.html). Software This is free software used for spatial analysis. The Poisson model was used to identify districts at high risk of DM during the period 1 January 2020 - 31 December 2022. Test the significance of case clustering (cluster) DM using value Likelihood Ratio (LLR), 999 permutations were carried out and the significance level was 0.05. The cluster with the highest LLR value is designated as the most likely cluster, while the other clusters are as secondary cluster DM (Kulldorf, 2005; Wang et al., 2012; Gwitira et al., 2021)

Analysis spatial autocorrelation

Analysis of spatial autocorrelation This is an analysis to see whether there is a regional auto-correlation in each sub-district (a local indicator of spatial autocorrelation/LISA) on the risk of developing DM. This analysis uses the software GeoDa, which can facilitate the calculation of the Moran Index to identify spatial autocorrelation on spatial data.

3. Result and Discussion

Descriptive Analysis

Over the three-year study period, the prevalence of DM varied from 0 to 94.7 per 100,000 population (mean 2.71 per 100,000 population). The subdistrict with the highest prevalence of DM is Tebo Ilir Subdistrict, Tebo Regency (94.7 per 100,000 population), followed by Gunung Kerinci Subdistrict (Kerinci Regency), Selamat Barat Subdistrict (Merangin Regency), and Limbur Lubuk Mengkuang Subdistrict (Bungo Regency) with the highest prevalence. respectively 86.7; 86.7; and 83.3 per 100,000.

population.

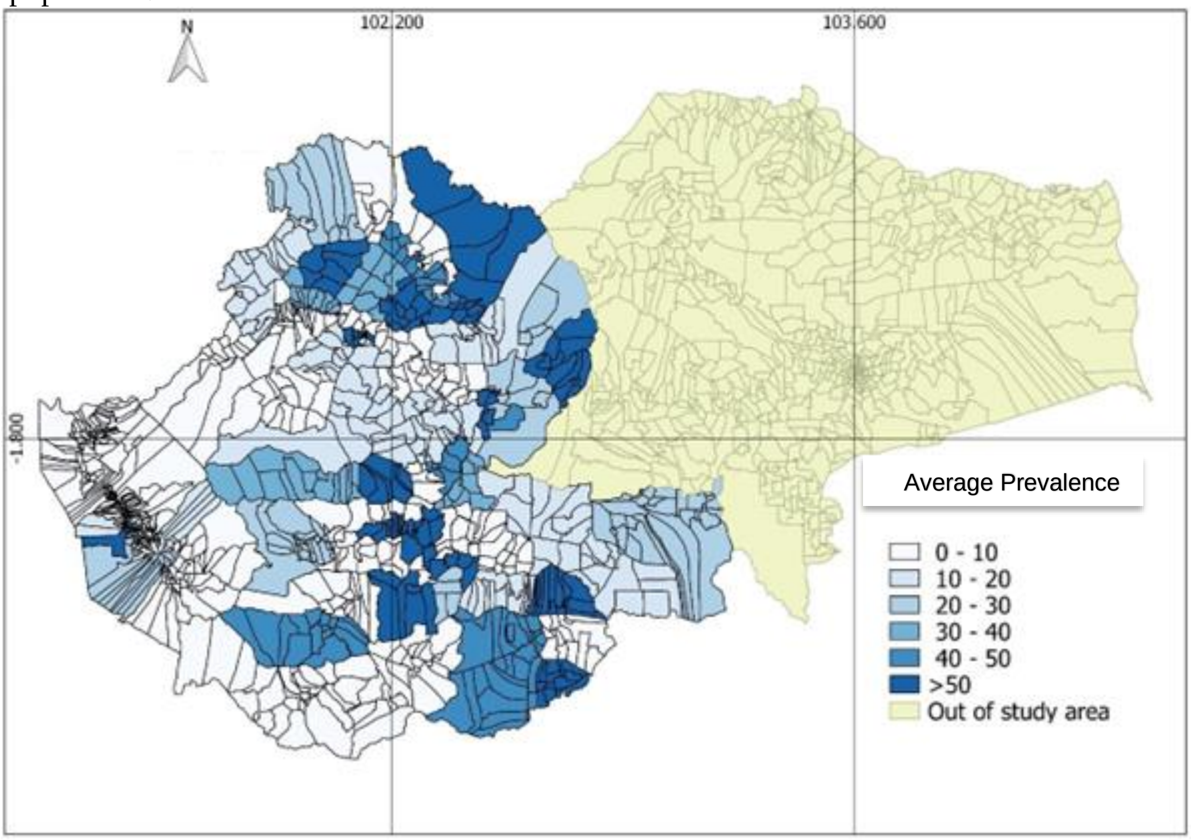

Figure 1. Average Prevalence of DM in 2020–2022.

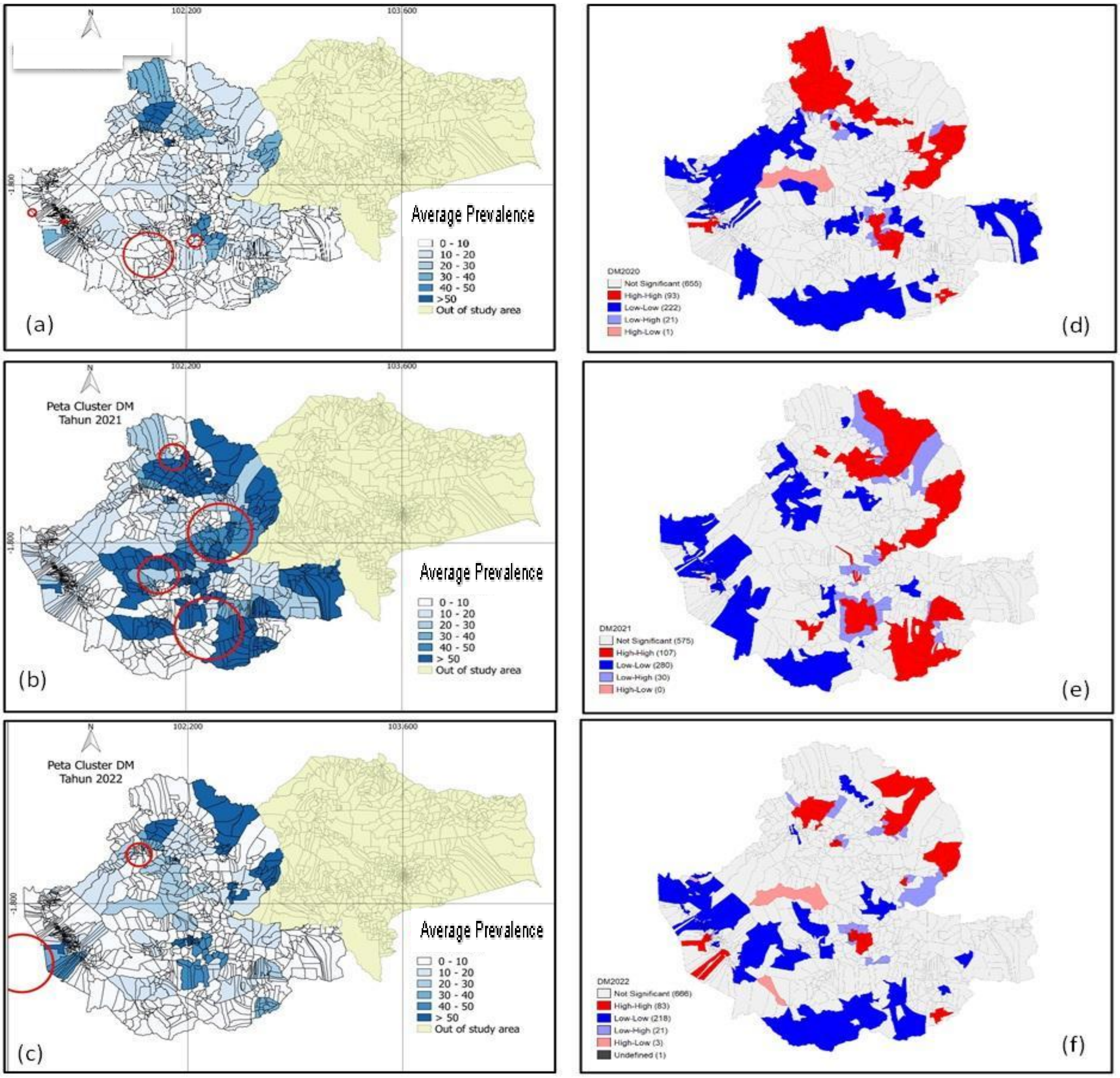

Figure 2: Figures (a) - (c) Analysis Map Space-Time Scan Statistic DM 2020-2022, (d) – (f) Analysis Map Spatial Autocorrelation DM 2020-2022

Space-time scan statistic

Results from the analysis of space-time scan statistics during the 2020-2022 period can be seen in Table 1. Based on the results of the analysis, 10 DM clusters were found with details of 3 most likely clusters and 7 secondary clusters. Seen in the following table:

Table 1. Cluster DM cases in Jambi Province in 2020-2022 based on analysis space-time scan statistic

Year	Type Cluster	Coordinate	Radius (km)	Jl. Case	Case Expectations	Populations at Risk	RR	LLR	p
2020	Most likely	1.9999397 S /101.1982399 E	2,9	1762	384	42.440	5,1	28,3	< 0,001
	1st secondary	2.0664513 S / 101.4080719 E	1,6	1348	324	35.780	4,5	26,1	< 0,001
	2nd secondary	2.205686 S / 102.2547916 E	4,9	511	349	38.548	1,5	19,3	< 0,001
	3rd secondary	2.3067382 S / 101.9536969 E	17,9	235	134	14.747	1,8	18,6	< 0,001
2021	Most likely	2.0280335 S / 102.0231273 E	14,6	333	85	35.834	4,3	217,2	< 0,001
	1st secondary	1.7274731 S / 102.4213928 E	23,1	590	245	104.129	2,7	190,4	< 0,001
	2nd secondary	2.4102575 S / 102.3471073 E	23,4	433	183	77.593	2,5	132,3	< 0,001
	3rd secondary	1/.1890696 S / 102.1197452 E	10,3	225	128	54.409	1,8	31,3	< 0,001
2022	Most likely	2.2251112 S / 101.1172235 E	22,8	176	664	65.153	2,8	65,4	< 0,001
	1st secondary	1.4526969 S / 101.8823394 E	9,1	101	647	63.447	1,5	9,1	< 0,001

Spatial autocorrelation

Software GeoDa was used to carry out spatial autocorrelation analysis with Moran's I index and a significance level of 0.05. It was found that there was spatial autocorrelation of DM in Jambi Province during the three-year research period. The results of the analysis can be seen in Table 2.

Table 2. Analysis results in spatial autocorrelation

Year	P	Moran's I	WITH
2020	0,001	0,589	31,29
2021	0,001	0,616	32,49
2022	0,001	0,591	31,78

Results of analytical research at the sub-district level were carried out in 6 districts in Jambi Province, namely Bungo, Tebo, Merangfin Sarolangun Kerinci, and Sei Districts. Full. There is spatial variability in DM cases as indicated by the clustering of cases in certain areas. Determining DM clusters spatially in the research area using the Poissn Model with SaTSCan software and the LISA Model with Geoda software. The research results show that in 2020 the most likely cluster will be: Sungai Banyak District, Sungai Banyak City. Secondary cluster: Pesisir Bukit District, Sungai Banyak City; District Muara Siau, Kab. Moaning; and District. Bangko Barat, Kab. Merangin, 2021: The most likely cluster is Kec. Nalo Tantan, Kab. Moaning. Secondary cluster: Kec. Tabir Ilir, Kab. Moaning; District Bungo Dani, Bungo Regency; and District. VII Koto Ilir, Kab. Tebo. Year 2022 Most likely cluster: Kec. Kumun Debai, Full River City. Secondary cluster: Kec. Sepenggal Land, Bungo Regency. Hotspot analysis shows that for 2020, namely Kec. Full River, Full River City; District VII Koto Ilir, Kab. Tebo; District Rimbo Ilir, Kab. Tebo; District Tebo Ilir, Kab. Tebo; District Bangko, Kab. Moaning. In 2021, namely District. Sumai and Kec. Tebo Ilir, Kab. Tebo; District Singkut, Kab. Sarolangun; Bangko & West Bangko District, Kab. Bangko Merangin. 2022: District. Sumai and Kec. Tebo Ilir, Kab. Tebo; District Kumun Debai, Sungai Banyak City; and District. Singkut District. Sarolangun.

This research found that both methods identified DM clusters in similar places. This shows that both methods are solutions that can be applied and are effective for determining and identifying areas with a high prevalence of DM. In a Geographic Information Systems study of a large cohort of Australians aged 45 years and over, significant geographic variation in the incidence of Type 2 DM was identified. Spatial mapping of DM cases to see distribution patterns. Are there areas with a high concentration of cases? The presence of clusters in this study could be because it is an urban area so there are also environmental factors. Previous research in East Java found that there was positive spatial autocorrelation of DM in East Java and formed a clustered pattern in the East Java region [22]. Spatial research on the prevalence of DM is also found in many developed and developing countries, one of which is in the United States. It found positive spatial clustering in the prevalence of diabetes at the district level by forming a clustered pattern in the United States [23].

There is a significant positive spatial autocorrelation between smoking risk factors, resulting in a high prevalence rate of DM in India [24]. Areas that are DM hotspots in Indonesia can become the government's focus in efforts to control and prevent DM. There is a link between regions with the prevalence of DM so that it can identify areas with a high spatial prevalence of the disease, enabling better decision-making related to public health planning and being able to focus disease interventions in areas at high risk [25]. In a large cohort GIS study of Australians aged 45 years and over, we identified significant geographic variation in the incidence of T2DM in NSW, Australia. We show that the incidence of T2DM is significantly correlated with the prevalence of obesity and the level of physical inactivity at the population level. The geographic variation and spatial clustering of T2DM incidence identified in this study are consistent with the results of a previous study comparing diabetes prevalence in large cities and remote areas in Australia (40). In addition, the high incidence of T2DM in rural NSW may be due to the local arid climate and lack of health resources in the region (41).

3.1. Conclusion Suggestions

There are clusters and hotspots of Type 2 DM disease in Jambi Province, there is a need for intervention in prevention and control programs in cluster and hotspot areas

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