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Spatial analysis and forecasting map of diarrhea incidents in Banjar District

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ABSTRACT

Diarrhea is a common disease in the community and can be fatal if treatment is delayed. Banjar District has recorded the highest prevalence of diarrhea in South Kalimantan for the past few years, making it one of the causes of death in toddlers. This study aims to conduct spatial analysis using Moran's I index and local indicators of spatial association (LISA). Diarrhea case predictions are made using the multiplicative decomposition time series method. The data used in this study are diarrhea case data from 20 sub-districts in Banjar District during the period 2016-2022. Although no global autocorrelation was found in Banjar District, there were two sub-districts that showed local autocorrelation. The prediction results show a decreasing trend in diarrhea cases in most sub-districts. Health interventions can be focused on areas with high risk, such as hotspot areas and areas predicted not to experience a decrease in diarrhea cases.

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1. INTRODUCTION

Diarrhea is a condition in which bowel movements are very loose or watery, usually occurring at least three times within a 24-hour period [1]. Out of an estimated 4,4 billion cases worldwide, 1,6 million result in death, with the majority of fatalities occurring in children younger than five year old [2], [3]. In nations characterized by low and lower-middle incomes, more than 90% of fatalities in children under the age of five are linked to diarrhea [4].

Indonesia, as one of the developing countries, also faces challenges with diarrhea. According to the Basic Health Research results in 2018, the prevalence of diarrhea was 8% across all age groups, 12.3% in toddlers, and 10.6% in infants. Meanwhile, Based on information provided by the Ministry of Health, diarrhea was the leading cause of death among newborns (7%) in 2018, and it increased to 14% in 2021, making diarrhea the second leading cause of death after pneumonia (14.4%). Diarrhea is additionally listed as a cause of death for 6% of newborns aged 28 days and 10.3% of toddlers in Indonesia [5], [6].

Data from the South Kalimantan Provincial Health Office stated that in 2020, there were 35,092 diarrhea incidents in South Kalimantan, with the highest incidence occurring in Banjar District with 5,516 cases, followed by Banjarmasin City (5,412 cases) and Kotabaru District (3,767 cases). From 2017 to 2020, Banjar District has consistently been the district with the highest of diarrhea incidents in South Kalimantan, and diarrhea has been one of the causes of infant mortality [7], [8].

Many factors, both directly and indirectly, can trigger diarrhea, including host, agent, and environmental factors. Host factors are influenced by age, education, knowledge, behavior, and socio-economic status. Diarrhea-causing agents are transmitted through contaminated food or drink in unhealthy environments. Environmental factors influencing diarrhea incidence include the type of latrine, waste management, and wastewater treatment facilities, in addition to other factors such as climate and population density [9]–[11].

To address the issue of diarrhea, an innovative and effective approach is needed. One of these approaches is by using geographic information systems (GIS). GIS is a technological tool that enables us to visually represent, comprehend, interrogate, analyze, and interpret data in order to grasp geographic connections, trends, and patterns [12]. GIS can be applied to study health data, enabling us to observe specific phenomena within an area [13].

GIS can also be combined with diarrhea forecasting as part of an early warning system. Forecasting utilizes statistical models developed based on historical data to predict the potential spread of diseases in the future [14], [15]. By combining these two methods, clear and easily understandable visualizations can be provided regarding which areas are most at risk of diarrhea. This approach can help formulate and implement more effective diarrhea control strategies, which have not been done previously in Banjar District.

2. METHOD

This study employs a descriptive analytic methodology, utilizing a secondary data analysis approach. Monthly diarrhea data per sub-district were obtained from the Banjar District Health Office from 2016 to 2022. The acquired data were then analyzed descriptively based on the number of cases, cases in toddlers, and population. The estimation of global grouping of diarrhea incidence was done using Moran's I statistics [16]. Univariate analysis of local indicators of spatial association (LISA) was conducted to identify high-risk sub-districts for diarrhea in Banjar District [17]. Spatial weighting was based on the first-order Queen contiguity matrix. Spatial autocorrelation was performed using GeoDA software version 1.20 with univariate Moran's I analysis and LISA using a queen contiguity spatial weighting matrix with an order of contiguity of 1 and performed permutations 999 times.

Forecasting was done using the Multiplicative Seasonal Decomposition Analysis method using statistical applications to decompose monthly sub-district diarrhea incidents (Y_t) into combined trend (T_t), seasonal component (S_t), and error or residual component (E_t). Unlike the additive method, the equation for the multiplicative method is $Y_t=T_t.S_t.E_t$. This method is used when the magnitude of a time series is not constant [18]. The results of the forecasting were then mapped using QGIS application version 3.32. This study received ethical approval from the research ethics committee at the Faculty of Medicine, Lambung Mangkurat University, with number 454/KEPK-FK ULM/EC/XI/2023.

3. RESULTS AND DISCUSSION

3.1. Diarrhea cases in situation Banjar District

Banjar District consists of 20 sub-districts with its capital located in Martapura Sub-district. As the center of government and economy, Martapura Sub-district has the largest population in Banjar District [19]. In Table 1, it can be seen that the peak of diarrhea cases occurred in Banjar district in 2017, with the highest number of cases occurring in Martapura Sub-district Figure 1. This is due to the population in the Martapura Sub-district being the highest in Banjar district. The high population is related to the level of residential density. High residential density results in poor environmental sanitation, thereby increasing the risk of diarrhea [20], [21]. Diarrhea cases in Banjar District have decreased, especially in 2019. This is related to several efforts that have been made by the health department to reduce diarrhea cases, including implementing health promotion and environmental sanitation, the activities of which are carried out in collaboration with other sectors [19].

Table 1. The annual diarrhea cases in Banjar District from 2016 to 2022

	2016		2017		2018		2019		2020		2021		2022	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Total number of cases	9,683	31.5	11,131	35.9	10,479	30.4	5,298	13.6	5,535	17.3	3,128	12.4	3,775	19.7
Number of cases in toddlers	3,902	40.30	4,258	38.52	3,951	37.70	1,951	36.83	1,966	35.52	1,229	39.29	1,360	36.03
Total population	562,411		571,156		580,088		589,158		598,375		605,526		571,444	

The highest incidence of diarrhea occurred among toddlers in 2017, with 9 infants dying [7]. Deaths of toddlers due to diarrhea are usually caused by severe dehydration [22]. To reduce the number of deaths of toddlers due to diarrhea, appropriate management is required. World Health Organization (WHO) recommends five main steps in the management of diarrhea, known as integrated diarrhea management (rehydration, zinc supplementation, nutritional support, targeted antibiotic therapy, and education for parents) [23]. Factors contributing to diarrhea incidence in toddlers include environmental conditions, maternal knowledge, and maternal personal hygiene. Regarding environmental factors, the most dominant are clean water supply facilities, family toilet facilities, waste management facilities, and household waste management facilities [24], [25].

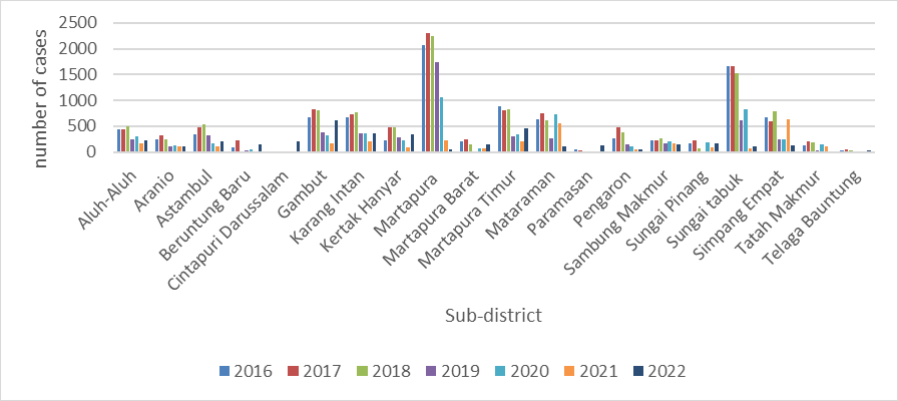

Figure 1. Annual cases of diarrhea by sub-district in Banjar District from 2016 to 2022

3.2. Autocorrelation of diarrhea cases in Banjar District

In the univariate Moran's I test, it was found that there is no global spatial autocorrelation of diarrhea cases in Banjar District from 2016 to 2022, with a Z-score of (0.2026)<$Z_{1-\alpha}$(1.645). The spatial pattern among regions in Banjar District is positive, meaning that the pattern of one region has similar characteristics to its surrounding regions (clustered) with an I value of (-0.09)>E(I) (-0.0526). This is in line with previous research conducted in the Ilubabore Zone, Oromia Regional State, Ethiopia, and in Mozambique, which stated that the spread of diarrhea cases occurs in clusters [16], [26].

LISA analysis was carried out to identify the distribution pattern of diarrhea cases in each area and assess its significance. Figure 2 as shown in the LISA analysis indicates the presence of local spatial autocorrelation in two sub-districts in Banjar District, namely Sungai Tabuk Sub-district and Pengaron Sub-district, with a significant value of 0.05 Figure 2(a). Pengaron Sub-district falls into the high-high quadrant, indicating that Pengaron Sub-district has high diarrhea cases and is adjacent to areas that also have high cases, indicating that this area is considered a hotspot. Sungai Tabuk Sub-district is in the high-low quadrant, indicating that Sungai Tabuk Sub-district has high diarrhea cases and is adjacent to areas with low cases, this area is called outliers [27]. The LISA Cluster map can be seen in Figure 2(b).

The sub-districts that become diarrhea case hotspots are located in the middle of Banjar District and are crossed by rivers connected to several other sub-districts. Rivers can be a means of diarrhea pathogen transmission because many people in Banjar District still use them for daily purposes, even though according to research conducted by Zubaidah *et al.* [28] the total coliform value of rivers in Banjar District does not meet the Class I quality standard according to Ministry of Health Regulation No. 32 of 2017. Fecal coliform bacteria, which are a subgroup of the total coliform bacteria category, are abundant in the intestines and feces of both humans and animals. If a water sample tests positive for fecal coliform, it often suggests recent contamination by fecal matter. This implies a higher likelihood of the presence of pathogens compared to when only total coliform bacteria are found [29], [30].

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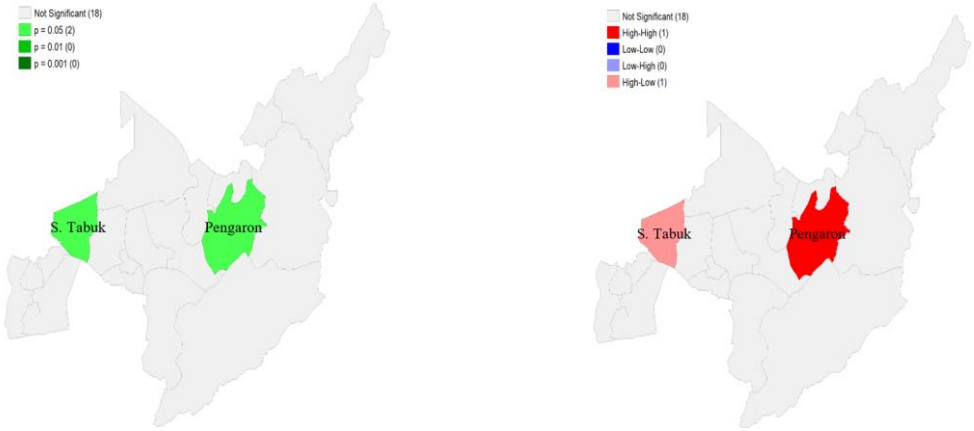

(a) (b)

Figure 2. Spatial cluster maps of cumulative diarrhea case 2016-2022 as identified by LISA analysis (a) LISA significance map of diarrhea and (b) LISA cluster map of diarrhea

Escherichia coli (*E. coli*) is a subset of the fecal coliform bacteria group. *E. coli* as one of the causes of diarrhea is a normal rod-shaped gram-negative flora found in the digestive tract of animals and humans. *E. coli* can turn into a pathogen under conditions where there is an increase in the number of bacteria in the digestive tract or when the bacteria are present outside of the intestines. If *E. coli* is found in large quantities in water, it indicates that the water has been contaminated by human or animal feces [29], [31]. Spatial analysis can identify high-risk sub-districts (hotspots) that need to be the focus of preventive measures and interventions by the health department. However, other sub-districts should not be neglected because this study did not find any areas categorized as cold spots or areas with low risk.

3.3. Forecasting of diarrhea cases in each sub-district in Banjar District

The forecasting of diarrhea cases in this study can only be conducted in 19 sub-districts. This is due to the limitation of case data in Cintapuri Darussalam Sub-district, which is insufficient for analysis. Cintapuri Darussalam Sub-district is a new sub-district formed from the division of Simpang Empat Sub-district. Therefore, relevant historical data for forecasting is not yet available in sufficient quantity. The forecasting results can be seen in Figure 3.

The forecasting results indicate that the majority of diarrhea cases are decreasing. This is good news and suggests that prevention and control efforts may already be yielding results. However, there are two sub-districts, namely Beruntung Baru Sub-district and Paramasan Sub-district, that show different trends.

One of the environmental sanitation efforts carried out by the local government of Banjar District is the program to eliminate 1,000 floating latrines, which is a priority for development in accordance with the vision and mission of the Regent of Banjar District [32]. Floating latrines in Banjar District are latrines located above rivers and do not have fecal storage, thus not meeting the standards for a healthy latrine. This program must also be accompanied by education about clean and healthy behaviors to increase knowledge and teach healthy perceptions to the community, so that long-standing unhealthy behaviors can be changed.

The forecasting results are then visualized in the form of a map and classified into three categories using the equal interval classification method for ease of interpretation and allowing direct comparison between regions Figure 4. In 2023, it is estimated that there will be five sub-districts classified in the red zone. However, this number continues to decrease over time, until in 2027 there are no more sub-districts in the red zone.

One interesting finding from this forecast is the Beruntung Baru Sub-district. From 2023 to 2027, this sub-district experienced no change and remained in the orange zone. Although not in the red zone, the fact that its condition did not change during this period suggests that there may be certain factors preventing improvement in this sub-district. This needs to be addressed by the Health Department besides hotspot areas.

The forecast results for diarrhea cases in Banjar District show fluctuating patterns every month, with the peak of diarrhea cases estimated to occur in March each year. This is a crucial period for public health intervention because the number of diarrhea cases is expected to reach its highest point. Therefore, prevention and control efforts should be intensified during this period to reduce the impact of the increasing cases.

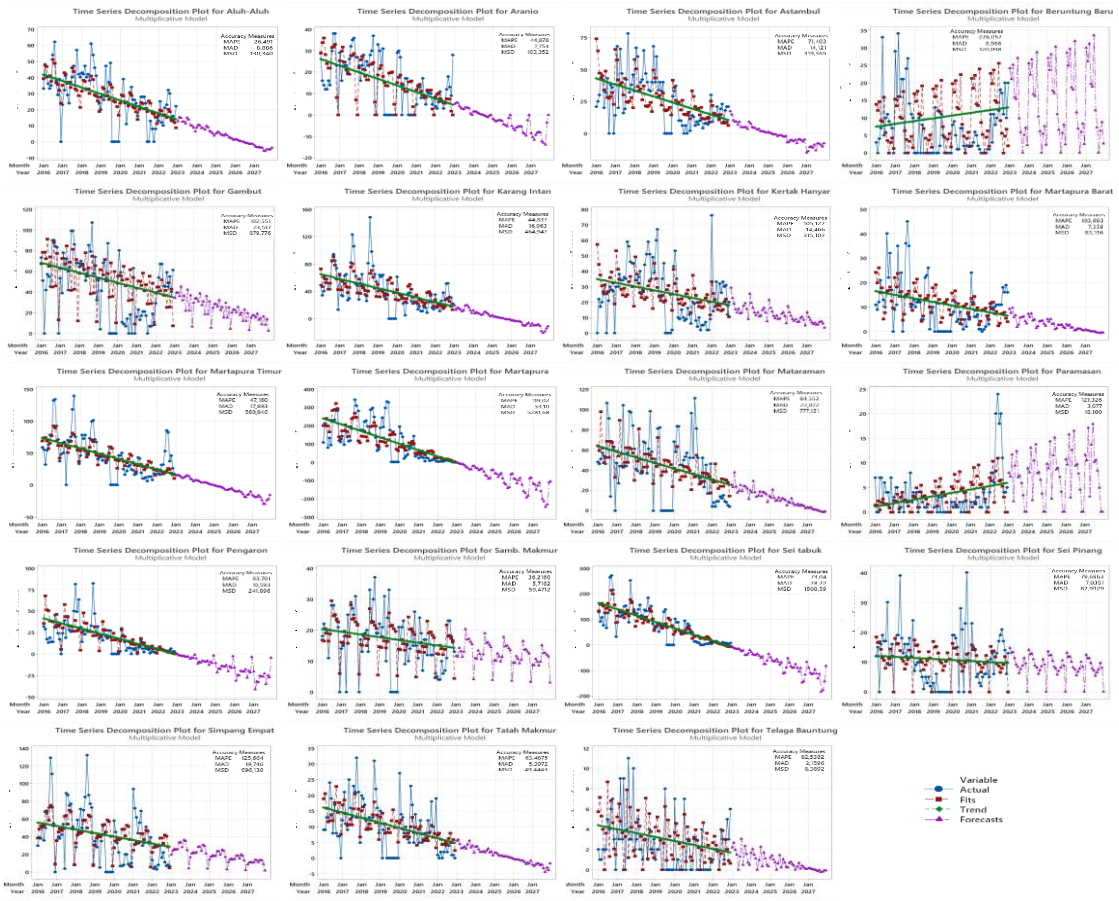

Figure 2. Multiplicative seasonal decomposition of diarrhea cases per sub-district in Banjar District

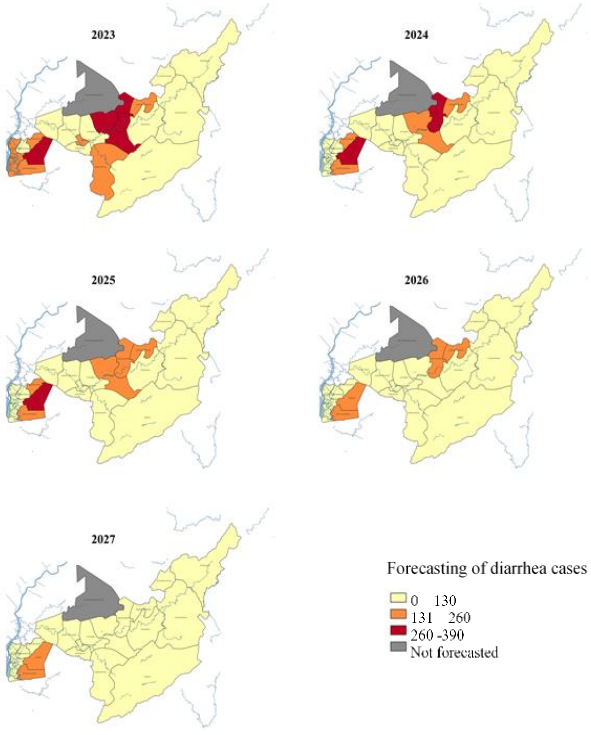

Figure 3. Map of diarrhea case forecasting in Banjar District

4. CONCLUSION

Inaccurate targeting of interventions can impede the control of diarrheal diseases. In this study, global spatial analysis does not indicate any autocorrelation, which means there is no significant pattern in the distribution of diarrhea cases across the entire area. However, when we look closer at the sub-district level using univariate LISA analysis, we find evidence of local spatial autocorrelation. This means there is a pattern in the distribution of diarrhea cases that is only visible at the local scale.

The focus of health intervention can be carried out in Pengaron District, which is a hotspot area, and in the Beruntung Baru District, where cases of diarrhea are not decreasing according to forecasting results. This can be achieved by improving sanitation and encouraging the community to avoid open defecation, while involving community leaders in the process.

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