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Spatial analysis of diarrhea in toddlers and environmental factors in the East Java Province Indonesia

Eka Satriani Sakti[1*], Martya Rahmaniati Makful[2], Romariana Dewi[1]

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[1]Public Health Science Program Study, Faculty of Public Health, Universitas Indonesia, Indonesia

[2]Department of Biostatistics and Population Studies, Faculty of Public Health, Universitas Indonesia, Indonesia

***Correspondence:**
eka.satriani01@ui.ac.id

Abstract

Purpose: The objective of this study was to conduct spatial analysis on the incidence of diarrhea in toddlers in East Java and to examine its relationship with environmental factors such as percentage of families with access to proper sanitation (healthy latrines), percentage of ODF (Open Defecation Free) villages, and percentage of drinking water facilities that meet the requirements in each district/city in East Java. **Methods:** The study utilized a cross-sectional study design with the 2020 East Java Province Health Profile serving as the data source. Moran's Index and the LISA bivariate test were used for the spatial analysis. **Result:** The findings revealed that there is a spatial autocorrelation in the number of diarrhea cases in toddlers (I value: 0.28, p value: 0.009). Out of the districts/cities studied, only 5 exhibited significant spatial correlation (Gresik, Sidoarjo, Mojokerto, Magetan, and Surabaya City) based on the LISA bivariate test results. **Conclusion:** Efforts to decrease the incidence of diarrhea cases in toddlers should focus on increasing the scope of environmental health programs, particularly in quadrant 1 (High-High) and 2 (Low-High) areas. Further analysis is required within the sub-district and village scope.

Keywords: autocorrelation; spatial; diarrhea; toddlers

INTRODUCTION

Diarrhea is a condition in which a person has three or more liquid bowel movements in a day. It is caused by bacterial, viral, or parasitic infections that occur through contamination of food and water, or unhealthy human behavior. Diarrhea can be prevented by improving environmental and behavioral factors, and it can be treated by administering oral rehydration solution (ORS) and zinc supplementation [1].

Diarrhea is a leading cause of infant mortality, accounting for 9% of deaths among children under five worldwide in 2019. The highest percentage of under-five deaths due to diarrhea occurs in Southeast Asia and Sub-Saharan Africa [2]. In Indonesia, diarrhea is the primary cause of death among children under five and the second leading cause of neonatal death [3].

The goal is to reduce the incidence of diarrhea in toddlers served in 2021 to 20%. However, in Indonesia, the incidence rate of diarrhea in toddlers in 2021 is currently 23.8%. Among the provinces in Indonesia, East Java has the third-highest rate of diarrhea in toddlers, with a rate of 39.4%, following Banten (55.3%) and West Nusa Tenggara (51.4%) [3].

Diarrhea is caused by a combination of factors, including nutrition, environment, and behavior. Nutritional factors, such as exclusive breastfeeding, nutritional status, immunization, and vitamin A supplementation, can play a role. Environmental factors, such as access to clean drinking water and proper sanitation facilities, also contribute. Behavioral

factors, such as handwashing and using a toilet, can also influence the incidence of diarrhea.

According to a study by Agus Tuang (2021) in Makassar City, there is a correlation between the availability of proper latrines and the incidence of diarrhea in children (with a p-value of 0.005). Children who have access to properly functioning latrines are less likely to experience diarrhea [4].

One aspect of the Community-Based Total Sanitation program is the achievement of ODF (Open Defecation Free) status. According to a study by Mukti et al (2016), there is a correlation between the implementation of the STBM (Community-Based Total Sanitation) program in achieving ODF status and the incidence of diarrhea in the Jatibogor Health Center in Tegal Regency (with a p-value of 0.020) [5].

Poor quality water can serve as a source of disease vectors, particularly diarrheal diseases. According to a study by Yantu et al (2021), there is a significant correlation between the quality of clean water facilities and the incidence of diarrhea [6].

Spatial analysis is a set of methods that use spatial concepts like location, area, distance, and interaction to analyze and explain data in a geographic context. It allows for the observation of patterns, actions, and behaviors of spatial objects. One of the main benefits of spatial analysis is the ability to detect geographic patterns in data. For example, it can help identify clusters of disease spread, which can be used to develop programs to control and prevent the disease [7].

Much research has been done on diarrhea and environmental health, but studies on correlations between adjacent areas based on spatial patterns are still few. In this study, researchers aim to conduct a spatial analysis of diarrhea incidence among toddlers and examine its relationship between environmental health variables such as percentage of families with access to proper sanitation (healthy latrines), percentage of Open Defecation Free (ODF) villages, and percentage of drinking water facilities that meet health requirements to diarrhea incidence among toddlers in each district/city of East Java Province in 2020. Through this research, it is hoped that policy makers can develop prevention and control programs based on autocorrelation relationships and hotspot areas.

METHODS

This research study was designed as a cross-sectional study, using data from the 2020 East Java Health Profile [8]. The data is publicly available and can be accessed at https://dinkes.jatimprov.go.id.

This study focused on the incidence of diarrhea cases in toddlers as the dependent variable. The independent variables examined were percentage of families with access to proper sanitation (healthy latrines), percentage of Open Defecation Free (ODF) villages, and percentage of drinking water facilities that meet the health requirements.

The spatial analysis method used in this study was Moran's Index and Local Indicator of Spatial Autocorrelation (LISA). Moran's index was used to examine the spatial autocorrelation of the variables. If the observed Moran's I Index results are greater than the expected E(I) value, it indicates a cluster. If the Moran's I Index results are less than the E(I) value, it means that neighboring locations do not have the same value or the pattern is spread out. The significance is determined by the p-value. If the p-value is large (> 0.05), then the null hypothesis (complete spatial randomness) cannot be rejected, indicating that there is no spatial autocorrelation. Conversely, if the p-value is small (< 0.05), then there is spatial autocorrelation [7].

The LISA univariate test was used to examine clusters based on cases of diarrhea. The LISA bivariate test was used to examine the pattern of spatial relationships between the dependent variable and each independent variable and the formed hotspots or coldspots.

The analysis was conducted using the GeoDa application. The neighbor weighting used the Queen contiguity method, with the regional analysis units being the 38 regencies/cities of East Java Province.

RESULTS

Table 1 shows Moran's Index value for the study variables. Index for the number of diarrhea cases in toddlers is 0.28, which is greater than E(I) of -0.0270, indicating that the cases of diarrhea exhibited a cluster pattern. The Z value is calculated to be 2.4298, which is greater than Z ($\alpha/2$) = 1.645, and the p-value was 0.009. These results indicated that there is spatial autocorrelation between locations, meaning that the number of diarrhea in toddlers served at health facilities is interrelated between neighboring locations.

Among the independent variables examined, the percentage of families with proper sanitation (with a p-value of 0.016) and the percentage of Open Defecation Free (ODF) villages (with a p-value of 0.044) showed spatial autocorrelation and exhibited a cluster distribution pattern. On the other hand, the percentage of drinking water facilities that meet the health requirements did not exhibit spatial autocorrelation (with a p-value of 0.243) and showed a dispersion pattern.

Table 1. Moran's index on variables

Variable	I	E(I)	Z score	Pattern
Number of cases of diarrhea in toddlers*	0,28	-0,027	2,4298	Clusters
Percentage of families with proper sanitation*	0,317	-0,027	2,6885	Clusters
Percentage of ODF villages*	0,1995	-0,027	1,779	Clusters
Percentage of drinking water facilities that meet the requirements	-0,1145	-0,027	-0,7121	Disperse

Note: *) significant alpha at 0.05

Figure 1 shows the distribution of cases of diarrhea in toddlers in East Java. The areas with the highest number of diarrhea cases among toddlers were found in Malang, Banyuwangi, Pasuruan, Sidoarjo, Bojonegoro, Lamongan, Gresik, and Surabaya City. According to Local Moran's univariate analysis of the number of cases of diarrhea in under-fives, the districts/cities included in quadrant 1 (High-High) were Sidoarjo, Gresik, and Surabaya City. These three districts/cities had a high number of diarrhea cases in toddlers and were surrounded by neighboring districts/cities with similarly high numbers of cases.

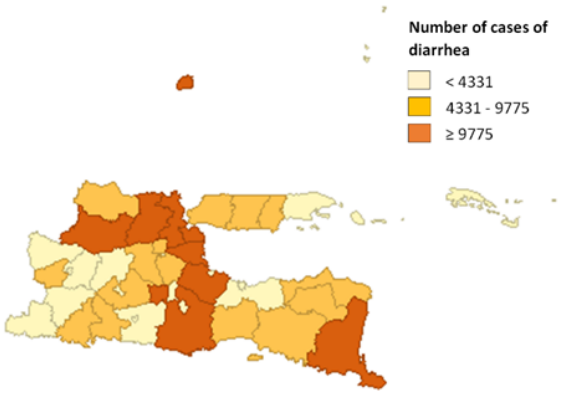

Figure 1. Distribution of Diarrhea Cases among Toddlers in East Java in 2020

In quadrant 2 (Low-High), there was Mojokerto District, which had a low number of diarrhea cases in toddlers but was surrounded by neighboring districts/cities with high numbers of cases. Meanwhile, districts/cities that were included in quadrant 3 (Low-Low), such as Magetan, had low numbers of diarrhea cases in toddlers and were surrounded by other districts/cities with similarly low numbers of cases. No districts/cities were found in quadrant 4 (High-Low).

Figure 2 presents the LISA bivariate test results between the independent variables (percentage of families with proper sanitation, percentage of Open Defecation Free (ODF) villages, and percentage of drinking water facilities that meet the necessary health requirements) and the number of diarrhea cases among toddlers. It showed that 33 districts/cities were not spatially related. Only five regencies/cities had p-values less than 0.05: Magetan, Sidoarjo, Gresik, Mojokerto, and Surabaya City.

Figure 2a shows the relationship between the percentage of families with proper sanitation and the number of diarrhea cases among toddlers. Gresik Regency and Surabaya City are in quadrant 1 (High-High), indicating that they had both a high percentage of families with proper sanitation and a high number of diarrhea cases among toddlers. Mojokerto and Sidoarjo Regencies were in quadrant 2 (Low-High), indicating that they had a low percentage of families with proper sanitation but a high number of diarrhea cases among toddlers. Magetan Regency was in quadrant 4 (High-Low), indicating that it had a high percentage of families with proper sanitation and a low number of diarrhea cases among toddlers.

Figure 2b shows a cluster pattern depicting the relationship between the variable percentage of ODF villages and the number of cases of diarrhea in toddlers. The quadrants help in categorizing the regions based on their ODF percentage and the number of diarrhea cases in toddlers. In quadrant 1 (High-High), Gresik Regency has a high percentage of ODF villages, but the number of cases of diarrhea in toddlers is also high. Quadrant 2 (Low-High) includes the Regencies of Mojokerto, Sidoarjo, and the City of Surabaya, indicating a low percentage of villages with ODF and a high number of cases of diarrhea in toddlers. Magetan Regency falls under quadrant 4 (High-Low) with a high percentage of ODF villages and a low number of cases of diarrhea in toddlers.

Figure 2c displays the results of the LISA bivariate test between the variable percentage of drinking water facilities meeting the requirements and the number of diarrhea cases in toddlers. The regions are divided into quadrants based on the percentage of drinking water facilities meeting the requirements and the number of diarrhea cases in toddlers. Quadrant 1 (High-High) includes Gresik, Mojokerto, and Sidoarjo Regencies, indicating a high percentage

of drinking water facilities meeting the requirements and a high number of diarrhea cases in toddlers. The city of Surabaya falls under quadrant 2 (Low-High), signifying a low percentage of drinking water facilities meeting the requirements and a high number of diarrhea cases in toddlers. Quadrant 4 (High-Low) includes Magetan Regency, which has a high percentage of drinking water facilities meeting the requirements and a low number of cases of diarrhea in toddlers.

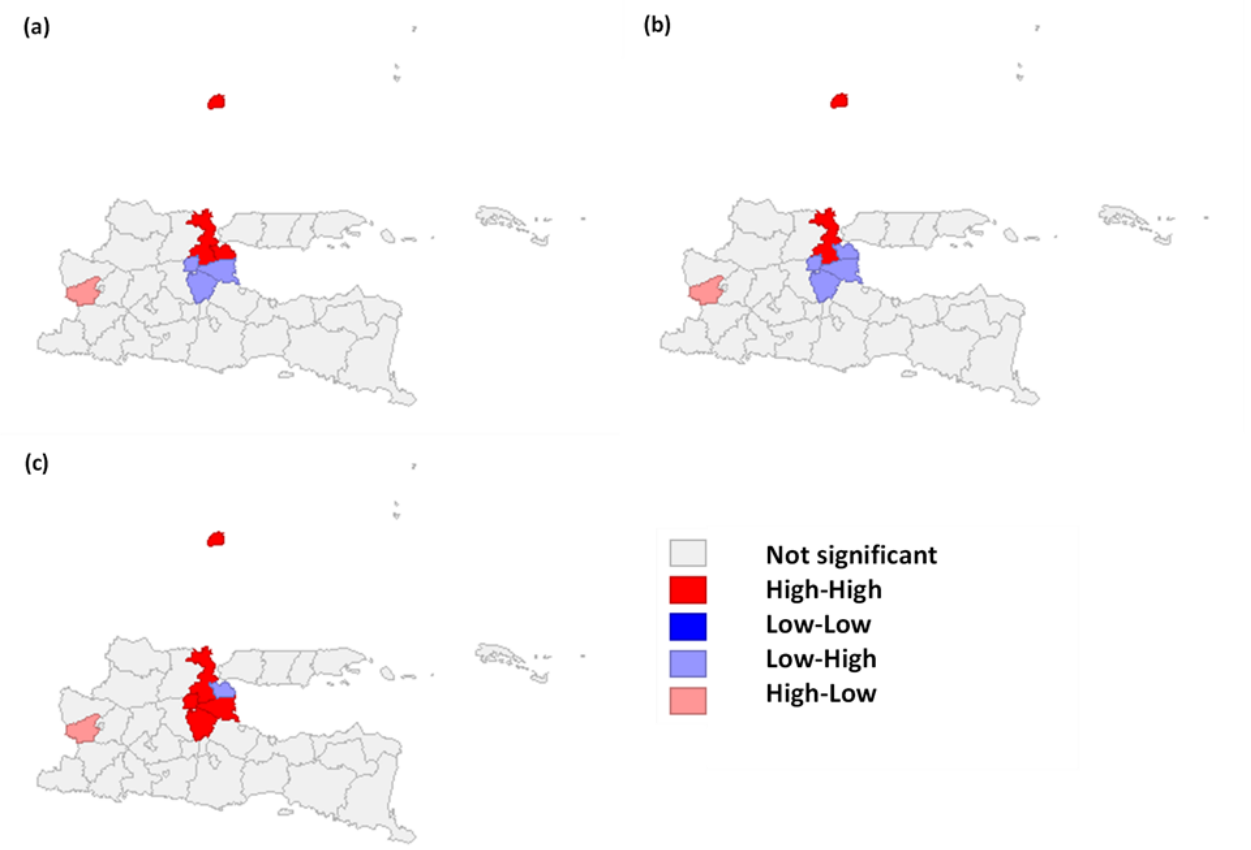

Figure 2. Cluster Pattern of LISA Bivariate Test Results between the independent variables and the number of cases of diarrhea among toddlers in East Java in 2020

DISCUSSION

Sanitation refers to the availability of facilities and the proper disposal of human waste, including urine and feces. The level of sanitation significantly impacts public health. The percentage of families with adequate sanitation, meaning healthy latrines, is determined by the number of families using healthy latrines compared to the total number of families. A healthy latrine is equipped with a gooseneck, a septic tank or Wastewater Treatment System (SPAL), and is either used by a single family or shared with other families [9]. Availability of family latrines that meet the requirements has a significant relationship to the incidence of diarrhea in toddlers as resulted from the study in Makassar City (p value 0.039) and Deli Serdang Regency (p value 0.046) [10,11]. The study on Basic Health Research (RISKESDAS) data for East Java Province in 2018 stated that the higher the percentage of access to healthy latrines, the lower the prevalence of diarrhea in toddlers [12].

Although the percentage of families with proper sanitation in Gresik Regency and Surabaya City is high (>98%), these areas still have a high number of diarrhea cases in children under five. Therefore, further investigation is necessary to identify other factors contributing to the high incidence of diarrhea cases in these two districts/cities. Meanwhile, in Mojokerto and Sidoarjo districts, the number of diarrhea in toddlers is still high, indicating a need to increase the use of healthy latrines in these areas as a strategy to reduce the number of diarrhea in toddlers.

The percentage of ODF villages refers to villages where the entire population no longer practices open defecation, which has been verified through a verification process. With this condition, it is hoped that there will be no direct spread of hazardous materials resulting from human waste disposal, and disease vectors will not be able to spread diseases to

the surrounding environment [13]. The results of the study in South Lampung Regency stated that open defecation behavior was associated with the incidence of diarrhea (p value: 0.0005) [14]. The declaration of the SBS village has a significant effect on reducing diarrhea cases. According to a study by Ermayendri & Widada (2020) in South Bengkulu Regency, the village declaration of ODF (Open Defecation Free) has reduced the average case of diarrhea by 35% [15].

The percentage of ODF villages in Mojokerto, Sidoarjo, and Surabaya City districts is still low (<50%), while the number of diarrhea cases in toddlers is high. Improving the triggering of ODF villages in these districts/cities is necessary to reduce the incidence of diarrhea, especially in toddlers. Meanwhile, Gresik Regency has a high percentage of ODF villages (100%) but still exhibits a high number of diarrhea cases in toddlers. This suggests that there may be other factors besides open defecation contributing to the incidence of diarrhea in the district.

The supervision of drinking water is essential to ensure that the community's right to safe and proper drinking water is met. Both internal and external supervision are carried out for this purpose, with the implementing agency for drinking water conducting internal supervision, and the health office carrying out external supervision. The drinking water facilities subject to supervision include drinking water depots, Regional Drinking Water Companies (PDAM), and the Community-Based Water Supply and Sanitation Program (PAMSIMAS) [13]. Drinking water is considered as meeting the requirements if it adheres to the drinking water quality standards specified in the Regulation of the Minister of Health Number 492 of 2010, which outlines the drinking water quality requirements. One of the requirements in terms of microbiological parameters is that it should be free from E.coli bacteria and Total Coliform Bacteria, which are some of the causes of diarrhea [16]. Study in Berbas Pantai Village, Bontang City in 2018, found that the presence of E. coli bacteria in drinking water depots had a significant relationship with diarrhea in toddlers (p value: 0.02) [17]. This is consistent with the findings of a study by Sari & Budyanra (2017), which reported that children from households with poor quality drinking water were at a 1.219 higher risk of experiencing diarrhea compared to children from households with good quality drinking water [18].

Despite having a 71.17% percentage of drinking water that meets the requirements, the number of diarrhea cases in toddlers in the city of Surabaya remains high at 13,244 cases. Therefore, it is essential to conduct further inspection of drinking water supply facilities, especially in sub-districts or villages with a high number of diarrhea cases. Meanwhile, Gresik, Mojokerto, and Sidoarjo districts exhibit a relatively high percentage of drinking water facilities meeting the requirements, but still, have a high number of diarrhea cases in toddlers. This suggests that there may be other factors besides the quality of drinking water contributing to the incidence of diarrhea in these districts and cities.

CONCLUSION

The spatial study's findings reveal that the locations (districts/cities) are interconnected, particularly in neighboring areas. Out of the independent variables studied, only 5 districts/cities exhibited a significant relationship (p <0.05) with the number of diarrhea cases in toddlers. The regencies/cities that require prioritization during program intervention are those distributed across quadrant 1 (High-High) and quadrant 2 (Low-High): Gresik, Sidoarjo, Mojokerto, and Surabaya City. It is recommended for the health office to focus on expanding programs that can help decrease the incidence of diarrhea cases in toddlers, such as proper sanitation access (healthy latrines) for the community, ODF villages, and monitoring drinking water facilities that meet the requirements, especially in areas such as Gresik Regency, Sidoarjo, Mojokerto, and Surabaya City. Other researchers can conduct further spatial analysis at the sub-district and sub-district/village levels, particularly in the aforementioned districts/cities. This would help identify which sub-district or sub-district/village requires intervention, enabling efforts to be more effective and targeted.

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