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Spatial Autocorrelation of Diarrhea Cases in West Java Province in 2023

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ABSTRACT

Introduction: Diarrhea have been being a significant public health threat for the community due to its impact on morbidity and even mortality especially among infants and toddlers. Understanding the pattern of diarrhea, how the key factors influence the prevalence of the disease and which areas are at the highest risk could help in controlling diarhhea.

Objective: Through spatial autocorrelation analysis of diarrhea prevalence with several risk factors, such as open defecation behavior, population density, access to proper sanitation, availability of drinking water facilities, and the number of health centers in West Java Province in 2023, this study aims to identify which districts/cities in the province are at high risk of diarrhea.

Method: This ecological study analyzed 27 districts/cities in West Java Province in 2023 using secondary data from Open Data Jabar. The dependent variable was the number of diarrhea cases, while independent variables included key factors influencing the prevalence of diarrhea. The Moran index was used for autocorrelation tests, The study used Geoda software version 1.22.

Result: The study found positive autocorrelation pattern between diarrhea prevalence and population density. Negative autocorrelatios found for the other factors i.e. number of drinking water facilities, number of villages that stopped open defecation, number of health centers and number of households with access to healthy latrines. The risk analysis reveals four high risk districts: Ciamis, Bekasi, Bogor City and Depok City. Depok City has the highest score of 9, with with population density being the main contributing factor. Bogor City, Ciamis, and Bekasi have the next highest scores.

Conclusion: Autocorrelation analysis can help understand diarrhea patterns and factors influencing its prevalence, provide guidance for program implementation and prioritization to address the most high risk areas. Key contributing factors to diarrhea prevention and control should be focused on specific interventions by district/city.

Keywords: Diarrhea; Autocorrelation; Moran Index

INTRODUCTION

A person is said having diarrhea if defecating 3 or more times a day with a liquid stool consistency (1). Diarrhea can be caused by viral, bacterial, or parasitic infections that attack the digestive system (1). Diarrhea is still one of the public health issues, especially in developing countries. In Indonesia, diarrhea is potential to cause outbreaks and is still one of the causes of death, especially among toddlers. According to the 2023 Indonesian Health Profile, there were 7,487,954 cases of diarrhea reported in Indonesia of which 3,683,780 sufferers were toddlers (2). The prevalence of diarrhea based on the 2018 Basic Health Research is 8% among all age groups, 10.6% among infants and 12.8% among children aged 1–4-year-old (3). Meanwhile, the 2023 Indonesian Health Survey (IHS) revealed that the prevalence of diarrhea reached 4.3% among total population, 6.4% among infants and 7.6% among children aged 1–4-year-old (4). This figure has decreased compared to 2018; however, control efforts must continue to be optimized.

West Java is a province with the largest population in Indonesia at 49,899,992 people and a population density of 3,857 people/km2 (5). The 2023 IHS captured the prevalence of diarrhea among total population in West Java is the fourth highest after Central, Highland and South Papua (1). Meanwhile, the prevalence in the under-five group also ranks third after Highland and Central Papua at 11% (1). However, if we look at the absolute number, this province contributes to a very large number of cases, higher than the other highhest prevalence provinces. In 2023, the West Java Provincial Government reported a total of 1,346,230 cases of diarrhea among all age groups (6).

To control diarrhea in West Java, a monitoring system is crucial to predict risk factors that contribute to the prevalence of diarrhea including open defecation behavior, population density, unimproved sanitation, and unavailability of drinking water facilities (7) as well as to identify which areas should be put as priority to be better control the disease efficiently and effectively. The use of spatial analysis methods such as spatial autocorrelation allows mapping the distribution pattern of diarrhea in an area because spatial analysis involves location-based data processing that shows a high correlation between observations in nearby areas (8). However, there have not been many studies that specifically analyze the relationship of spatial autocorrelation to diarrhea prevalence, specifically analyze and address which locations are the most at risk.

This study aims to understand the spatial patterns of the disease and determine which districts/cities in West Java Province that are at high risk of diarrhea through spatial autocorrelation analysis of diarrhea prevalence with several factors that increase the risk of diarrhea prevalence, namely open defecation behavior, population density, access to improved sanitation, availability of drinking water facilities and the number of health centers in West Java Province in 2023.

METHOD

This research was conducted with an ecological study approach using secondary data issued by the West Java provincial Government through Open Data Jabar and the West Java Provincial Health Profile. The unit of analysis is 27 districts/cities in West Java Province. The analysis year is 2023, to get the most current picture to enable immediate improvements. The dependent variable is the number of diarrhea cases, and the independent variables are potential factors influencing the diarrhea prevalence in the area: the number of villages that stopped open defecation, population density, number of households using healthy latrines, number of drinking water facilities and number of health centers.

The global index used in performing autocorrelation analysis is the Moran index, but this index can only provide general information, it cannot identify spatial patterns. Therefore, in addition to the Moran index, this study also used the Local Indicator of Spatial Association (LISA) as a local index to determine the existence of clustering and see spatial relationships based on the studied variables (1,9,10). The specific objective of analyzing LISA is to identify hot spots and cold spots, therefore helping us in understanding what underlying factors that may be related to the high prevalence of the disease (11,12). The significance level is 0.05.

This research used Geoda software version 1.22 where the data processing produced Moran's Scatter Plot, Cluster Map and Significance Map. GeoDa was used by considering several advantages. This software focuses on spatial autocorrelation analysis, particularly using Moran's I and LISA tools. It offers easy-to-interpret Moran and LISA maps, therefore allowing users to identify spatial clusters and outliers. GeoDa is also open source and free, also able to provide interactive visualizations for quick exploration of results.

The Moran Index (I) has a range of values between -1 and 1. If the value of I is between -1 and 0, it means that the spatial autocorrelation is negative or spread out, if the value of I is between 0 and 1, it means that the spatial autocorrelation is positive or clustered, while if the value of I =0, it shows a random pattern (1,14,15). The null hypothesis for spatial autocorrelation is that there is no spatial autocorrelation between regions. Moran's Scatter Plot is divided into 4 quadrants that can explain the autocorrelation of the areas being analyzed (1,16,17):

Table 1. Quadrants of Moran's Index in Explaining Spatial Autocorrelation

Quadrant I High-High (HH)	Shows areas that have high observed values surrounded by areas that also have high observed values, also known as hot spots.
Quadrant II Low-High (LH)	Shows regions that have low observed values surrounded by regions that have high observed values, also called outliers.
Quadrant III Low-Low (LL)	Shows areas that have low observed values surrounded by areas that also have low observed values, also called cold spots.
Quadrant IV High-Low (HL)	Shows regions that have high observed values surrounded by regions that have low observed values, also called outliers.

RESULTS

Univariate Analysis

Univariate analysis including mean, median, standard deviation as well as minimum and maximum numbers for each variable both dependent and independent can be seen in Table 2.

Table 2. Univariate Analysis of Each Independent and Dependent Variable

Variables	Mean	Median	Standard Deviation	Minimum	Maximum
Number of Diarrhea Cases	49,860.37	50,210.00	32,835.80	5,603	151,930
Population Density	3,856.81	1,439.00	4,575.20	392	15,421
Drinking Water Facilities	54.74	43.00	54.27	2	196
Number of Households Using Healthy Latrines	487,764.33	426,823.00	318,350.04	29,422	1,119,445
Number of villages that stopped open defecation	205.00	219.00	135.92	15	442
Number of health centers	40.74	38.99	21.380	10	101

Based on the Moran Index value of each variable, the variables of the number of diarrhea cases, population density, and number of drinking water facilities have positive spatial autocorrelation or clustering patterns, while the other 3 variables have negative spatial autocorrelation or have spread out patterns.

Table 3. Moran Index Values of Dependent and Independent Variables

Variables	Moran Index Value	Conclusion of Autocorrelation
Number of Diarrhea Cases	0.100	Positive (Clustered)
Population Density	0.242	Positive (Clustered)
Number of Drinking Water Facilities	0.040	Positive (Clustered)
Number of Households Using Healthy Latrines	-0.023	Negative (Dispersed)
Number of villages that stoped open defecation	-0.034	Negative (Dispersed)

Number of health centers	-0.148	Negative (Dispersed)

Positive autocorrelations for diarrhea prevalence, population density, and drinking water facilities show there are clustering patterns between adjacent districts/cities, while negative autocorrelation captures dispersing patterns between districts/cities which are close to each other in terms of healthy latrine use, stop open defecation behaviour and health center availability.

Bivariate Analysis

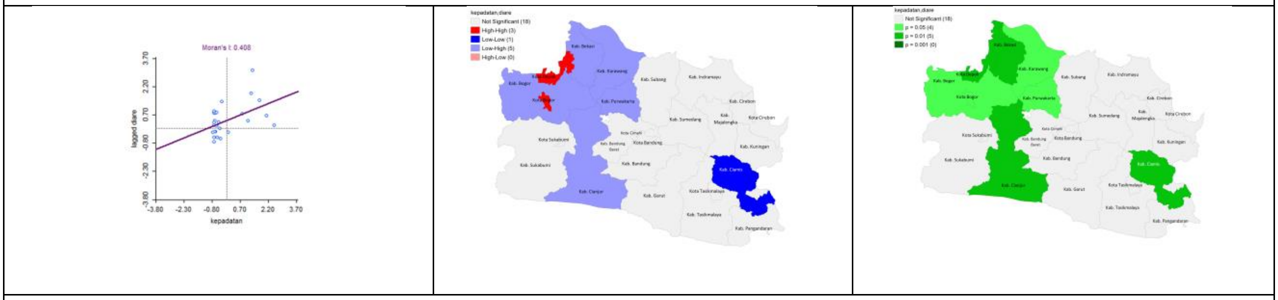
The I value of each independent variable on the prevalence of diarrhea in West Java shows that only population density has clustering spatial relationships with I of 0.408. The other four independent variables have spatially dispersed relationships: number of drinking water facilities (I = -0.337), number of households using healthy latrines (I = -0.045) number of villages that stopped open defecation (I = -0.246) and the number of health centers (I = -0.037).

Table 4. Moran Index Value of Independent Variables on the Number of Diarrhea Cases in West Java in 2023

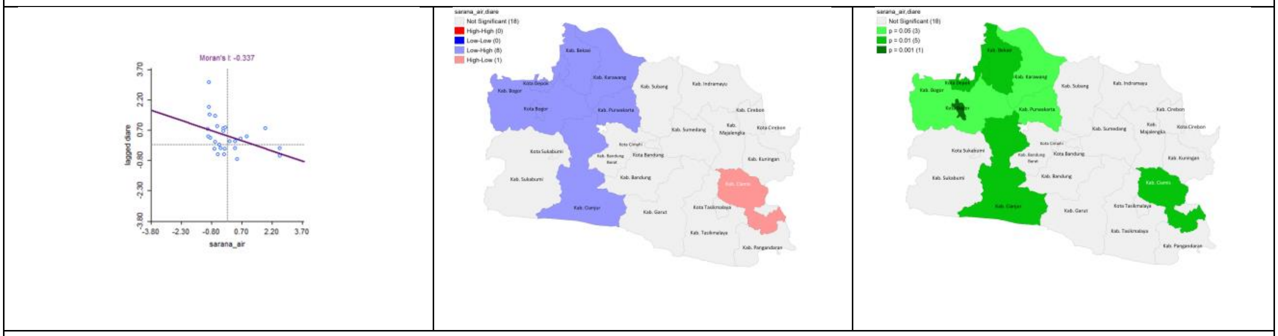
Variables	Moran Index Value	Conclusion of Autocorrelation
Population Density	0.408	Positive (Clustered)
Number of Drinking Water Facilities	-0.337	Negative (Dispersed)
Number of Households Using Healthy Latrines	-0.045	Negative (Dispersed)
Number of villages that stopped open defecation	-0.246	Negative (Dispersed)
Number of health centers	-0.037	Negative (Dispersed)

Positive autocorrelation figures out that the correlation establishes parallel pattern, while negative result forms opposite pattern. Moran's Scatter Plot, Cluster Map and Significance Map of variables potentially affecting the prevalence of diarrhea in West Java in 2023 can be seen in Figure 1.

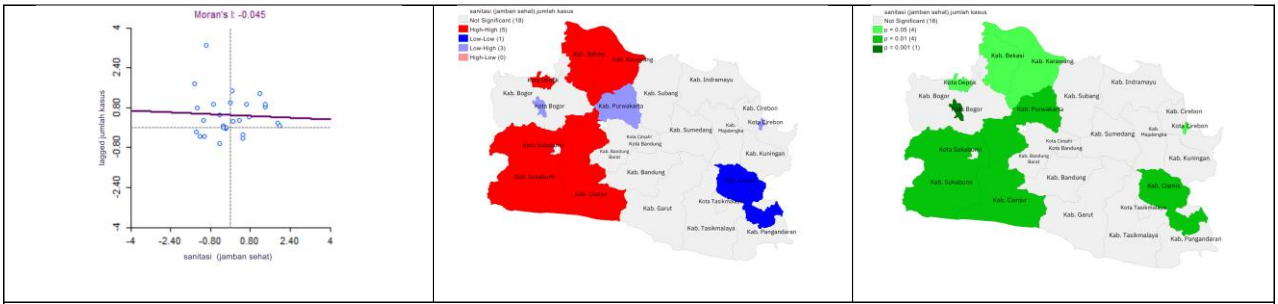
Population Density



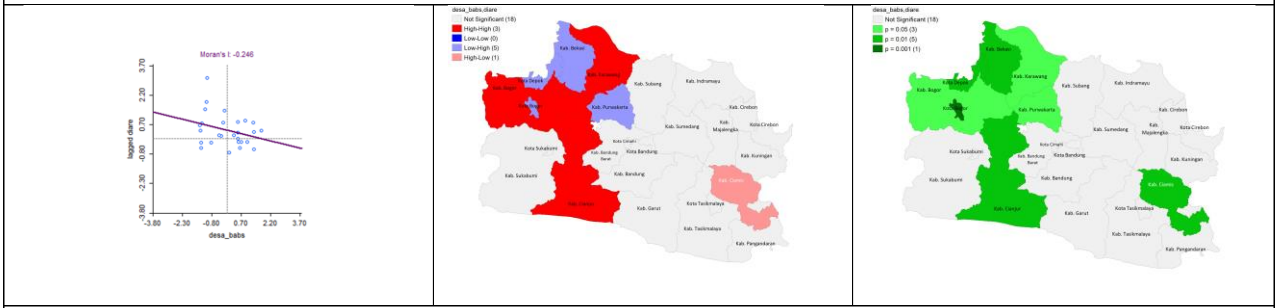
Number of Drinking Water Facilities



Number of households using healthy latrines



Number of villages that stopped open defecation



Number of health centers

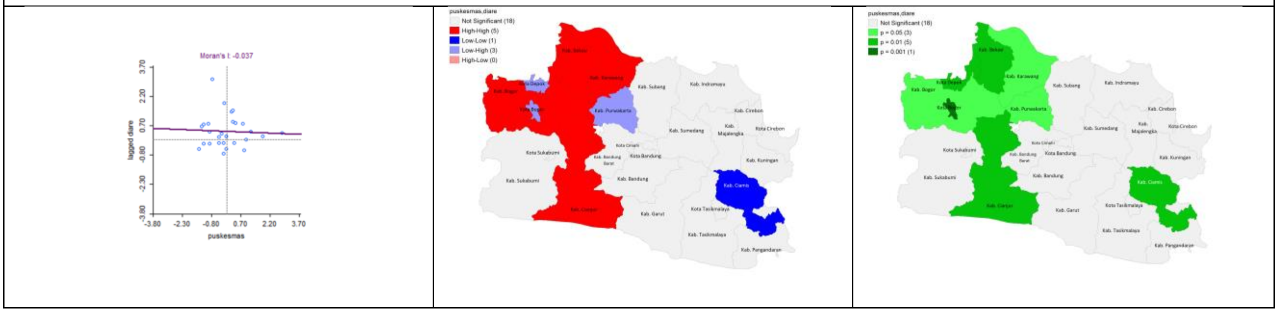


Figure 1. Moran's Scatter Plot, Cluster Map and Significance Map of Potential Factors Influencing the Prevalence of Diarrhea in West Java in 2023

DISCUSSION

Spatial Autocorrelation Analysis of the Number of Diarrhea Cases in West Java in 2023

When looking at the Morans's Cluster Map and Significance Map for the variable number of diarrhea cases, there are 5 districts/cities i.e. Bekasi, Karawang, Depok City, Bogor, and Cianjur that are categorized as hot spots of diarrhea cases which means that these five districts/cities have high diarrhea cases and are also surrounded by other districts/cities with high diarrhea cases. Of these five HH districts, only 3 districts had strong significance ($P < 0.05$), that are Bekasi, Depok City and Cianjur. Meanwhile, one district, Ciamis, is identified as a cold spot area because it has low diarrhea cases and is surrounded by other areas with low diarrhea cases, with a strong significance level.

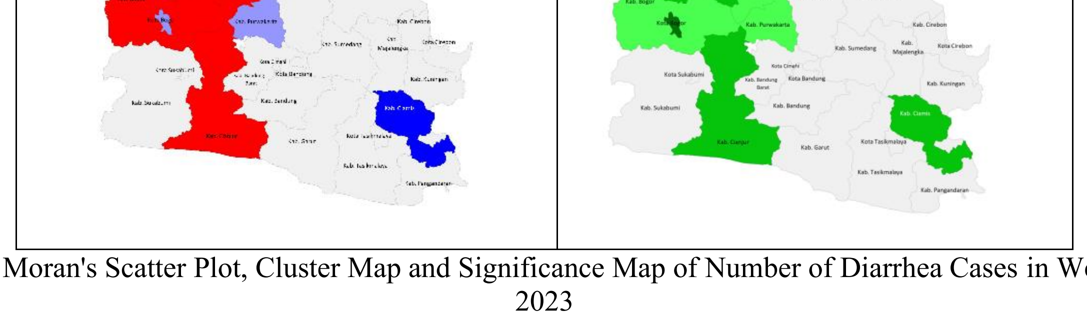


Figure 2. Moran's Scatter Plot, Cluster Map and Significance Map of Number of Diarrhea Cases in West Java in 2023

Spatial Autocorrelation Analysis of Factors Potentially Affecting the Number of Diarrhea Cases

This study found positive autocorrelation relationships between the prevalence of diarrhea and population density. The value of I shows a positive value so that it illustrates the pattern of data that is grouped or clustered. Broadly speaking, this pattern illustrates that there are similar characteristics between adjacent districts/cities related to population density and diarrhea cases data. In more details, this pattern with a positive I value can be interpreted that the higher the population density, the higher the diarrhea cases. For the population density factor, this finding is in line with a study conducted by Fajriyah (2023) that diarrhea cases increase in situation of high population density (5). The biggest impact of the high population density of an area is the decline in quality of education, health, income and livelihood or employment sectors [4]. Population density has an important influence on the degree of public health. If the population density in an area is high, problems will arise, one of which is the inadequate availability of land and clean water (4). If access to clean water is hampered, it will increase the risk of diarrhea.

The other two variables, drinking water facilities and the number of villages that stopped open defecation, produce negative autocorrelation which gives us an idea that the pattern that occurs is spread out, not clustered. It can also be interpreted that the more drinking water facilities, the lower the prevalence of diarrhea, and the higher the number of villages that stopped open defecation, the lower the prevalence of diarrhea.

Clean and safe drinking water facilities can ensure that the drinking intake consumed by the community is not contaminated with germs that cause diarrhea. Another study by Yantu et al also found an association between clean water facilities and the prevalence of diarrhea. Open defecation behavior will also greatly increase the risk of diarrhea because this behavior contributes to the spread of germs that cause diarrhea in the environment (3). Conditions will get worse if the community also does not implement a clean and healthy lifestyle. As diarrhea is transmitted through fecal oral route, contaminants in food and beverages as well as poor hygiene and sanitation can greatly influence the prevalence of diarrhea.

This study also found that the higher the number of households utilizing healthy latrines, the lower the prevalence will be. However, a previous study concluded different finding that the condition of latrines used by the family had no association with the prevalence of diarrhea among under five children (22). The most likely reason why it is different is because among under five kids there are many other factors that contribute to the disease such as nutrition, parents' education, and family walfare status (22).

The variable number of health centers also has negative autocorrelation, which means that the more the number of health centers, the lower the diarrhea cases in the area. This is related to the role of health centers in implementing diarrhea prevention and control efforts including health promotion and communication efforts in the context of changing behaviors that can increase the risk of diarrhea; environmental health; and diarrhea case management according to standard procedures (7,15).

Risk Analysis per District/City Based on Spatial Autocorrelation of Factors Potentially Affecting Diarrhea Prevalence in West Java in 2023

Based on bivariate analysis using Moran's Cluster Map and Significance Map, districts/cities at high risk of diarrhea can be identified based on the influence of different independent variable factors. A scoring system is carried out for risk mapping with the provision of scores that are differentiated in order by considering the results of the autocorrelation test for each variable as follows:

Table 5. Risk Determination Scoring

Variables	Variables with positive autocorrelation: population density	Variables with negative autocorrelation: Number of drinking water facilities, number of HH using healthy latrines, number of villages stopped open defecation and number of health centers
Scores	a. High-High: score 3 b. High-Low: score 2 c. Low-High: score 1 d. Low-Low: score 0 Areas with "not significant" result: score 0	a. High-High: score 0 b. High-Low: score 1 c. Low-High: score 2 d. Low-Low: score 3 Areas with "not significant" result: score 0

The higher the score, the higher the risk of diarrhea in a district/city. Determining the quadrant position of an area not only looks at the quadrant mapping in the Cluster Map but also the level of significance.

Table 6. Diarrhea Risk Scoring by District/City in West Java in 2023

District/City	Population Density	Number of Drinking Water Facilities	Number of Households Using Healthy Latrines	Number of Villages Stopped Open Defecation	Number of Health Centers	Conclusion
Bogor	0	0	0	0	0	0
Sukabumi	0	0	0	0	0	0
Cianjur	1	2	0	0	0	3
Bandung	0	0	0	0	0	0
Garut	0	0	0	0	0	0
Tasikmalaya	0	0	0	0	0	0
Ciamis	0	1	3	1	0	5
Brass	0	0	0	0	0	0
Cirebon	0	0	0	0	0	0
Majalengka	0	0	0	0	0	0
Sumedang	0	0	0	0	0	0
Indramayu	0	0	0	0	0	0
Subang	0	0	0	0	0	0
Purwakarta	0	0	2	0	0	2
Karawang	0	0	0	0	0	0
Bekasi	1	2	0	2	0	5
West Bandung	0	0	0	0	0	0
Pangandaran	0	0	0	0	0	0
Bogor City	0	2	2	2	2	8
Sukabumi City	0	0	0	0	0	0
Bandung City	0	0	0	0	0	0
Cirebon City	0	0	0	0	0	0
Bekasi City	0	0	0	0	0	0
Depok City	3	2	0	2	2	9
Cimahi City	0	0	0	0	0	0
Tasikmalaya City	0	0	0	0	0	0
Banjar City	0	0	0	0	0	0

With this risk analysis, we can identify that there are 4 districts categorized as high risk of diarrhea with a score of ≥5: Depok City, Bogor City, Ciamis, and Bekasi. There are also 2 districts, Cianjur and Purwakarta, with a score of 3 and 2, while the others have scores of 0. From this scoring, we have an idea of which districts need to be prioritized in the implementation of diarrhea control efforts through improving the situation of the independent factors that affect them.

Of a total of 27 districts/cities in West Java, Depok City has the highest score of 9. Main factors contributing to the high score for this city is its high population density. Other factors, such as the number of drinking water facilities, the number of villages that stopped open defecation and the number of health centers that are still not as expected, also contributed to the score, further increasing the risk of this area. The districts/cities with the next highest scores are Bogor City, Bekasi, and Ciamis. Factors contributing to the high risk of these 3 areas are varied. For Bogor city, all variables except population density are the largest contributing factors. The main contributing factors for Bekasi are inadequate number of drinking water facilities and low number of villages stopped open defecation, while low number of households using healthy latrines is the largest contributor for Ciamis. Other districts/cities that score <5 or even zero cannot be instantly interpreted as having no risk, as this analysis focuses on the risks posed by spatial relationships between neighboring districts.

Key contributing factors can be the center of improvements aimed at preventing and controlling diarrhea. As we see that main contributing factors in each area are different, therefore interventions should be specific by district/city to have better results. It is also recommended that the finding of the risk scoring be used to determine which district/city to be prioritized. As a result, the execution of the program can be more precisely targeted and concentrated in the critical regions.

Referring to the integrated Global Action Plan for Pneumonia and Diarrhoea (GAPPD), one of the recommended interventions especially to control diarrhea among under five children is to improve access to safe drinking water and sanitation (21). Engagement to all cross-sectoral parties is crucial, especially for control on population density and improvement on open defecation behaviour, including the Provincial Health Office itself, Provincial Regional Planning Agency, Provincial Public Works Department, Non-Government Organizations working focusely on water and sanitation improvement, and all relevant stakeholders.

CONCLUSION

Positive autocorrelation found between population density and the prevalence of diarrhea in West Java in 2023. This pattern shows the higher population density, the higher the cases will be. Strategies to control population density would benefit the prevention of diarrhea cases in the province. The number of drinking water facilities, households using healthy latrines, villages that stopped open defecation and health centers have shown negative autocorrelation patterns towards diarrhea prevalence. This can be interpreted that by increasing the number of drinking water facilities, the number of families utilizing healthy latrines, the number of villages that stopped open defecation as well as the number of well-functioning health centers, diarrhea prevalence can be decreased. In terms of risk of diarrhea at district/city level, measured by analyzing pattern of several influencing factor towards diarrhea cases, there are 4 high risk districts/cities namely Ciamis, Bekasi, Bogor City and Depok City.

SUGGESTION

Autocorrelation analysis helps us to understand the pattern of disease and the factors that influence it in the community. The prevalence of diarrhea in West Java is influenced by variables such as population density, access to healthy latrines, drinking water facilities, open defecation behaviour and the number of health centers. In efforts to prevent and control diarrhea in this province, the focus of improvements can be directed at these factors. Prioritization can be advised to be done by utilizing the results of risk scoring analysis per district/city. Thus, the program implementation can be better targeted and focused at the very needed areas.

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