Analysis Autocorrelation Spatial Diarrhea, Typhoid and Leptospirosis on The East Flood Canal, Semarang City : Moran Index Method

by Elanda Fikri

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ABSTRACT

Waterborne disease is a disease with water-borne media. Waterborne disease can occur when people come into contact with water that is high in *Escherichia coli* (a pathogen that causes diarrhea), *Salmonella spp* (a pathogen that causes typhoid) and *Leptospira* (a pathogen that causes leptospirosis). This study aims to provide information on the relationship and distribution pattern between canal water consumption and the incidence of waterborne diseases using spatial autocorrelation analysis using the Moran index method. This research is a development research with a spatial approach and the Moran index method. The result demonstrates significant spatial autocorrelation in diarrhea prevalence rate and leptospirosis incidence rate in Semarang, Moran's index (I) 0.086 ($p < 0.1$) and 0.105 ($p < 0.05$), respectively. On the other hand, prevalence rate of typhoid fever do not show significant negative autocorrelation, Moran's I -0.015 ($p > 0.1$). The pattern of prevalence and incidence rate of diarrhea and leptospirosis at each public health center working area are clustered, excepting prevalence of typhoid which is randomly distributed. Efforts are needed for the participation of the Semarang City government in providing access to clean water in several urban urban areas of Semarang City, assessing parameters and processing water for the East Flood Canal.

Keywords: Moran Index, Diarrhea, Thypoid, Leptospirosis

ABSTRAK

Penyakit yang ditularkan melalui air adalah penyakit dengan media yang terbawa air. Penyakit yang ditularkan melalui air dapat terjadi ketika orang bersentuhan dengan air yang tinggi *Escherichia coli* (patogen penyebab diare), *Salmonella spp* (patogen penyebab tifus) dan *Leptospira* (patogen penyebab leptospirosis). Penelitian ini bertujuan untuk memberikan informasi tentang hubungan dan pola distribusi antara konsumsi air saluran dengan kejadian penyakit yang ditularkan melalui air menggunakan analisis autokorelasi spasial menggunakan metode indeks Moran. Penelitian ini merupakan penelitian pengembangan dengan pendekatan spasial dan metode indeks Moran. Hasil penelitian menunjukkan adanya autokorelasi spasial yang signifikan pada angka prevalensi diare dan angka kejadian leptospirosis di Semarang, statistik Moran's I masing-masing 0,086 ($p < 0,1$) dan 0,105 ($p < 0,05$). Di sisi lain, tingkat prevalensi demam tifoid tidak menunjukkan autokorelasi negatif yang signifikan, Moran's I -0,015 ($p > 0,1$). Diperlukan upaya peran serta Pemerintah Kota Semarang dalam penyediaan akses air bersih di beberapa wilayah perkotaan Kota Semarang, pengkajian parameter dan pengolahan air untuk Kanal Banjir Timur**.**

Kata kunci: Indek moran, diare, tifoid, leptospirosis

INTRODUCTION

Waterborne disease is transmitted by water that is contaminated by biological pollutants such as Coliform and *Leptospira* bacteria (Chowdhury and Al-Zahrani, 2015). The waterborne disease occurs due to water contamination of biological pollutants such as coliform bacteria and leptospires (Cobo, J. R., Lock, K., Van Butsel, J., Pauta, G., Cisneros, F., Nopens, I., & Goethals, 2018; Mukate et al., 2018; Wu, Wang, Chen, Cai, & Deng, 2018; Xue et al., 2018). These pathogens cause diarrhea, typhoid, and leptospirosis. The scope of the place in this research is the city of Semarang. Data from the Department of Health of Semarang City indicates that the incidence rate of 60 per 1,000 toddlers. While typhoid cases reported in Semarang City were 412 cases diagnosed clinically with an incidence rate of 25 clinically diagnosed patients per 100,000 population. For laboratory-positive confirmed cases, there were 124 cases with an incidence rate of 7 laboratory-positive confirmed patients per 100,000 population. In other diseases, leptospirosis in Semarang City has reported as many as 47 cases and a crude fatality rate 5 patients died with an incidence rate of 4 patients per 100,000 population.

The East Flood Canal is one of the water sources in Semarang City. Categorized in class 2, the East Flood Canal is intended for water recreation facilities/infrastructure, fish cultivation, livestock water sources, and rice field irrigation. Some communities, such as in the villages of Lamper Tengah, Lamper Lor, Lamper Kidul, and Jangli, consume canal water because these areas often have clean water crises. Contaminated water due to domestic activities will increase biological pollutants in it such as the presence of coliform bacteria and leptospires (Deshpande et al., 2020). Waste from untreated domestic activities in wastewater treatment plants is the main source of contamination for coliform bacteria such as *Escherichia coli* and *Salmonella spp* which are pathogens of diarrhea and typhoid (Effendi, Romanto, & Wardiatno, 2015). Furthermore, farms are the main source of *Leptospira* bacteria contamination as a pathogen for leptospirosis (Frena et al., 2019). Raw water contaminated with Coliform and *Leptospira* bacteria used for rice field irrigation can be a transmission factor for pathogens of diarrheal, typhoid, and leptospirosis diseases (Fatica and

Schneider, 2011). Water used for fish ponds with concentrations of coliform and *Leptospira* bacteria that exceed the quality standard (total coliform 5,000 MPN/100 ml) can cause the accumulation of these bacteria in the fish body (Kouamé et al., 2014).

In epidemiological studies, which include man, time, and place studies, spatial analysis can be used as a study method to examine the place of occurrence of waterborne diseases. Spatial analysis can be used to assess the spread of infectious diseases in this case water-borne media. The study area of the public health center in this study is a buffer distance of 1 km from the East Flood Canal flow. Autocorrelation analysis is used to see the estimated correlation of the incidence of waterborne diseases with the water consumption of the East Flood Canal in Semarang City (Gazzaz, N.M.; Yusoff, M.K.; Ramli, M.F.; Aris, A.Z.; Juahir, 2012). Therefore, this study aims to provide information on the relationship and distribution pattern between canal water consumption and the incidence of waterborne diseases using spatial autocorrelation analysis using the Moran index method.

METHOD

This research is development with spatial analysis approach. Spatial analysis used is autocorrelation. Autocorrelation is a method of estimating the relationship of waterborne diseases (diarrhea, typhoid, and leptospirosis) with spatial locations in this study based on public health center with a buffer distance of 1 km from the East Flood Canal in Semarang City. The meaning of autocorrelation is categorized into two, positive if the value of the spatial location is in the form of a clustered distribution and negative if the value of the location of the distribution is dispersed (Gazzaz, N.M.; Yusoff, M.K.; Ramli, M.F.; Aris, A.Z.; Juahir, 2012). One of the measures of spatial autocorrelation can be determined by using the Moran index method. The Moran index can be used to detect the onset of a random spatial location. From a random spatial pattern, it will produce a dispersed, random, and clustered distribution. Sources of data in this study are secondary data, data on diarrheal diseases, typhoid, and leptospirosis obtained from the Semarang City Health Office. The data collection in this study was in the form of a cross section, data on the incidence of diarrhea, typhoid, and leptospirosis were taken during 2020.

RESULTS AND DISCUSSION

Diarrhea

From the results of spatial observations, it was found that health centers with a buffer distance of 1 km from the East Flood Canal included Rowosari, Kedungmundu, Lamper Tengah, Halmahera, Bugangan, Karangdoro, Tlogosari Wetan, Tlogosari Kulon, Gayamsari, and Genuk health centers. It was reported that there were 323 cases of diarrhea among toddlers in the Rowosari work area, with an incidence rate of 80 toddlers suffering from diarrhea per 1,000 toddlers. The Kedungmundu Health Center reported 444 cases of diarrhea in toddlers, with an incidence rate of 33 toddlers suffering from diarrhea per 1,000 toddlers. The working area of the Central Lamper Health Center reported 225 cases of diarrhea in toddlers with an incidence rate of 133 toddlers suffering per 1,000 population. The Halmahera Health Center reported as many as 270 cases of diarrhea among toddlers in its working area with an incidence rate of 160 toddlers suffering from diarrhea per 1,000 toddlers. It was reported that there were 157 cases of diarrhea among toddlers in the Bugangan working area, with an incidence rate of 162 toddlers suffering from diarrhea per 1,000 toddlers. Karangdoro Health Center reported 115 cases of diarrhea in toddlers, with an incidence rate of 71 toddlers suffering from diarrhea per 1,000 toddlers.

The working area of the Tlogosari Wetan Public Health Center reported 367 cases of diarrhea in toddlers with an incidence rate of 50 sufferers per 1,000 toddlers. The Tlogosari Kulon Health Center reported 421 cases of diarrhea in its working area with an incidence rate of 65 toddlers suffering from diarrhea per 1,000 toddlers. At the Gayamsari Public Health Center, 369 cases of diarrhea were reported in its working area with an incidence rate of 72 toddlers suffering from diarrhea per 1,000 toddlers. And for the Genuk Public Health Center, 290 cases of diarrhea were reported in its working area with an incidence rate of 91 toddlers suffering from diarrhea per 1,000 toddlers. The results of the Moran index analysis, the pattern of distribution of diarrhea cases are clustered and is depicted in figure 1

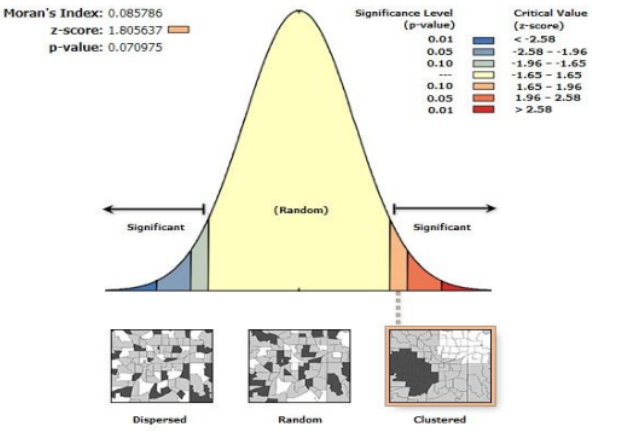

Figure 1. Analysis Moran's Index of Diarrhea

From the results of the spatial autocorrelation analysis with the geography information system (GIS). The results of the Moran's I statistic of diarrhea prevalence rate is shown in figure 1, with Moran's I 0.086 ($p < 0.1$). Given that the z-score was 1.806, where there was < 10% likelihood that the pattern could be the result of random chance. Consequently, the result suggests that the pattern of diarrhea prevalence rate at each public health center working area in Semarang is clustered.

The public health center with the highest incidence rate at a buffer distance of 1 km is Bugangan. The Bugangan Health Center has a scope of work in the sub-districts of Mtrainarjo, Bugangan, and Kebonagung villages. The working area of the Bugangan Health Center often experiences floods and tidal waves, causing the availability of clean water and poor access to sanitation. Floods and tidal waves can be sourced from the East Flood Canal water, the concentration of fecal coliform (*Escherichia coli*) above the quality standard of 1000 MPN/100ml can be an agent of diarrheal disease in toddlers (Safitri, L, F., Widyorini, N., dan Jati, O, 2016). In additional, areas that frequently experience floods and tidal waves have a higher risk of diarrhea in toddlers (Lima, Lombardo, & Magaña, 2018).

Halmahera public health center is the second health center with the highest incidence rate at a buffer distance of 1 km from the East Flood Canal. The working areas of the Halmahera Health Center are Sarirejo, Rejosari, Karangtempel, and Karangturi. From the observations, people in the Karangtempel and Karangturi villages consume East Flood Canal water for washing clothes and cooking utensils when there is a clean water crisis. Cooking utensils that are not washed with clean water can cause *Escherichia coli* transmission (Deshpande et al., 2020).

Central Lamper Health Center is the third with the highest incidence rate of diarrhea in toddlers. The working areas of the Central Lamper Health Center include the villages of Central Lamper, Lamper Lor, Lamper Kidul, and Peterongan. Similar to the villages of Karangtempel and Karangturi, the villages of Lamper Tengah, Lamper Lor, and Lamper Kidul often have clean water crises. The community carried out washing activities for cooking utensils, clothes, and taking raw water for cooking from the water of the East Flood Canal. The use of unclean water for washing equipment and boiling water properly can lead to the transmission of *Escherichia coli* bacteria (Paterson, Wright, & Harris, 2018).

Typhoid

From the results of spatial observations, it was found that health centers with a buffer distance of 1 km from the East Flood Canal included Rowosari, Kedungmundu, Lamper Tengah, Halmahera, Bugangan, Karangdoro, Tlogosari Wetan, Tlogosari Kulon, Gayamsari, and Genuk health centers. It was reported that there were 1 cases of typhoid in the Rowosari work area, with an incidence rate of 2 patients suffering from typhoid per 100,000 population. The Kedungmundu Health Center reported 163 cases clinically diagnosed and 19 confirmed positive by the laboratory of typhoid, with an incidence rate of 140 patients suffering from typhoid per 100,000 population. The working area of the Central Lamper Health Center reported 5 cases clinically diagnosed of typhoid with an incidence rate of 17 patients suffering per 100,000 population. The Halmahera Health Center reported as many as 10 cases clinically diagnosed of typhoid is in its working area with an incidence rate of 33 patients suffering from typhoid per 100,000 population. It was reported that there were 6 cases clinically diagnosed of typhoid in the Bugangan working area, with an incidence rate of 33 patients suffering from typhoid per 100,000 population. Karangdoro Health Center reported 4 cases clinically

diagnosed and 4 confirmed positive by the laboratory of typhoid, with an incidence rate of 33 patients suffering from typhoid per 100,000 population.

The working area of the Tlogosari Wetan Public Health Center reported 6 cases clinically diagnosed and 4 confirmed positive by the laboratory of typhoid with an incidence rate of 12 patients sufferers typhoid per 100,000 population. The Tlogosari Kulon Health Center reported 42 cases clinically diagnosed of typhoid in its working area with an incidence rate of 46 patients suffering from typhoid per 100,000 population. At the Gayamsari public health center, 10 cases clinically diagnosed and 10 confirmed positive by the laboratory of typhoid were reported in its working area with an incidence rate of 27 patients suffering from typhoid per 100,000 population. And for the Genuk public health center, 9 cases clinically diagnosed of typhoid were reported in its working area with an incidence rate of 21 patients from typhoid per 100,000 population. The results of the Moran index analysis, the pattern of distribution of typhoid cases are random and is depicted in figure 2,

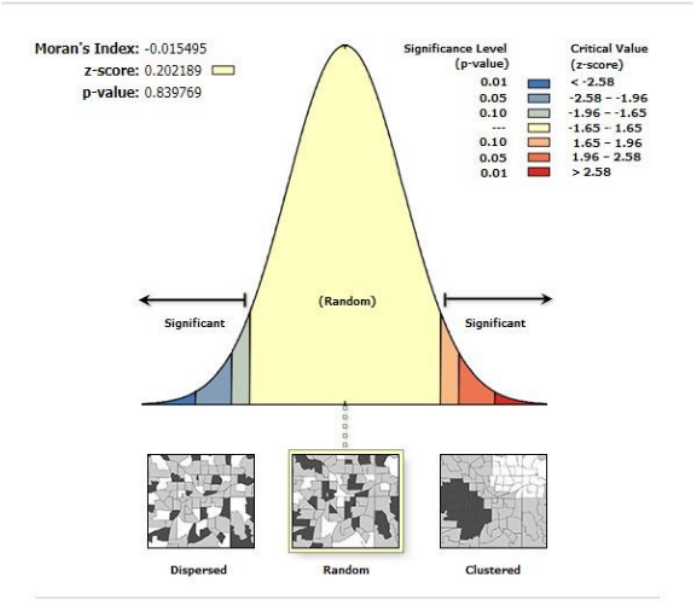

Figure 2. Analysis Moran's Index of Typhoid

From the results of the spatial autocorrelation analysis with the geography information system (GIS). The results of the Moran's statistic of typhoid prevalence rate is shown in figure 1, with Moran's I -0.01 ($p < 0.1$). Given that the z-score was 0.2, the pattern did not appear to be significant than random. Consequently, the result suggests that the pattern of typhoid prevalence rate at each public health center working area in Semarang is random

The Kedungmundu Public Health Center became the first health center with the highest incidence rate of typhoid cases. The working areas of the Kedungmundu health center include, Sendang Mulyo, Mangunharjo, Sambiroto, Kedungmundu, Tandang, Jangli, Sendangguwo. From the results of field observations, there has been a use of water from the East Flood Canal by people in the Jangli sub-district for activities to boil water, wash clothes, and cook utensils when there is a clean water crisis. Total coliform bacteria (*Salmonella spp*) in the water of the East Flood Canal which exceeds 5,000 MPN/100 ml can be pathogenic for typhoid (Levantesi, C., Bonadonna, L., Briancesco, R., Grohmann, E., Toze, S., Tandoi, 2012). In Sendangguwo and Mediummulyo sub-districts, the community uses East Flood Canal water for irrigation of rice fields. Rice irrigation water contaminated with total coliform bacteria (*Salmonella spp*) can be a pathogen of typhoid disease (Frena et al., 2019).

Tlogosari Kulon Public Health Center is the second health center with the highest incidence rate of typhoid. The working areas of the Tlogosari Kulon Public Health Center include Tlogosari Kulon, Muktiharjo Kidul, Gemah, and Kalicari. From the results of field observations, people who live in the working area of the Tlogosari Kulon Health Center do not consume water from the East Flood Canal. However, the solid waste system in the surrounding area is very poor, such as people littering, there is no place for temporary waste disposal. In other cases, open waste systems can be a transmission of *Salmonella spp* pathogens (Sun, W., Xia, C., Xu, M., Guo, J., & Sun, 2016).

The public health center with the thrid highest incidence rate at a buffer distance of 1 km is Bugangan. The Bugangan Health Center has a scope of work in the sub-districts of Mtrainarjo, Bugangan, and Kebonagung villages. The working area of the Bugangan Health Center often experiences floods and tidal waves, causing the availability of clean water and poor access to sanitation. Floods and tidal waves can be sourced from the East Flood Canal water (Wu et al., 2018), the concentration of total coliform (*Salmonella spp*) above the quality standard of 5,000 MPN/100ml can be an agent of typhoid. In additional, areas that frequently experience floods and tidal waves have a higher risk of typhoid (Fatica, M.K., Schneider, 2011).

Leptospirosis

From the data from the Semarang City Health Office, the Kedungmundu and Lamper Tengah Health Centers became the health centers with the highest leptospirosis case reports.There were 6 cases of leptospirosis reported at the Kedungmundu Public Health Center, with 1 case of death, and the incidence rate was 5 leptospirosis sufferers per 100,000 population. Meanwhile, the Central Lamper Health Center reported 2 cases of leptospirosis, with 1 case of death, and the incidence rate was 7 leptospirosis sufferers per 100,000 population. The pattern of distribution of leptospirosis cases are clusterd and is depicted in figure 3,

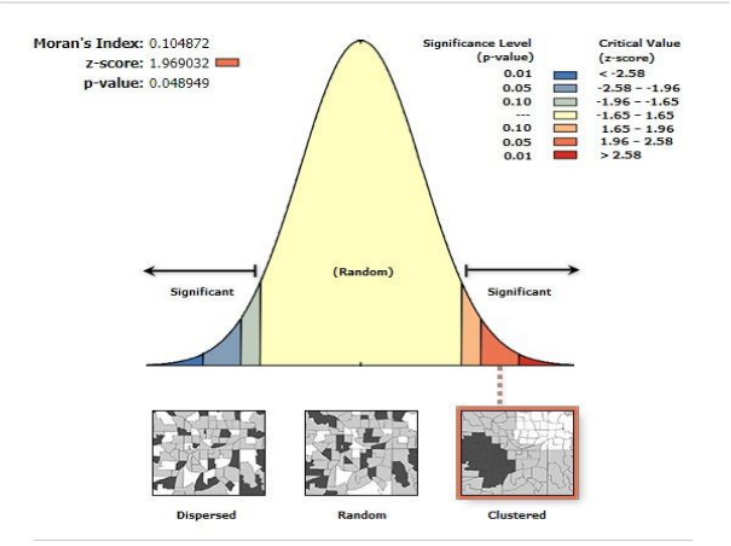

Figure 3. Analysis Moran's Index of Leptospirosis

From the results of the spatial autocorrelation analysis with the geography information system (GIS). The results of the Moran's I statistic of leptospirosis incident rate is shown in figure 1, with Moran's I 0.1 ($p < 0.1$). Given that the z-score was 1.97, where there was < 10% likelihood that the pattern could be the result of random chance. Consequently, the result suggests that the pattern of leptospirosis incident rate at each public health center working area in Semarang is clustered.

The working areas of the Kedungmundu health center include, Sendang Mulyo, Mangunharjo, Sambiroto, Kedungmundu, Tandang, Jangli, Sendangguwo. From the results of field observations, people in the Jangli village often carry out washing activities in the East Flood Canal water flow. *Leptospira* bacteria can live in rivers and canals, can become leptospirosis pathogens if they enter the skin or stick to laundry equipment (Sato et al., 2019). People in the villages of Lamper Tengah, Lor, and Kidul use the water from the East Flood Canal to irrigate their rice fields. Sources of raw water from rivers and canals for irrigation of rice fields have a risk of leptospirosis transmission (Blettler et al., 2019).

CONCLUSIONS AND SUGGESTIONS

Waterborne disease is a disease caused by water-borne media. Biological pollutants such as coliform bacteria (*Escherichia coli* and *Salmonella spp*) and *Leptospira* can be agents of diarrhea, typhoid and leptospirosis. The use of

water from the East Flood Canal in Semarang City can trigger the transmission of waterborne diseases. The result demonstrates significant spatial autocorrelation in diarrhea prevalence rate and leptospirosis incidence rate in Semarang, Moran's index (I) 0.086 ($p < 0.1$) and 0.105 ($p < 0.05$), respectively. On the other hand, prevalence rate of typhoid fever do not show significant negative autocorrelation, Moran's I -0.015 ($p > 0.1$). The pattern of prevalence and incidence rate of diarrhea and leptospirosis at each public health center working area are clustered, excepting prevalence of typhoid which is randomly distributed. Efforts are needed for the participation of the Semarang City government in providing access to clean water in several urban urban areas of Semarang City, assessing parameters and processing water for the East Flood Canal.

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