

SPATIAL PATTERNS OF ENVIRONMENTAL SANITATION FACTORS AS DETERMINANTS OF TODDLERS' DIARRHEA IN PAUH DISTRICT, PADANG CITY IN 2021

Andika Agus Iryanto^{1*}, Yura Witsqa Firmansyah², Wahyu Widyantoro¹, Annisa Zolanda¹

¹Master Student in Environmental Health, Faculty of Public Health, Diponegoro University, Semarang 50275, Indonesia

²Department of Hospital Administration, Akademi Teknik Elektro Medik, Semarang 50222, Indonesia

Corresponding Author:

*) andika.iryanto8@gmail.com

Article Info

Submitted : 19 October 2021
In reviewed : 26 October 2021
Accepted : 3 February 2022
Available Online : 30 April 2022

Keywords : Diarrhea, Sanitation, Spatial, Toddlers

Published by Faculty of Public Health Universitas Airlangga

Abstract

Introduction: The Padang City Health Office reported 9,452 diarrhea cases in 2019, 2,248 in toddlers. The Pauh District reported 413 diarrhea cases, 110 of which occurred in toddlers. Spatial analysis was used to assess environmental sanitation as determinant of toddlers' diarrhea incidence in Pauh District, Padang City. **Methods:** This observational study used a cross-sectional approach. The population was 4,653 toddlers, and the sample was 100 toddlers. The independent variables in this study include environmental sanitation factors such as the quality of clean water (presence of *Escherichia coli*), the condition and quality of the waste container, the quality and condition of sewerage, and the density of flies in the trash and household sewerage. The spatial analysis used was Moran Index I to examine the distribution pattern of variables. **Results and Discussion:** The incidence of diarrhea in toddlers, unstandardized household waste containers, unqualified waste sewerage, high fly density in household trash bins, and high fly density in sewerage was randomly distributed with a Moran index consecutively -0.130524; 0.315524; 0.153129; -0.174424; -0.025798. Then, clean water quality, waste management, and sewerage conditions that did not meet the requirements were randomly distributed with a Moran index of -0.158512; -0.160688; -0.117502. **Conclusion:** The spatial pattern of environmental sanitation factors as determinants of the incidence of diarrhea in toddlers was randomly distributed, and there was no autocorrelation found among the villages in Pauh District.

INTRODUCTION

Diarrhea is a disease related to the environment. The dominant environmental factors that affect the likelihood of contracting it are the availability of clean water facilities and a place of fecal disposal. In developing countries, there are still many people of low socioeconomic status who practice open defecation due to lack of knowledge about environmental health and family culture. The impacts of this practice include contamination of soil and water, contamination of food, and breeding of flies (1). A preliminary study conducted in 2019 in Padang found that there were 9,452 cases of diarrhea, including 2,248 cases of diarrhea in toddlers. In Pauh District, diarrhea incidence increased from the previous year with a total of 413 cases, of which 110 cases were found in toddlers. This was a twofold increase from the previous year. Pauh sub-district has the worst sanitation in Padang at 64% in the category of families

who have access to proper sanitation facilities (2). One of the effects of diarrhea is dehydration. Patients will lose five liters of water in a day along with the main electrons in the body. The loss of electrons may cause restlessness in babies, heart rhythm disturbances, and bleeding in the brain. Dehydration in toddlers is more dangerous than in children and adults (3).

In addition to the intrinsic factor of toddlers, environmental sanitation factors mainly cause diarrhea. These factors include facilities and quality of clean water (presence of *Escherichia coli*), facilities and quality of wastewater disposal, waste management, and density of flies in the yard (4-5). Diarrheal prevention efforts that can be done by the community include improving household environmental sanitation, improving hygiene, and increasing access to clean water. A healthy environment will minimize the risk of environmental-based diseases, especially diarrhea (6).

Cite this as :

Iryanto AA, Firmansyah YW, Widyantoro W, Zolanda A. Spatial Patterns of Environmental Sanitation Factors as Determinants of Toddlers' Diarrhea in Pauh District, Padang City in 2021. *Jurnal Kesehatan Lingkungan*. 2022;14(2):71-81. <https://doi.org/10.20473/jkl.v14i2.2022.71-81>

The use of spatial analysis in the study aimed to map the distribution of diarrhea cases in toddlers under five with environmental sanitation factors. The Geographic Information System (GIS) is a special system designed to collect, store, and analyze objects geographically as a reference in a computer analysis. The GIS has been utilized in the health field for a long time, especially in controlling infectious diseases, but its impacts and benefits have not been recognized (7).

Based on the data that have been obtained in the preliminary study, environmental sanitation was still shown to be poor. This is considered to be a potential risk factor for diarrhea in toddlers. A spatial approach can be used to determine the distribution of diarrhea cases and environmental sanitation risk factors in Pauh sub-district; therefore, the purpose of this study was to study the geographical distribution of diarrhea cases through the lens of environmental sanitation conditions in Pauh District, Padang City.

METHODS

This research is an observational study with a cross-sectional study design and spatial approach. All children under five in the Pauh District, Padang City, were totaled into a population of 4,653 toddlers, and a sample of 100 toddlers was used for the Slovin calculation.

$$n = \frac{N}{1+N(d)^2}$$

Explanation:

- n = sample / Tota respondents
- N = number of population
- d = Percentage of errors that can be tolerated

The unit of analysis of the research was taken from families with toddlers in Pauh by observing the environmental sanitation conditions in their living areas. The independent variable in this study was environmental sanitation, including the quality of water (presence of *Escherichia coli*) which was examined from water samples tested in the laboratory, sewerage conditions, waste containers, quality of sewerage, waste management, and density of flies in the trash. The dependent variable was incidence of diarrhea in children under five. This research used observation sheets adopted from previous research (8), health regulations related to household environmental sanitation, namely the Indonesian Ministry of Health Regulations Number 3 of 2014 on Community-Based Total Sanitation (9), and the use of fly grills to calculate fly density. Data were analyzed spatially using the Moran's I Index test. Moran's Index I is a popular method in determining

autocorrelation globally. Moran's Index I was used to analyze the spatial distribution pattern of the variables. The range of Moran I Index values is $-1 < I < 0$, which can be interpreted as autocorrelation negative spatial. If it is $0 < I < 1$, it can be interpreted as positive autocorrelation. A Moran I Index of 0 means the autocorrelation is not grouped. The existence of autocorrelation between regions can be seen from the Z score. If the Z score is below the Z value (1.64), then H0 is accepted, thereby assuming there is no spatial autocorrelation between regions. If the Z score is above $Z\alpha$, then H0 is rejected. This means there is a spatial autocorrelation between regions (10). This revealed the distribution pattern of the existence of independent variables that did not meet the requirements at the sub-district level (ArcView GIS 10.3).

RESULTS

The results showed that diarrhea occurred in 71 children under five in Pauh in the last three months (April-June 2021), and only 29 of the observed children were diarrhea-free. The highest diarrhea incidence was found in Limau Manis Selatan Village as many as 12 children (16.9%), Cupak Tengah Village as many as 10 toddlers (14.08%), and Koto Lua Village as many as 10 toddlers (14.08%).

The spatial autocorrelation analysis of the incidence of diarrhea in infants obtained a Moran index of -0.130524, which means there was an autocorrelation with an expected value of -0.125000 and a variation of 0.023472. A negative Moran Index value indicates a pattern distribution. The value of z-score of -0.036059 p-value of 0.971235 mean that the distribution pattern of the incidence of diarrhea in children under five in Pauh was distributed randomly or there was no autocorrelation between villages (Figures 1 and 2).

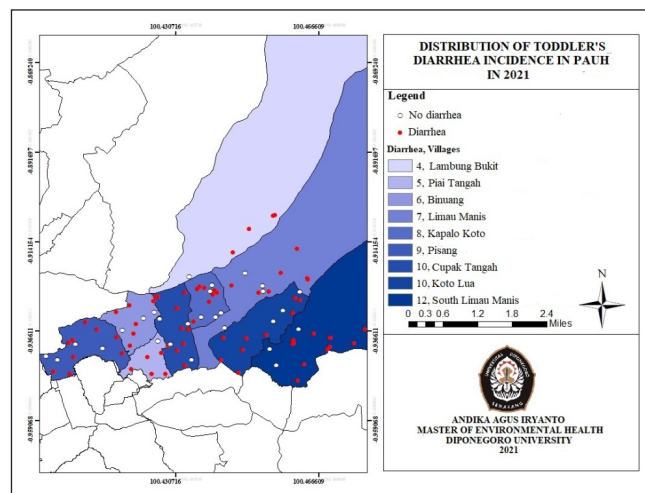


Figure 1. Distribution of Toddler's Diarrhea Incidence in Pauh in 2021

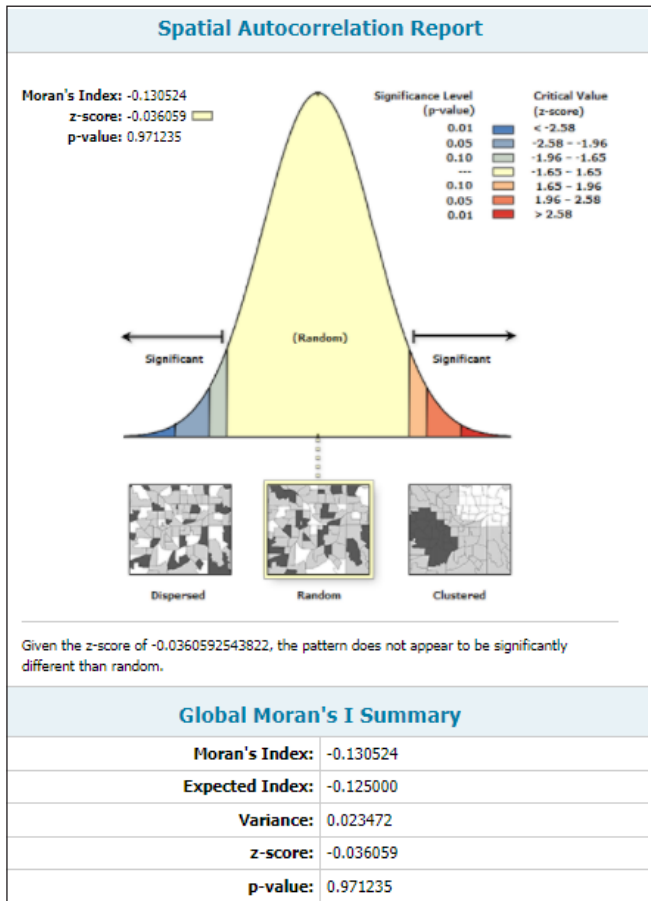


Figure 2. Autocorrelation Moran Index of Toddler's Diarrhea in Pauh in 2021

For the water quality variable (presence of *Escherichia coli*), it was found that 57 houses (57%) had clean water facilities containing *Escherichia coli* and 51 children under five with diarrhea (51%). The remaining 43 houses (43%) had clean water facilities that did not contain *Escherichia coli* and 20 children under five with diarrhea (20%).

The spatial autocorrelation analysis of clean water facilities containing *Escherichia coli* obtained a Moran Index of -0.158512 which indicated an autocorrelation with an expected value of -0.125000 and a variation of 0.024184. A negative Moran Index value indicates a random patterned distribution. The value of z-score of -0.215494 and p-value of 0.829382 mean that the distribution pattern of clean water facilities containing *Escherichia coli* was distributed randomly or there is no autocorrelation between villages (Figures 3 and 4).

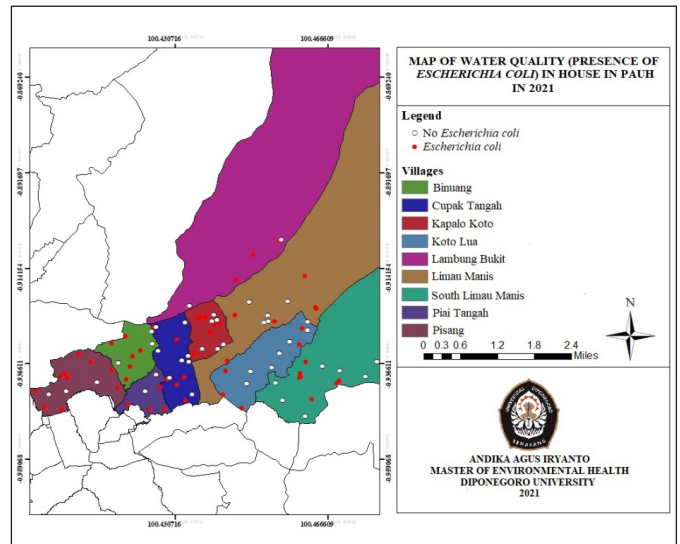


Figure 3. Map of Water Quality (Presence of *Escherichia coli*) in Houses in Pauh in 2021

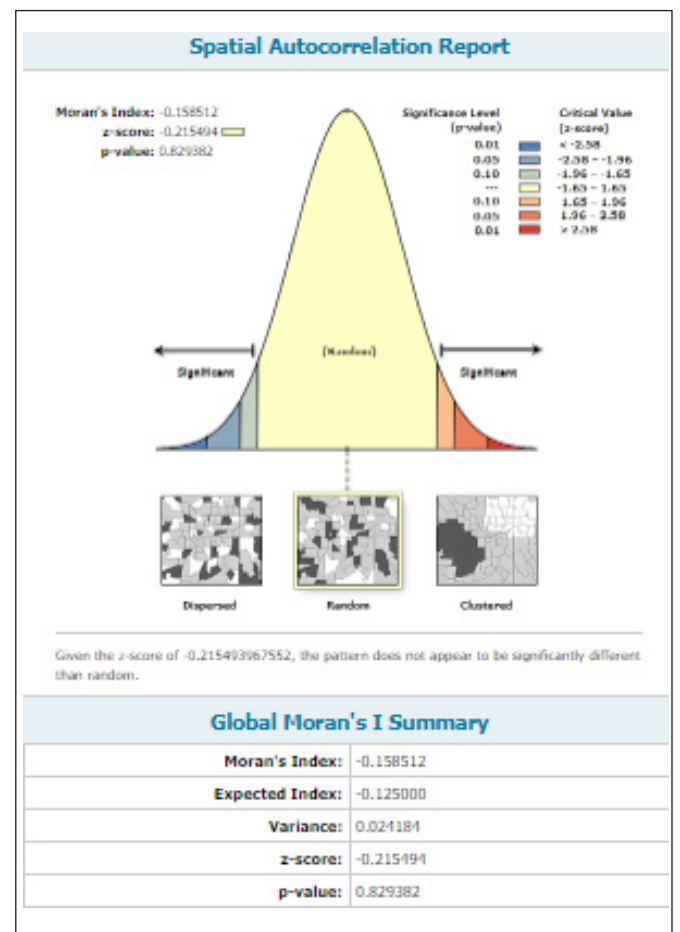


Figure 4. Autocorrelation of Water Quality and Toddler's Diarrhea in Pauh in 2021

In the final waste processing variable, it was found that 89 houses (89%) processed waste by burning or throwing garbage into the ravine, and they had a total of 70 children with diarrhea (70%). The remaining 11 houses (11%) threw their garbage into temporary dumps and final dumps, and they had only one toddler with diarrhea (1%).

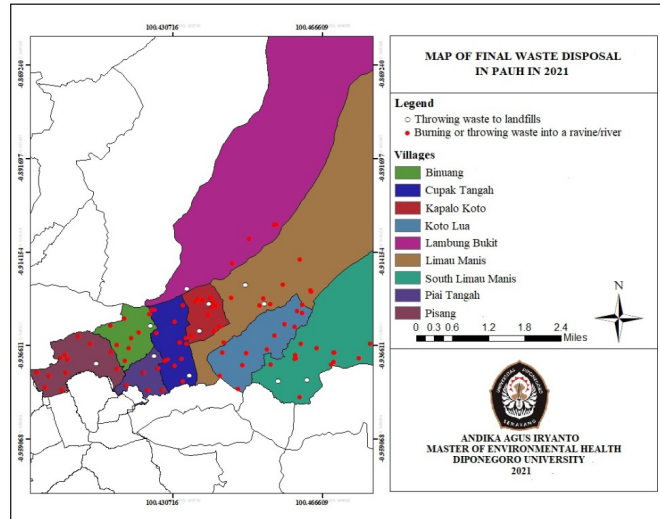


Figure 5. Map of Final Waste Disposal in Pauh in 2021

indicating that there was an autocorrelation with an expected value of -0.125000 and a variation of 0.023435. A negative Moran Index value indicates a random pattern distribution. The value of z-score of -0.233125 and p-value of 0.815664 mean that the distribution pattern of household waste management in Pauh did not meet the requirements and was distributed randomly or there was no autocorrelation between villages (Figures 5 and 6).

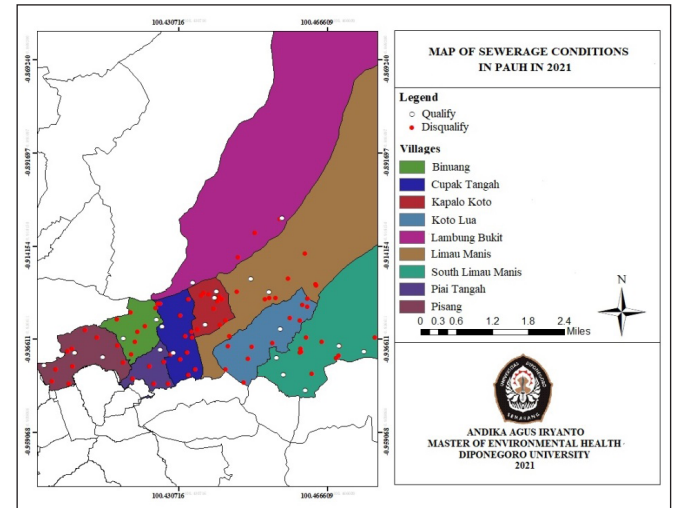


Figure 7. Map of Sewerage Conditions in Pauh in 2021

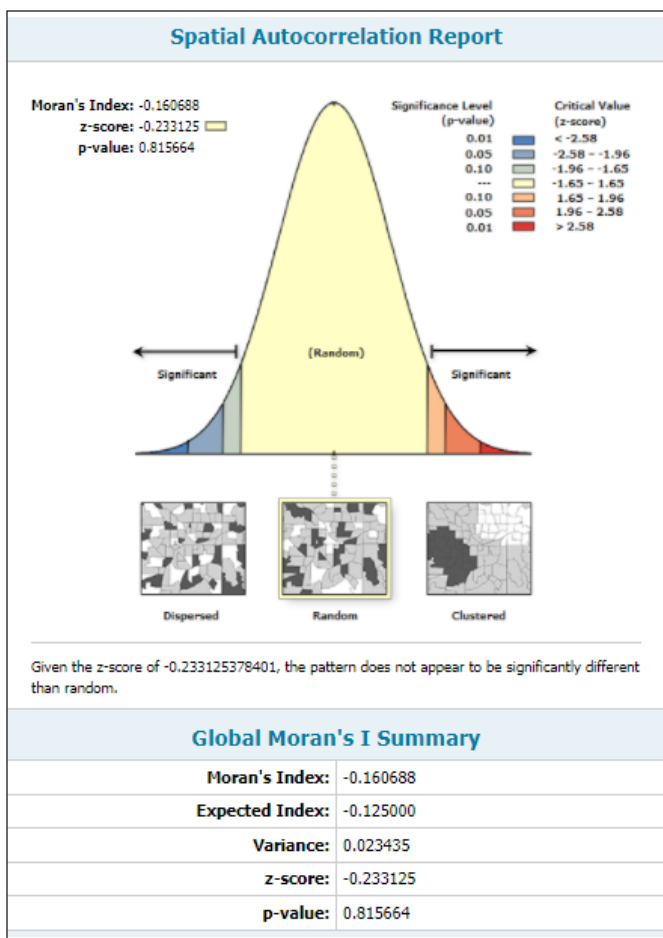


Figure 6. Autocorrelation of Unqualified Waste Processing and Toddler's Diarrhea in Pauh in 2021

The spatial autocorrelation analysis of household waste processing that did not meet the requirements obtained a Moran Index of -0.160688,

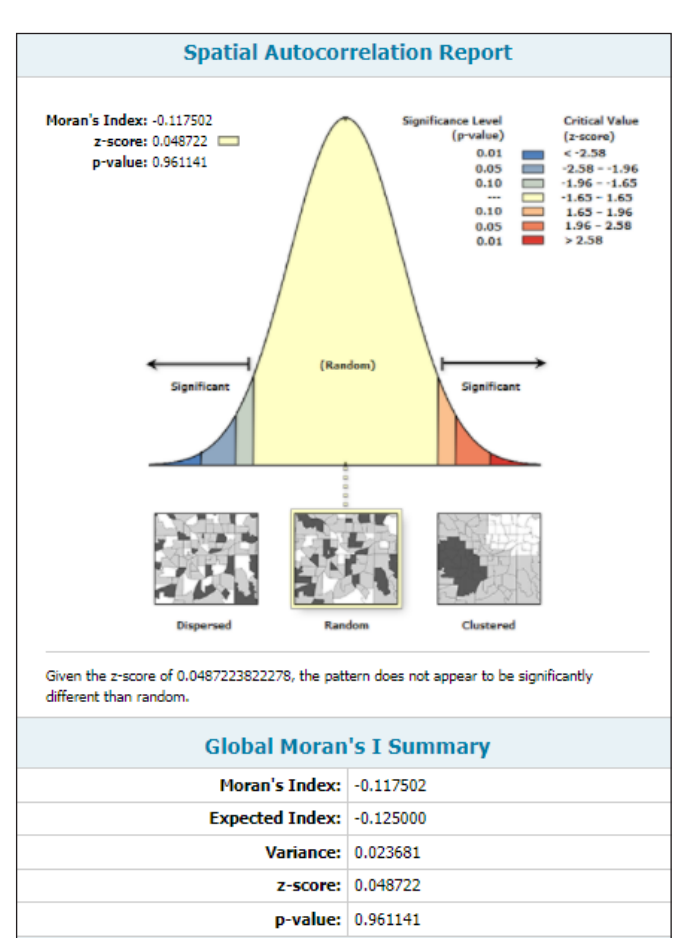


Figure 8. Autocorrelation of Unqualified Sewerage Conditions and Toddler's Diarrhea in Pauh in 2021

Regarding the sewerage conditions variable, it was found that 78 houses (78%) did not meet the requirements, and they had 67 toddlers with

diarrhea (67%). The remaining 22 houses (22%) met the requirements and had four toddlers with diarrhea (4%).

Spatial autocorrelation analysis of the condition of wastewater disposal did not meet the requirements. A Moran Index of -0.17502 obtained means there was an autocorrelation with an expected value of -0.125000 and a variation of 0.023681. A negative Moran Index value indicates a random patterned distribution. The z-score of -0.048722 and p-value of 0.961141 mean that the household sewerage condition that did not meet the requirements was distributed randomly, or there was no autocorrelation between villages (Figures 7 and 8).

In relation to the quality of waste storage, it was found that 63 houses (63%) did not meet the requirements, and they had 52 toddlers having diarrhea (52%) The remaining 37 houses (37%) met the requirements, and they had 19 toddlers having diarrhea (19%).

The spatial autocorrelation analysis of household waste containers that did not meet the requirements obtained a Moran Index of -0.315524, which means there was an autocorrelation with an expected value of -0.125000 and a variation of 0.023561. A negative Moran Index value indicates a random pattern distribution. The z-score of -1.241235 and p-value of 0.214519 mean that household waste containers that did not meet the requirements were distributed randomly or there was no autocorrelation between villages (Figures 9 and 10).

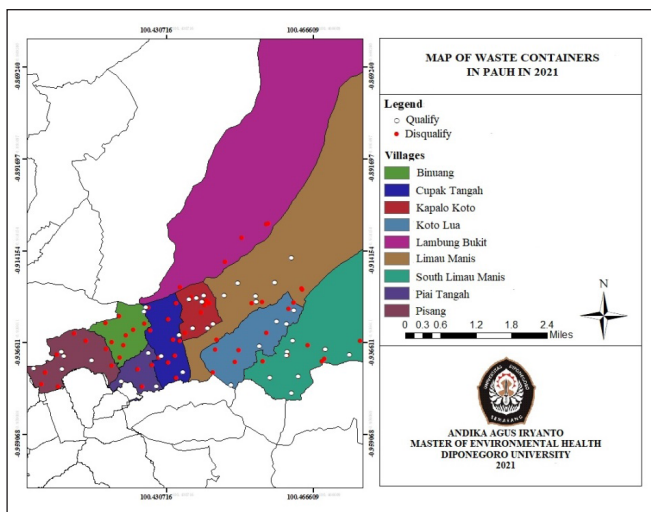


Figure 9. Map of Waste Containers in Pauh in 2021

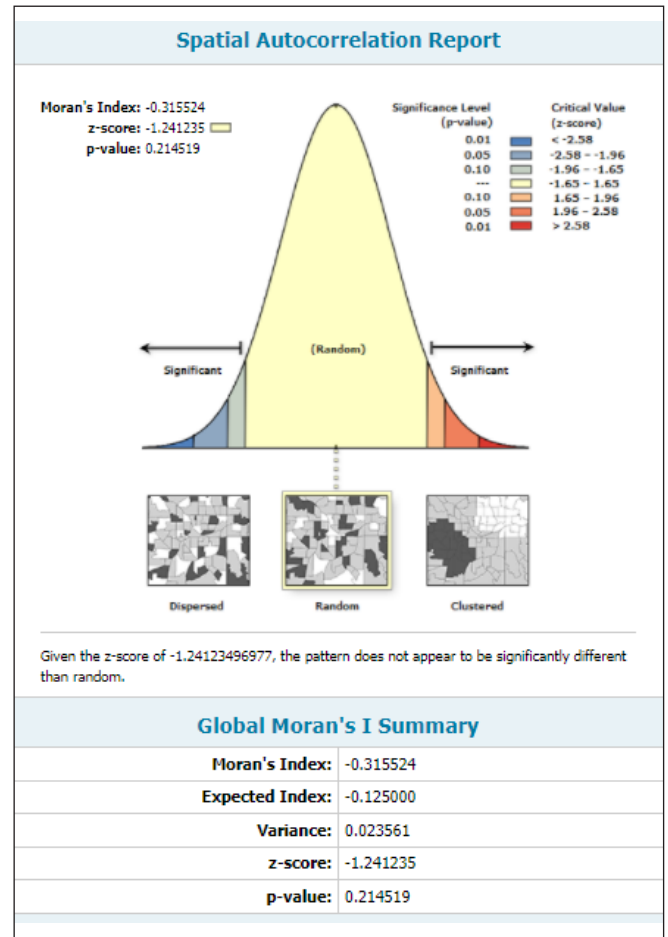


Figure 10. Autocorrelation of the Unqualified Waste Containers and Toddler's Diarrhea in Pauh in 2021

In the category of sewerage quality, it was found that 82 houses (82%) did not meet the requirements, and they had 67 toddlers with diarrhea (67%). The remaining 18 houses (18%) met the requirements, and they had four toddlers with diarrhea (4%).

The spatial autocorrelation analysis of unqualified sewerage obtained a Moran's Index of -0.153129, which means there was an autocorrelation with an expected value of -0.125000 and a variation of 0.023755. A negative Moran Index value indicates a random patterned distribution. The z-score of -0.182510 and p-value of 0.855182 mean that the pattern of distribution of poor-quality sewerage in Pauh was distributed randomly or there was no autocorrelation between villages (Figures 11 and 12).

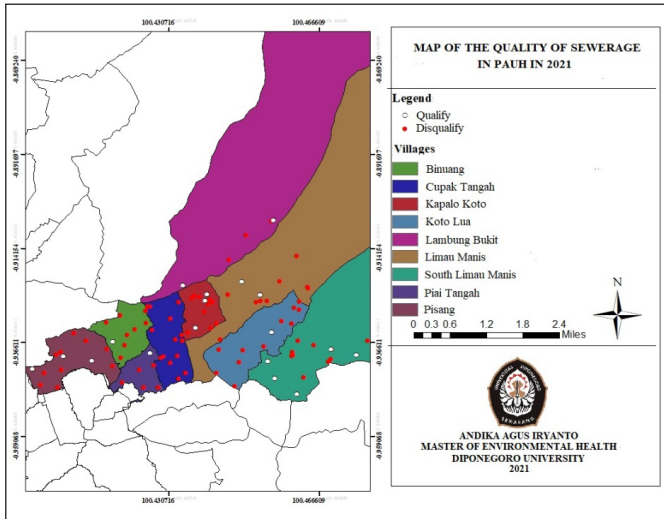


Figure 11. Map of the Quality of Sewerage in Pauh in 2021

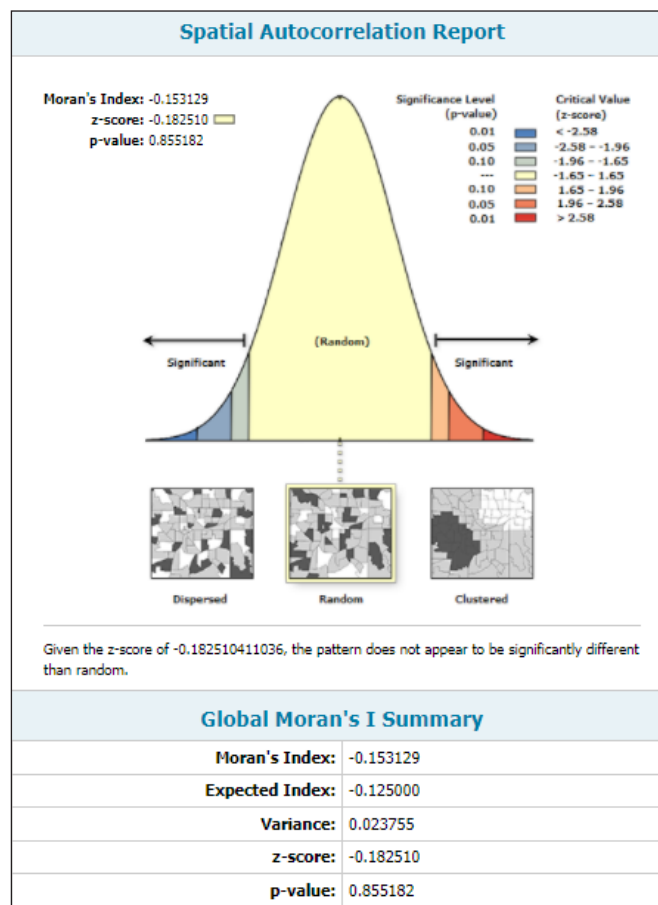


Figure 12. Autocorrelation of Unqualified Sewer and Toddler's Diarrhea in Pauh in 2021

Relating to the density of flies in the household waste bins variable, it was found that 88 houses (88%) had a category of high fly density (>2) with a total of 66 children under five with diarrhea (66%). The remaining 12 houses (12%) had a low fly density category (0-2) with five children under five with diarrhea (5%).

Spatial autocorrelation analysis of fly density with a high level in the toddlers' home trash bins obtained a Moran Index of -0.174424, which means there was an autocorrelation with an expected value of -0.125000 and a variation of 0.023579. A negative Moran Index value

indicates a random patterned distribution. The z-score of -0.321867 and p-value of 0.971235 mean that the pattern of high fly density in the trash bins of toddlers' homes in Pauh was distributed randomly or there was no autocorrelation between villages (Figures 13 and 14).

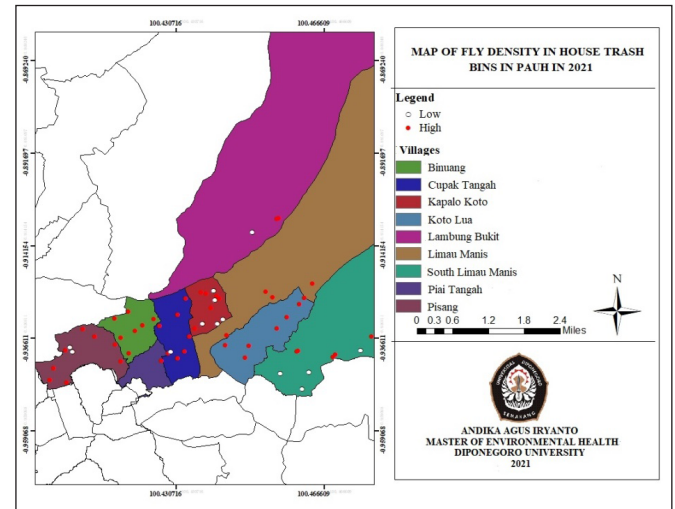


Figure 13. Map of Fly Density in House Trash Bins in Pauh in 2021

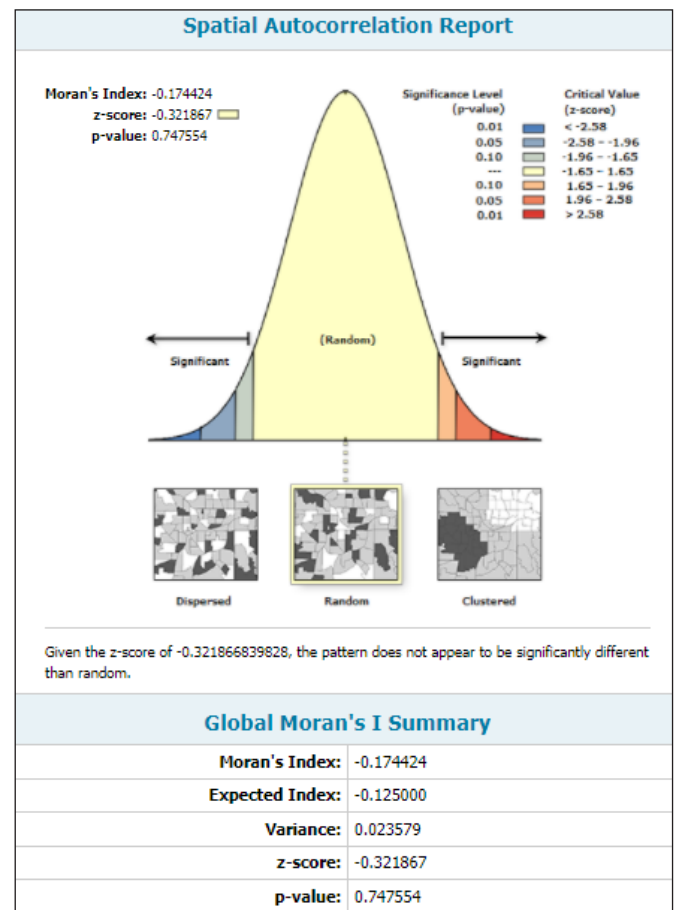


Figure 14. Autocorrelation of High Fly Density in House Trash Bins and Toddler's Diarrhea in Pauh in 2021

On the topic of the density of flies in the sewerage channel variable, it was found that seven houses (7%) had a category of high fly density (>2) with three children under five with diarrhea (3%). The remaining 93 houses (93%) had a low fly density category (0-2) with 68 children under five with diarrhea (68%).

Autocorrelation analysis of fly density with a high level of SPAL in under-five children's homes obtained a Moran Index of -0.025798, which means there was an autocorrelation with an expected value of -0.125000 and a variation of 0.023941. A negative Moran Index value indicates a random patterned distribution. The z-score of -0.641139 and p-value of 0.521433 mean that the distribution pattern of high fly density in the sewerage of the toddlers' houses in Pauh District was distributed randomly, or there was no autocorrelation between villages (Figures 15 and 16).

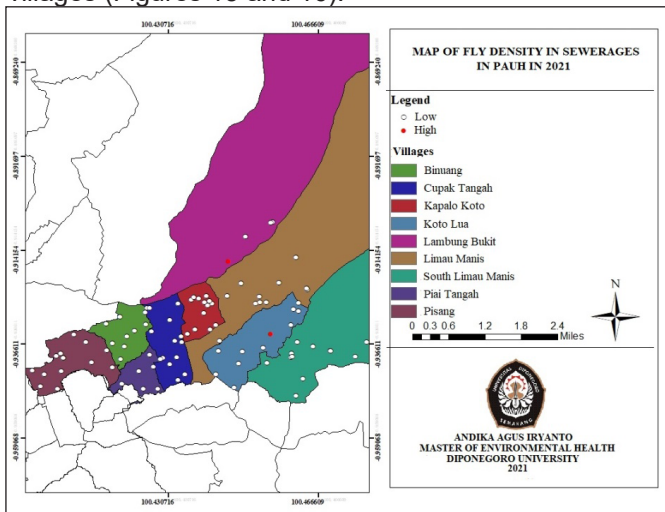


Figure 15. Map of Fly Density in Sewerages in Pauh in 2021

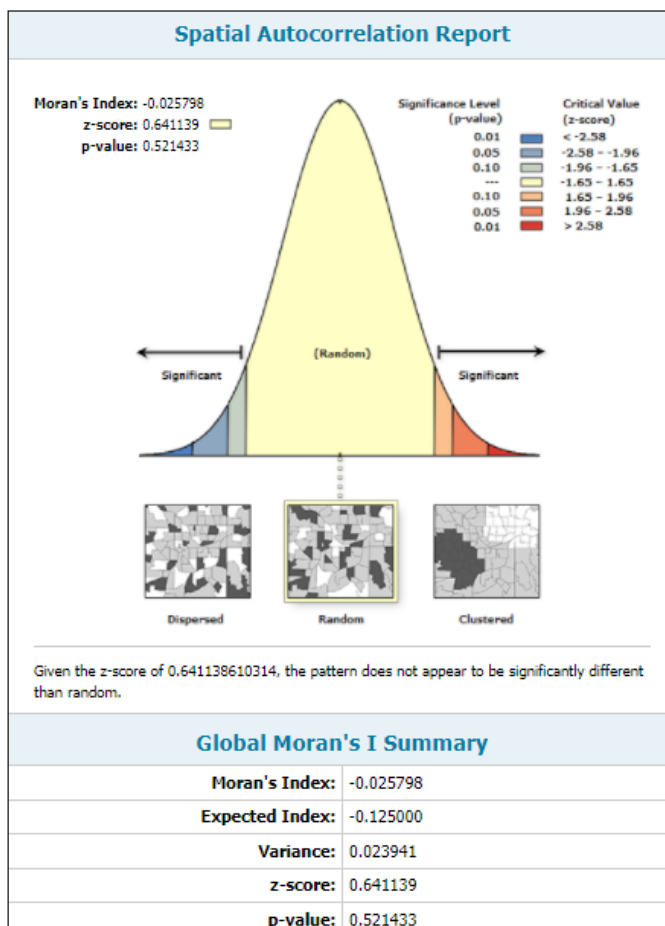


Figure 16. Autocorrelation of High Fly Density Sewerage and Toddler's Diarrhea in Pauh in 2021

DISCUSSION

Spatial Analysis of Toddler's Diarrhea

The research found that 71 out of 100 toddlers (71%) experienced diarrhea. A similar study conducted in Pauh, Padang City, in 2018 found more than half (61.6%) of the toddlers in Pauh had diarrhea (8). These results indicate that there was an increase in diarrhea cases in the following year's study. This is in line with research in Tanah Laut Regency in 2020, which found diarrhea in more than half (61.1%) of children under five in the working area of the Bati-Bati Health Center, Tanah Laut Regency (11). The previous research mentioned above showed that the incidence of diarrhea in toddlers was more than 50%, which means that diarrhea in toddlers is considered a significant issue that must be addressed immediately.

These results indicate that the distribution pattern of diarrhea among children under five in Pauh can be identified using the spatial analysis. The distribution of cases of diarrhea cases under five in Pauh has been proven to be randomly distributed. The highest incidence of diarrhea in children under five was found in South Limau Manih village as many as 12 cases (16.9%), followed by 10 cases in Cupak Tengah and Koto Lua, respectively (14.08%). These three sub-districts have the highest cases due to densely populated houses and a high number of children under five. The sanitation factor is possibly very influential on the incidence of toddlers in the three villages because the community still throw household waste and garbage into rivers.

The spatial analysis showed some risk factors that did not meet the requirements such as waste management, waste water disposal, quality of waste containers, quality of wastewater management, and density of flies in trash cans and sewers. The results showed that the cases were randomly distributed, or there was no autocorrelation between regions. It can be concluded that the spread of diarrhea cases were not concentrated in a dominant village but spreads to every village. Previous research in Brebes Regency in 2016 showed a discrepancy with this study. That study found there was a relationship between environmental sanitation, healthy behavior, and population access (12). The difference is that the diarrhea cases in Pauh were scattered, and the environmental sanitation conditions of each house varied.

Diarrhea is an conditions where an individual has watery/fluid bowel movements that occurs more than three times a day (4). This disease includes diseases related to the environment with the dominant factors which are clean water facilities and fecal disposal facilities (1). Components related to unhealthy human behavior can also contribute to diarrheal disease (13).

Spatial Analysis of Clean Water Quality (Presence of *Escherichia coli*) and Diarrhea among Toddlers

The results of autocorrelation analysis using the Moran's Index showed that the presence of *Escherichia coli* in clean water facilities was randomly distributed or there was no autocorrelation between regions. The highest presence of *Escherichia coli* was in Pisang Village with 11 houses (19.30%), followed by South Limau Manih Village with eight houses (14%), and Kapalo Koto Village with seven houses (12.30%). The majority of the residents in these three sub-districts used well water as daily water resource. The community well itself was adjacent to the river that people usually disposed of wastewater and household waste.

Escherichia coli are fecal coliform bacteria often found in the digestive tract of humans (small intestine) and animals (warm blood). The identification of *Escherichia coli* in water bodies indicates that the contamination comes from feces. Besides being used as drinking water, clean water is used to wash tableware so that it can be contaminated with *Escherichia coli* (14). Boiling water can kill *Escherichia coli* and prevent digestive tract diseases, especially diarrhea. Boiling water can kill all *Escherichia coli* bacteria, thereby preventing digestive tract diseases including diarrhea. *Escherichia coli* can grow at temperatures between 7-44°C and optimally at 37°C. If the water temperature exceeds 44°C, *Escherichia coli* will experience inactivation. It can grow at a minimum temperature of 15-20°C and optimally at 20-45°C (15).

Based on the Indonesian Ministry of Health Regulations Number 32 of 2017 concerning environmental health quality standards and water health requirements for sanitary hygiene, swimming pools, solus per aqua, and public baths, it was determined that the biological parameter of the *Escherichia coli* quality standard is 0 CFU/100 ml. This means that this bacterium should not be present in the environment or in the water for daily use (16).

Based on the direct observation, some people still consumed clean water from well water. Residents preferred to process well water instead of consuming distilled water. They assumed that the distilled water was still raw, and it contained bacteria. However, some residents consumed drinking water refilled daily and used well water for other purposes.

Spatial Analysis of Waste Disposal Processing and Toddler's Diarrhea

The autocorrelation analysis of the Moran Index showed that waste management that did not meet the requirements was randomly distributed, or there was no autocorrelation between regions. A similar study

conducted in the working area of the Bambaira Primary Health Care in Pasangkayu Regency in 2018 found a link between waste disposal facilities and toddlers' diarrhea (17). This in line with a study done in Sindang Barang Village, Bogor City in 2018, which explained that there was a link between household waste management and toddler's diarrhea (18).

Burning or throwing waste into a ravine/river were the most common methods used in Pisang, Cupak Tengah, Koto Lua, and South Limau Manih. Besides these villages had the large population of children under five in these three sub-districts.

Waste management aims to prevent interference with human health and environmental cleanliness. Management starts from waste collection and end with final waste management (19). Garbage collection is the family's responsibility to provide temporary trash cans that comply with quality standards. Separation of organic and inorganic waste is needed in waste management (20). It has been concluded that healthy waste management has an impact on reducing diarrhea in children under five. Waste management that does not meet the requirements has the potential to increase the risk of diarrhea, especially in toddlers. In order to avoid this, waste disposal must meet the requirements.

Field observations found that the community felt fortunate for living near a river as they could burn and throw the waste into rivers or ravines. They assumed that these methods could solve the waste management issues. However, these methods certainly will cause new problems such as flooding, contamination, unaesthetic issues, health issues, and damage in aquatic biota.

Spatial Analysis of Sewerage Conditions and Diarrhea in Toddlers

The autocorrelation analysis with Moran's index showed that the household sewerage conditions that did not meet the requirements were randomly distributed, or there was no autocorrelation between regions. Sewerage conditions that did not meet the requirements were mostly found in Cupak Tengah Village and Koto Lua Village which had 12 houses each (15.40%), followed by Kapalo Koto Village and South Limau Manih Village which had 10 houses each (12.80%). A similar study was conducted on the administration of the Rembang 2 Primary Health Care in Rembang Regency in 2016 found a link between the sewerage system and toddlers' diarrhea (21).

Domestic wastewater may come from bathing, food waste ingredients, urine, and human feces. Good wastewater management has an impact on human health and the environment. Poor wastewater disposal will

contaminate water and soil and cause diarrheal disease transmission. Proper domestic waste management is done using closed channels where wastewater will ultimately end up in septic tanks. Open sewerage will be used as a vector breeding ground. Waste water management must meet quality standards in order not to be a detriment to health (21). Observations showed most residents already had closed channels, which are connected to rivers. Wastewater and household waste are often thrown to the river, and eventually it polluted the river and had an impact on health sanitation.

Spatial Analysis of Waste Container Quality and Toddler's Diarrhea

The results of the autocorrelation analysis with the Moran's Index showed that the waste container that did not meet the quality requirements was randomly distributed or there was no autocorrelation between regions. Those unqualified waste containers were mostly found in Pisang Village with 11 houses (17.5%), followed by Cupak Tengah Village with 10 houses (15.90%), Binuang Village and Koto Lua Village 8 houses each (12.7%). Research in Mangkang Primary Health Care, Semarang City in 2016 showed a relationship between the quality of trash bins and toddlers' diarrhea. A similar study was conducted in the administrative area of the Tasikmadu Primary Health Care, Karanganyar Regency in 2017 found a relationship between the quality of waste containers and diarrhea in toddlers (22-23).

Waste container must meet the requirements to avoid the growth of germs that will nest in the trash. A good waste container must be waterproof, affordable, aesthetic, easy to clean, close, and transport. Unsanitary containers have the potential to develop disease vectors which can interfere with human health and cause diarrhea (24).

Pauh residents commonly use trash baskets without lids. Furthermore, they used plastic bags as temporary trash containers at home and then they reused after they threw the rubbish to a ravine or river. Such harmful actions will pollute the surrounding environment since plastic waste takes years to decompose.

Spatial Analysis of Sewerage Quality and Toddler's Diarrhea

The autocorrelation analysis showed that the household sewerage that did not meet the requirements was randomly distributed. In other words, there was no autocorrelation between regions. The quality of sewerage that did not meet the requirements was mostly found in Cupak Tengah Village with 14 houses (17.10%), followed by Koto Lua Village with 12 houses (14.60%),

and Pisang Village 11 houses (13.40%). Since people's houses and lands were not spacious, they disposed waste to the rivers. A similar study in West Martapura Primary Health Care, Banjar Regency in 2018 showed the use of healthy latrines and diarrhea in toddlers were correlated. In Tasikmadu Primary Health Care, Karanganyar Regency in 2017, research also showed a relationship between the quality of the sewerage and the incidence of diarrhea in children under five (23, 25).

Waste water disposal facilities must meet health requirements to prevent the spread of diseases such as diarrhea. Improper sanitation and wastewater management possibly accelerates the spread of diseases caused by feces. To secure household waste, kitchen and bathroom waste should not be mixed with latrine water, and thus there will be no vector breeding sites, water stagnation or slippery surfaces prone to accidents, and stuck absorbent area (26). The requirements for healthy latrines include the use of a watertight septic tank and air pipe over 10 meters from a water source; availability of adequate water supply and cleaning equipment; waterproof roofs, walls, and floors; availability of adequate lighting and ventilation; uncontaminated surrounding soil.

Poor quality of latrines will become a place for the spread of *Escherichia coli* as diarrheal bacteria to develop. Unqualified wastewater disposal sites seems to increase in the risk of toddlers' diarrhea twofold. Technically, although the houses already had a latrines, but they did not have a septic tanks to drain the wastewater into the rivers due to limited funds and lack of installment areas.

Spatial Analysis of Fli Density in House Trash Bins and Toddler's Diarrhea

The autocorrelation analysis results showed that the fly density in the trash bins was randomly distributed. It means there was no autocorrelation between regions. The highest fly density was found in Pisang Village, Cupak Tengah Village, and Koto Lua Village with 13 houses each (14.80%). Research in the coastal area of Abeli Primary Health Care in Kendari City and Siko Primary Health Care, Ternate City showed relationship between fly density in houses and toddlers' diarrhea (27-28).

Flies are considered disease vectors in human health, especially in the digestive tract. Flies can lay their eggs and grow in damp and dirty places such as landfills where they also find food (29). The density of flies is an important factor in the incidence of diarrhea in toddlers. The high density of flies in the trash bins or houses will cause contamination in food and drinks. Eliminating

breeding sites for flies can be done by installing wire nets and storing food in safe places such as food container, refrigerator, and others.

Spatial Analysis of Fly Density in Sewerage and Toddler's Diarrhea

The autocorrelation analysis showed that the distribution of high fly density in the sewerage was randomly distributed. It indicates there was no autocorrelation between regions (Figure 9). The lowest fly density in the sewerage channel was mostly found in Pisang Village and Cupak Tengah Village with 14 houses each (15.10%), followed by Kapalo Koto Village with 13 houses (14%). As pipes were used as closed sewerage channels, they drained the waste to the rivers. This is in line with research in Tanjung Pinang Village, Jambi City which found no significant relationship between fly density and the incidence of toddler's diarrhea (30).

Previous research in Tanjung Karang Sub-district, Bandar Lampung also found a relationship between fly density and the condition of sewerage (31). Unmanaged sanitation will pollute the soil and water, and it can trigger the growth of flies. The high density of flies in the sewerage happen due to open and not impermeable drainage, thereby causing the water stuck and odorous. Sewerage must meet health quality standards to prevent health and environmental problems as well as the growth of disease vectors. This study found that the use of pipelines likely make the fly density low since they hampers the flies to lay eggs and breeding.

CONCLUSION

Several sanitation factors that have the potential to cause toddlers' diarrhea in Pauh District, Padang City. They include the type of clean water facilities, water quality (presence of *Escherichia coli*), final waste processing and waste storage, quality of sewerage condition, and fly density in house trash. The toddler's diarrhea incidence and sanitation factors between sub-districts in Pauh did not from cluster or random patterns or did not have autocorrelation. This study showed high heterogeneity in the risk distribution pattern throughout.

REFERENCES

1. Saputri N, Astuti YP. Hubungan Faktor Lingkungan Dengan Kejadian Diare Pada Balita di Puskesmas Bernung. *J Ilmu Keperawatan dan Kebidanan*. 2019;10(1):101–110. <http://dx.doi.org/10.26751/jikk.v10i1.619>
2. District Health Office of Padang. Health Profile of Padang City 2019. Padang: District Health Office of Padang; 2019. 1–81 p. <https://dinkes.padang.go.id/profil-kesehatan-tahun-2019>
3. Wijoyo Y. Diare Pahami Penyakit dan Obatnya. Yogyakarta: Citra Aji Pratama; 2013.
4. Ariani AP. Diare, Pencegahan dan Pengobatannya. Yogyakarta: Nuha Medika; 2017. 1–156 p. <http://sippanon.bantenprov.go.id:8123/inlislite3/opac/detail-opac?id=28261>
5. Ministry of Health of Republic Indonesia. Regulation of Ministry of Health of Republic Indonesia No. 50 Year 2017 about Environmental Health Quality Standards and Health Requirements for Disease-Carrying Vectors and Animals and Their Control. Jakarta: Ministry of Health of Republic Indonesia; 2017. 1–83 p.
6. Katiandagho D, Darwel D. Hubungan Penyediaan Air Bersih dan Jamban Keluarga dengan Kejadian Diare pada Balita di Desa Mala Kecamatan Manganitu Tahun 2015. *J Sehat Mandiri*. 2019;14(2):64–78. <https://doi.org/10.33761/jsm.v14i2.118>
7. Sumantri SH, Supriyatno M, Sutisna So, Widana IDKK. Sistem Informasi Geografis (Geographic Information System) Kerentanan Bencana. In: Inaqa S, editor. Jakarta: CV. Makmur Cahaya Ilmu; 2019.
8. Irfan A, Delima D. Sarana Sanitasi Dasar dengan Kejadian Diare pada Balita. *J Sehat Mandiri*. 2018;13(2):42–47. <https://doi.org/10.33761/jsm.v13i2.59>
9. Ministry of Health of Republic Indonesia. Regulation of Ministry of Health of Republic Indonesia No. 3 Year 2014 about Community Based Total Sanitation. Jakarta: Ministry of Health of Republic Indonesia; 2014.
10. Fikri E, Firmansyah YW, Ramadhansyah MF, Widyantoro W, Lewinsca MY, Arumdani IS, et al. Autocorrelation Spatial Diarrhea, Typhoid and Leptospirosis on The East Flood Canal, Semarang City : Moran Index Method. *JAisyah J Ilmu Kesehat*. 2021;6(4):747–752. <http://dx.doi.org/10.30604/jika.v6i4.734>
11. Dewi M. Hubungan Faktor Lingkungan dengan Kejadian Diare pada Anak Balita di Wilayah Kerja Puskesmas Bati-Bati Kabupaten Tanah Laut 2020. Skripsi. Banjarmasin: Universitas Islam Kalimantan Muhammad Arsyad Al Banjari; 2020. <http://eprints.uniska-bjm.ac.id/2832/>
12. Muliawan YMRB, Prasetyo S. Spatial Analysis of Diarrhoea in Brebes District, Indonesia. *International Journal of Scientific and Research Publications*. 2019;9(6):530–537. <http://dx.doi.org/10.29322/IJSRP.9.06.2019.p9076>
13. Deni R. Hubungan Pengetahuan, Sikap, dan Tindakan Masyarakat dalam Penggunaan Jamban dengan Kejadian Diare di Kelurahan Sitinjau Kecamatan Angkola Barat Tahun 2019. *Skripsi*. Medan: Universitas Sumatera Utara; 2021. <https://repositori.usu.ac.id/bitstream/handle/123456789/30919/151000177.pdf?sequence=1&isAllowed=y>
14. Firmansyah YW, Ramadhansyah MF, Fuadi MF, Nurjazuli N. Faktor - Faktor yang mempengaruhi Kejadian Diare pada Balita : Sebuah Review. *Bul Keslingmas*. 2020;40(1):1–6. <https://doi.org/10.31983/keslingmas.v40i1.6605>

15. Kurniati E, Huy VT, Anugroho F, Sulianto AA, Amalia N, Nadhifa AR. Analisis Pengaruh pH dan Suhu pada Desinfeksi Air menggunakan Microbubble dan Karbondioksida Bertekanan. *J Pengelolaan Sumberd Alam dan Lingkung (Journal Nat Resour Environ Manag.* 2020;10(2):247–256. <https://doi.org/10.29244/jpsl.10.2.247-256>
16. Ministry of Health of Republic Indonesia. Regulation of Ministry of Health of Republic Indonesia No. 32 Year 2017 about Environmental Health Quality Standards and Water Health Requirements for Hygiene Purposes Sanitation, Swimming Pools, Solus Per Aqua and Public Bathing. Jakarta: Ministry of Health of Republic Indonesia; 2017.
17. Azmi A, Sakung J, Yusuf H. Hubungan Sanitasi Lingkungan dengan Kejadian Diare pada Anak Balita di Wilayah Kerja Puskesmas Bambaira Kabupaten Pasangkayu. *J Kolaboratif Sains.* 2018;1(1):313–322. <https://doi.org/10.31934/jom.v1i1.363>
18. Oktora B. Hubungan Pengelolaan Sampah Rumah Tangga dengan Kejadian Diare pada Balita di Kelurahan Sindang Barang Kota Bogor. *J Ilm Wijaya.* 2018;10(1):47–58. <https://doi.org/10.46508/jiw.v10i1.10>
19. Iryanto AA, Joko T, Raharjo M. Literature Review : Faktor Risiko Kejadian Diare Pada Balita Di Indonesia. *J Kesehat Lingkung.* 2021;11(1):1–7. <https://doi.org/10.47718/jkl.v11i1.1337>
20. Notoatmodjo. Kesehatan Masyarakat Ilmu dan Seni. 2nd ed. Jakarta: Rineka Cipta; 2011.
21. Langit LS. Hubungan Kondisi Sanitasi Dasar Rumah dengan Kejadian Diare pada Balita di Wilayah Kerja Puskesmas Rembang 2. *J Kesehat Masy.* 2016;4(2):160–165. <https://doi.org/10.14710/jkm.v4i2.11941>
22. Murtadla MF. Hubungan Penyediaan Air, Pengelolaan Sampah, dan Kebiasaan Ibu dalam Mengawasi Kebersihan Tangan Balita dengan Kejadian Diare pada Balita di Wilayah Kerja Puskesmas Mangkang Semarang Tahun 2016. Skripsi. Semarang: Universitas Negeri Semarang; 2016.
23. Putra ADP, Rahardjo M, Joko T. Hubungan Sanitasi Dasar dan Personal Hygiene dengan Kejadian Diare Pada Balita di Wilayah Kerja Puskesmas Tasikmadu Kabupaten Karanganyar. *J Kesehat Masy.* 2017;5(1):422–429. <https://doi.org/10.14710/jkm.v5i1.15791>
24. Sidhi AN, Raharjo M, Astorina N, Dewanti Y. Hubungan Kualitas Sanitasi Lingkungan dan Bakteriologis Air Bersih Terhadap Kejadian Diare Pada Balita di Wilayah Kerja Puskesmas Adiwerna Kabupaten Tegal. *J Kesehat Masy.* 2016;4(3):665–676. <https://doi.org/10.14710/jkm.v4i3.13480>
25. Irianty H, Hayati R, Riza Y. Hubungan Perilaku Hidup Bersih dan Sehat (PHBS) dengan Kejadian Diare pada Balita. *Promot J Kesehat Masy.* 2018;8(1):1–10. <https://doi.org/10.31934/promotif.v8i1.224>
26. Indah FPS, Ismaya NA, Puji LKR, Hasanah N, Jaya FP. Penerapan Program Sanitasi Total Berbasis Masyarakat (STBM) dengan Kejadian Diare pada Balita. *J Ilm Kesehat.* 2021;20(1):10–15. <https://doi.org/10.33221/jikes.v20i1.596>
27. Nurnaningsi S, Sabilu Y, Fachlevy AF. Faktor yang Berhubungan dengan Kejadian Diare pada Balita di Wilayah Kerja Puskesmas Abeli Bagian Pesisir Kota Kendari Tahun 2017. *J Ilm Mhs Kesehat Masy.* 2017;2(6):1–12. <http://dx.doi.org/10.37887/jimkesmas.v2i6>
28. Soamole S. Analisis Hubungan Antara Faktor Lingkungan dengan Kejadian Diare di Puskesmas Siko Kota Ternate Tahun 2017. *J Hibualamo.* 2018;2(1):26–36. <https://garuda.kemdikbud.go.id/journal/view/16703>
29. Safira S, Nurmanini, Dharma S. Hubungan Kepadatan Lalat, Personal Higiene Dan Sanitasi Dasar Dengan Kejadian Diare Pada Balitadi Lingkungan Kelurahan Paya Pasir Kecamatan Medan Marela Kota Medan Tahun 2015. *J Lingkungan dan Keselamatan Kerja.* 2016;4(3):1–10. <https://www.neliti.com/id/publications/14582/hubungan-kepadatan-lalat-personal-hygiene-dan-sanitasi-dasar-dengan-kejadian-dia>
30. Listautin L. Faktor Risiko Kepadatan Lalat dan Sanitasi Rumah dengan Kejadian Diare di Kelurahan Tanjung Pinang Kota Jambi Tahun 2017. *J Ilm Univ Batanghari Jambi.* 2018;18(1):208–214. <http://dx.doi.org/10.33087/jiubj.v18i1.449>
31. Andriani U. Hubungan Fasilitas Sanitasi Dasar dengan Tingkat Kepadatan Lalat pada Rumah Makan di Kecamatan Tanjung Karang Pusat Kota Bandar Lampung. *Ruwa Jurai J Kesehat Lingkung.* 2019;13(2):64–69. <http://dx.doi.org/10.26630/rj.v13i2.2780>