Spatial Analysis of Diarrhea Incidences, Environmental Influences, and Behavioral Factors in An Ecological Study

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ABSTRACT

Diarrhea is a global health problem that causes morbidity and death in all age groups. Among the cities in Indonesia, Depok has the second-highest incidence of diarrhea outbreaks. Although previous studies have shown the correlation between diarrhea and environmental and behavioral factors, the spatial analysis of these factors is still very limited. Therefore, in this study, we investigated the spatial analysis of the association between diarrhea incidence and environmental and behavioral factors using an ecological study. The secondary data from the Depok City Health Office were used in the analysis. Our results showed a significant relationship between proper drinking water coverage (p = 0.00; r = -0.289) and healthy latrine coverage (p = 0.02; r = -0.233) with the incidence of diarrhea. Meanwhile, household coverage of Clean and Healthy Behavior (*Perilaku Hidup Bersih dan Sehat (PHBS)*) and population density showed no significant association. Spatial analysis maps also revealed the distribution pattern of diarrhea in Depok City from 2013 to 2021, tending to be more common in areas with low coverage of adequate drinking water. The findings from this study will contribute to optimizing diarrhea control and prevention programs.

INTRODUCTION

Diarrhea is a disease characterized by more frequent bowel movements compared to the normal frequency and produces stools with a more liquid consistency.[1] Diarrhea is still one of the global public health problems that never end. In the world, 1.7 billion cases of childhood diarrhea are found each year.[1] Diarrhea is also an increasing burden of disease in elderly.[2] Referring to the 2018 Primary Health Research data, the prevalence of diarrhea in Indonesia was 6.8% for all ages and 11% for toddlers.[3] The province in Indonesia with a high incidence of diarrhea is West Java. The prevalence of diarrhea in West Java is 7.4% for all age groups and 12.8% for children under five, both of which are still above the national prevalence.[4] Depok City is one of the West Java areas facing diarrhea problems. Depok City has experienced diarrhea outbreaks in 2018 and 2021.[5,6] Diarrhea is also included in the top 15 most common diseases at public health centers and hospitals in Depok City.[7,8]

Diarrhea is often associated with environmental factors such as drinking water quality and basic sanitation conditions.[9] Poor access to drinking water is associated increased disease cases, especially waterborne diseases such as diarrhea, cholera, and typhoid.[10] Open defecation also leads to fecal contamination of water and food, potentially resulting in diarrhea.[11] The combination of a contaminated environment and unhealthy behavior also causes diarrhea. Hygiene and health behaviors such as washing hands with soap and clean water, using healthy latrines, implementing waste management, using clean water, and handling food correctly are also correlated with diarrhea prevention.[12] In addition, high population density results in poor environmental conditions that increase the potential for diarrhea transmission.[13]

While previous studies have established a correlation between diarrhea and environmental and behavioral factors, the spatial analysis of these variables remains limited. Notably, Depok City ranks second in terms of diarrhea incidence, with certain areas still facing challenges such as improper access to drinking water and insufficient availability of healthy latrines.[6] Therefore, this study focuses on investigating the spatial analysis of the association between diarrhea incidence and environmental and behavioral factors in Depok City.

MATERIAL AND METHOD

This research is a quantitative study using ecological study design. The independent variables consisted of exposure behavioral factors (households with *PHBS* coverage and population density) and environmental factors (proper drinking water coverage and healthy latrines coverage), while the dependent variable was the incidence of diarrhea. The research was conducted in Depok City with the research population of all diarrhea patients recorded by the Depok City Health Office during 2013-2021. The data used were secondary data from the Depok City Health Office.

The analysis conducted in this study was bivariate analysis and spatial analysis. Bivariate analysis is correlation test used Spearman test because the diarrhea incidence data were not normally distributed. Spatial analysis used overlay method which integrates data from different layers to produce a new map containing the results of the analysis. The data on the independent variable and the dependent variable were grouped into three categories- namely low, medium, and high-using the Natural Breaks (Jenks) method for the spatial analysis. This research has undergone ethical screening by The Research and Community Engagement Ethical Committee of FKM UI and has obtained Ethical Approval with number: Ket-180/UN2.F10.D11/PPM.00.02/2023.

RESULTS

The results of spatial analysis between households with *PHBS* coverage and incidence of diarrhea showed a varied distribution pattern. Sawangan District has a relatively high incidence of diarrhea with low coverage of households with *PHBS*. Sukmajaya and Pancoran Mas Districts experienced a fluctuating incidence of diarrhea even though both districts had a high coverage of households with *PHBS*. Therefore, there is no consistent pattern of relationship between the two variables (Figure 1).

The spatial analysis result between population density and diarrhea incidence showed a varied distribution pattern. Sukmajaya and Cipayung Districts experienced fluctuating diarrhea incidence despite having high

population density. Meanwhile, Sawangan District with a low population density experienced a higher incidence of diarrhea. Therefore, there is no consistent pattern of relationship between the two variables (Figure 2).

The spatial analysis result between the proper drinking water coverage and incidence of diarrhea had a varied distribution pattern in each year, but showed a tendency of a negative relationship. Cinere District, which almost every year is always included as a district with high proper drinking water coverage, has the lowest incidence of diarrhea. Sawangan and Cimanggis Districts, which are in the low and medium proper drinking water coverage, have a relatively higher incidence of diarrhea (Figure 3).

The spatial analysis result between healthy latrines coverage and incidence of diarrhea showed a varied distribution pattern. Pancoran Mas District has a high incidence of diarrhea with low coverage of healthy latrines. However, Tapos, Sukmajaya and Cimanggis Districts still have a high incidence of diarrhea despite having high healthy latrines coverage. Therefore, there is no consistent pattern of association between the two variables (Figure 4).

The correlation between diarrhea incidence with environmental and behavioral factors is shown in Table 1. Our results showed a significant negative correlation between proper drinking water coverage and healthy latrines and the incidence of diarrhea, indicating that an increase will follow a decrease in these variables. On the other hand, households with PHBS coverage and population density did not have a significant relationship with diarrhea incidence (Table 1).
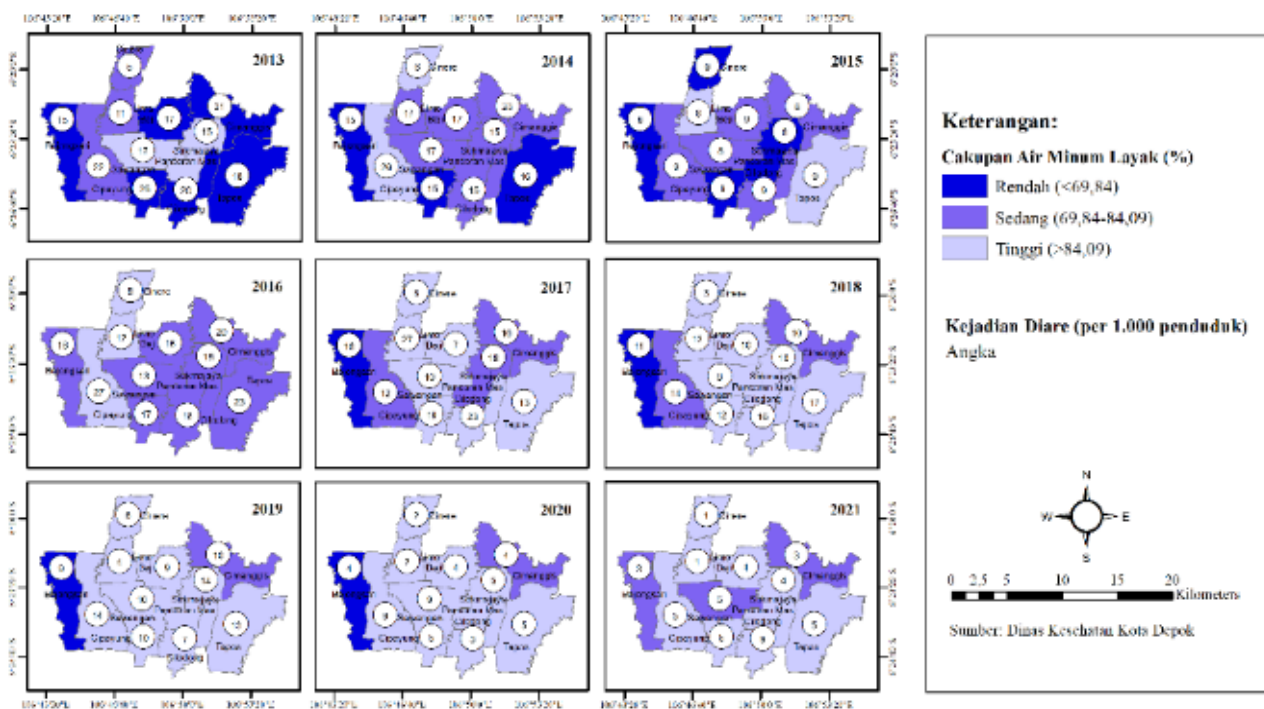

Source: Secondary Data of the Depok City Health Office, 2013-2021

Figure 1. Spatial Analysis Map of Households with *PHBS* Coverage and Diarrhea Incidence in Depok City 2013-2021
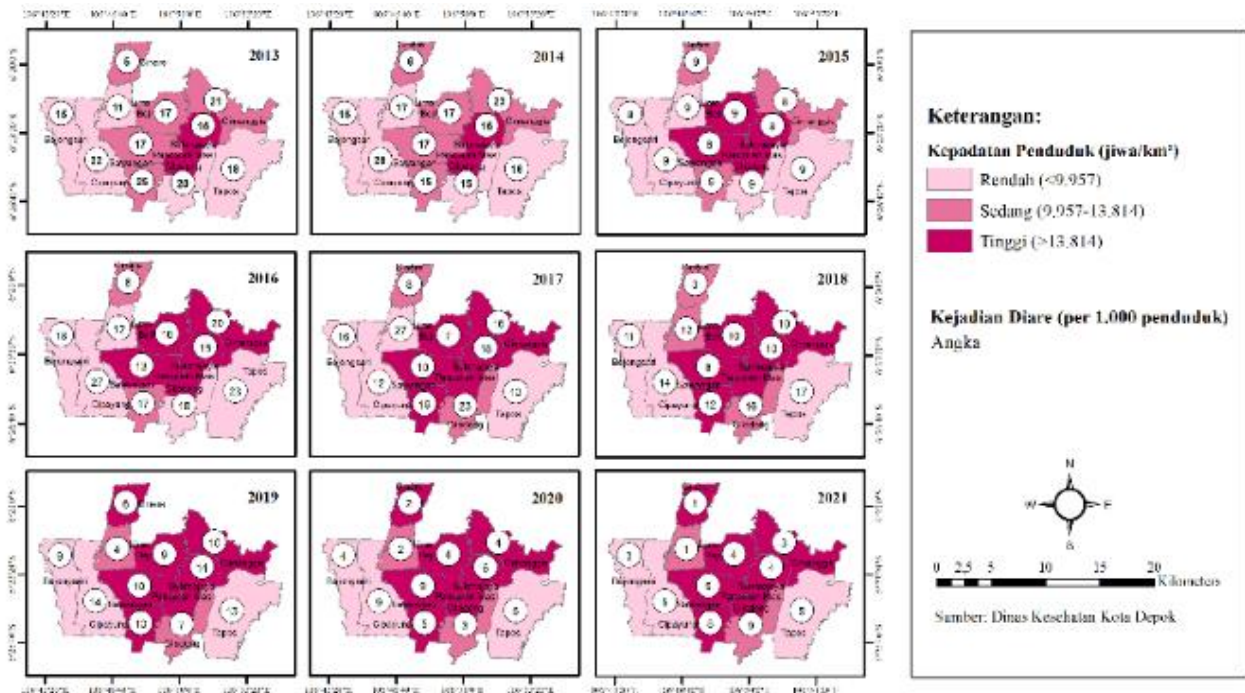
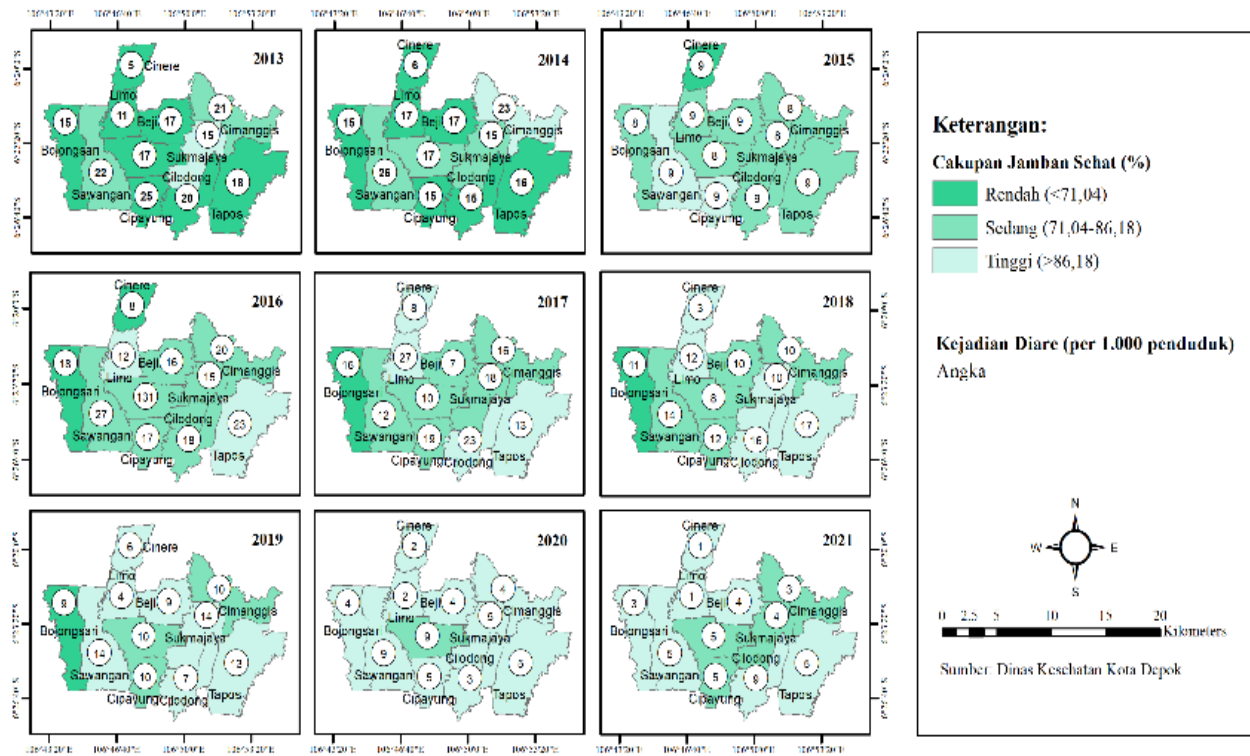Source: Secondary Data of the Depok City Health Office, 2013-2021

Figure 2. Spatial Analysis Map of Population Density and Diarrhea Incidence in Depok City 2013-2021

Source: Secondary Data of the Depok City Health Office, 2013-2021

Figure 3. Spatial Analysis Map of Proper Drinking Water Coverage and Diarrhea Incidence in Depok City 2013-2021

Source: Secondary Data of the Depok City Health Office, 2013-2021

Figure 4. Spatial Analysis Map of Health Latrines Coverage and Diarrhea Incidence in Depok City 2013-2021

DISCUSSION

This study aimed to investigate the association between diarrhea incidence and environmental and behavioral factors. Our results revealed a significant correlation between proper drinking water and the incidence of diarrhea in Depok City. Diarrhea is a disease known to be transmitted through the fecal-oral route, with water playing a crucial role as a transmission medium.[10] Groundwater, commonly used as a drinking water source in Depok City, may naturally contain germs and harmful chemicals. Human activities further exacerbate contamination.[25] Therefore, effective drinking water management, including water treatment and storage, is crucial to ensure water safety for human consumption. Simple treatment methods such as boiling water, filtration, coagulation to collect particles causing turbidity, chlorination, and disinfection to destroy unfiltered microorganisms are essential.[19] Proper drinking water storage involves storing water in a safe, enclosed place and placing water storage containers in a clean environment.[21]

Table 1. The Correlation Between Diarrhea with Environmental and Behavioral Factors in Depok city

Variables	r-value	p-value
Household with *PHBS*	0,083	0,41
Population density	0,047	0,64
Proper drinking ater	-0,289	0,00*
Healthy latrines	-0,233	0,02*

*Statistically significant
Source: Secondary Data of the Depok City Health Office, 2013-2021

In addition to proper drinking water coverage, our results demonstrated a significant correlation between healthy latrine coverage and the incidence of diarrhea. Open defecation poses a high risk of water source pollution, while healthy latrines offer a solution to prevent contamination.[26,27] Conversely, latrines that do not meet health requirements can increase the potential for diarrhea transmission.[26] Healthy latrines represent a manifestation of sanitary sanitation facilities-facilities that prevent direct transmission through proper feces disposal and inhibit disease vectors from spreading to users and the surrounding environment. Therefore,

the use and maintenance of healthy latrines are crucial to prevent the transmission of diarrhea and other diseases within the community.[21]

In this study, other variables, including households with *PHBS* and population density, do not show a significant correlation with diarrhea incidence. *PHBS* itself consists of 10 indicators, namely, labor assisted by health workers, exclusive breastfeeding, regular weighing of babies and toddlers, handwashing with soap and clean water, use of clean water, use of healthy latrines, consumption of fruits and vegetables, eradication of mosquito larvae, daily physical activity, and not smoking at home.[14] However, previous studies indicate that among these indicators, only handwashing, using healthy latrines, and using clean water have shown a correlation with diarrhea.[15-19] The Indonesian Ministry of Health has implemented the Community-Based Sanitation (*Sanitasi Total Berbasis Masyarakat/STBM*) program as an approach to reduce diarrhea and other environment-based diseases related to behavior and sanitation.[20] *STBM* is designed to strengthen clean and healthy behavior, prevent the spread of environment-based diseases, improve community capabilities, and increase access to drinking water and basic sanitation.[21] Some of the pillars promoted in the STBM program align with the household setting indicators of *PHBS*, such as stopping open defecation, washing hands with soap, and handling drinking water and food properly.[22] Therefore, the promotion of clean and healthy behaviors should consistently be enforced as a supportive measure to strengthen the sustainability of diarrhea prevention programs.

Densely populated areas have the potential to give rise to slums, contributing to environmental degradation. A poor environment can impact the transmission of diseases, making areas with high population density more susceptible to disease transmission, including diarrhea.[23] The construction of septic tanks is often constrained in densely populated area leading to them being situated close to drinking water sources. Septic tanks that do not adhere to construction requirements can contaminate groundwater, which is then consumed by the population.[13] Another prevalent issue in densely populated areas is waste management. With the increase in population, the volume and diversity of garbage

rise. Improper disposal practices, such as piling up garbage or throwing it into waterways, lead to stagnant water bodies and rotting garbage. The decomposition of garbage attracts vectors like flies, which act as intermediaries for diarrhea transmission.[24] In light of these circumstances, it becomes evident that population density indirectly influences the incidence of diarrhea. The lack of a significant relationship between population density and diarrhea incidence may be attributed to other factors that hold a more dominant association with the occurrence of diarrhea.

CONCLUSION AND RECOMMENDATION

In this study, the risk factors that exhibit a significant relationship with the incidence of diarrhea are proper drinking water coverage and healthy latrine coverage. However, the risk factors related to household *PHBS* coverage and population density did not show a significant relationship with the incidence of diarrhea. Spatial analysis results indicate a tendency for a negative relationship between proper drinking water coverage and the incidence of diarrhea. Using the results from this study, we recommend the optimizations of diarrhea control and prevention in each district through community empowerment and collaboration across sectors.

AUTHOR CONTRIBUTIONS

Conceived and designed the study by BPA, RAW; BPA performed the study; BPA analyzed the data; BPA and RAW wrote the initial manuscript. FK review and editing the manuscript. The authors read and approved the final manuscript.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

REFERENCES

1. World Health Organization. Diarrhoea [Internet]. 2023. Available from: https://www.who.int/health-topics/diarrhoea

2. Dadonaite B, Ritchie H, Roser M. Diarrheal diseases [Internet]. Our World in Data. 2019. Available from: https://ourworldindata.org/diarrheal-diseases

3. Badan Penelitian dan Pengembangan

Kesehatan. Kuesioner Individu Riskesdas 2018. Riset Kesehatan Dasar 2018. 2018.

4. Kementerian Kesehatan Republik Indonesia. Laporan Nasional Riset Kesehatan Dasar (Riskesdas) Tahun 2018. Jakarta; 2019.

5. Kementerian Kesehatan Republik Indonesia. Profil Kesehatan Indonesia Tahun 2018. Jakarta: Kementerian Kesehatan Republik Indonesia; 2019.

6. Dinas Kesehatan Kota Depok. Profil Kesehatan Kota Depok Tahun 2021 [Internet]. Depok; 2022. Available from: http://dinkes.depok.go.id/

7. Dinas Kesehatan Kota Depok. Profil Kesehatan Kota Depok Tahun 2019 [Internet]. Depok; 2020. Available from: http://dinkes.depok.go.id/

8. Dinas Kesehatan Kota Depok. Profil Kesehatan Kota Depok Tahun 2020 [Internet]. Depok; 2021. Available from: http://dinkes.depok.go.id/

9. Agustina, Dukabain Mariana O, Singga S, Wanti W, Suluh DG, Mado FG. Home sanitation facilities and prevalence of diarrhea for children in Oelnasi Village, Kupang Tengah Sub-district. *Gaceta Sanitaria*. 2021;35:393–395. https://doi.org/10.1016/j.gaceta.2021.10.059

10. World Health Organization. Drinking-water [Internet]. 2023. Available from: https://www.who.int/news-room/fact-sheets/detail/drinking-water

11. Hasan FA, Ayuningsih F, Juraiti W, Sidiqah F. Open Defecation Behavior of Elementary School-Aged Children in the Coastal Region, Indonesia : A pilot study. P*ublic Health of Indonesia*. 2021;7(3):133–138. https://doi.org/10.36685/phi.v7i3.437

12. Pahmi L, Endah WC. Household Risk Factors For Diarrhoea Disease In Children Under Five Years Old In Indonesia. *Jurnal Ilmu Kesehatan Masyarakat.* 2019;10(1):50–58. https://doi.org/10.26553/jikm.2019.10.1.50-58

13. Margarethy I, Suryaningtyas NH, Yahya Y. Kejadian Diare Ditinjau dari Aspek Jumlah Penduduk dan Sanitasi Lingkungan (Analisis Kasus Diare di Kota Palembang Tahun 2017). *Medica Arteriana.* 2020;2(1):10–16. https://doi.org/10.26714/medart.2.1.2020.10-16

14. Direktorat Promosi Kesehatan Kementerian Kesehatan Republik Indonesia. PHBS [Internet]. 2016. Available from: https://promkes.kemkes.go.id/phbs

15. Direktorat Promosi Kesehatan Kementerian Kesehatan Republik Indonesia. Perilaku Hidup Bersih dan Sehat di Rumah Tangga. 2022.

16. Alamsyah T, Marianthi D. Correlation between Incidence of Diarrhea in Toddlers and Housewife's Clean and Healthy Lifestyle. *J-Kesmas: Jurnal Fakultas Kesehatan Masyarakat (The Indonesian Journal of Public Health)*. 2020;7(1):57–62. https://doi.org/10.35308/j-kesmas.v7i1.1938

17. Setyarini DMD, Hidaayah N. The Correlation between Clean and Healthy Living Behavior and Diarrhea Incidence in Children Under Five Years Old: A Literature Review Study. *Journal of Health Sciences*. 2022;15(1):58–66. https://doi.org/10.33086/jhs.v15.i1.2346

18. Pati DU. Risk Factors For Diarrhea In Noebeba District, Timor. J*urnal Kesehatan Tambusa*i. 2023;4(2):2539–2546. https://doi.org/10.31004/jkt.v4i2.14709

19. Harsa IMS. Hubungan Antara Sumber Air Dengan Kejadian Diare Padawarga Kampung Baru Ngagelrejo Wonokromo Surabaya. *Journal of Agromedicine and Medical Scince*. 2019;5(3):124–129. https://jurnal.unej.ac.id/index.php/JAMS/article/view/13813/7162

20. Kementerian Kesehatan Republik Indonesia. Pedoman Pelaksanaan Teknis STBM. 2012.

21. Kementerian Kesehatan Republik Indonesia. Peraturan Menteri Kesehatan Republik Indonesia Nomor 3 Tahun 2014 Tentang Sanitasi Berbasis Masyarakat. 2014.

22. Moranti D. Penerapan Program Sanitasi Total Berbasis Masyarakat (STBM) dengan Kejadian Diare pada Masyarakat (Kabupaten Ciamis, Jawa Barat). *Journal of Baja Health Science.* 2021;1(1):43–54. https://doi.org/10.47080/joubahs.v1i01.1173

23. Sembiring WSRG, Hasan A, Ferdina AR. Diarrhea Incidence in Tanah Bumbu, South Kalimantan, Under A Spatial Approach. *Jurnal Kesehatan Masyarakat.* 2022;17(4):526–534. https://doi.org/10.15294/kemas.v17i4.28709

24. Wijayanti SPM, Sidik M, Iqbal A. The Determinants of Diarrhea Disease Incidence in Densely Populated Area of West Nusa Tenggara, Indonesia. *Journal Kesehatan Lingkungan.* 2020;12(2):107–114. https://doi.org/ 10.20473/jkl.v12i2.2020.107-114

25. Centers for Disease Control and Prevention. Groundwater Awareness Week. 2022. Available from: https://www.cdc.gov/healthywater/drinking/groundwater-awareness-week.html

26. Kementerian Kesehatan Republik Indonesia. Buku Panduan Kader Posyandu "Jangan Sebar Kotoranmu! Ayo Pakai Jamban Sehatmu!". 2022. Available from: https://promkes.kemkes.go.id/buku-bacaan-kader-posyandu-jangan-sebar-kotoranmu-ayo-pakai-jamban-sehatmu

27. Amelia RN, Halim R, Lanita U. Faktor-Faktor yang Berhubungan dengan Kepemilikan Jamban Sehat di Desa Sungai Itik Kecamatan Sadu Kabupaten Tanjung Jabung Timur Tahun 2021. *Electronic Journal Scientific of Environmental Health and Disease.* 2021;1(2):52–62. https://doi.org/10.22437/esehad.v2i1.13575