CLIMATIC FACTORS AND CHILDHOOD DIARRHEA IN SOUTH KALIMANTAN IN 2017-2020

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Abstract. Childhood diarrhea is still a public health problem, specifically in developing countries such as Indonesia, because the outbreak keeps occurring alongside a high mortality rate. The control of this disease in Indonesia experiences a challenge of increasing climate variability, while poor hygiene behavior can also affect the occurrence. Therefore, this research aimed to examine the correlation between climatic factors (rainfall, temperature, and humidity) and proper behavior (hand washing and defecation) with diarrhea incidence in children under five years old in South Kalimantan Province in 2017-2020. Datasets were collected from the Ministry of Health for monthly diarrhea case reports and hygiene behavior data surveys, as well as the Indonesian Meteorological, Climatological, and Geophysical Agency for monthly climate data from January 2017 to December 2020. The result showed a decrease in cases reported in this province for four years, and Pearson analysis indicated that the climate variables influence the incidence. Additionally, hand washing with soap in running water and defecating in the latrine correlate with diarrhea in children under five years old. Even though climatic factors are statistically significant in diarrhea incidence, good hygiene practice is crucial in reducing the occurrence.

Keywords: children under five, diarrhea, climate, hygiene behavior

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INTRODUCTION

Diarrhea is still a public health problem in developing countries, such as Indonesia, because of the associated high morbidity and mortality (GBD 2017 Diarrhoeal Disease Collaborators, 2020). This is an endemic infection and its outbreak is potentially followed by death (MOH RI, 2014). According to the Indonesian Ministry of Health (MOH RI, 2021), 1,140,503 cases with a morbidity rate of 843 persons per 1000 population were reported in children under five years old in different health facilities in 2020. In South Kalimantan, diarrhea remains a health problem, and it caused post-neonatal and under-five deaths in 2017-2020, with 64.2% of cases in 2019 (South Kalimantan Provincial Health Office, 2020).

Several factors influence diarrhea occurrence, including hygiene behaviors, environmental conditions, socio-economics, and climate (Azage *et al*, 2017; Onuoha, 2018; Sudasman *et al*, 2019; Dharmayanti and Tjandrarini, 2020). Variations in temperature, rainfall, and humidity can affect the resistance, virulence, and transport of pathogens, as well as changes in exposure patterns in the host (Malik *et al*, 2021). The research conducted in Northwest Ethiopia on diarrhea incidence in 2013-2015 with climatic factors showed a significant relationship to temperature, humidity, and rainfall (Azage *et al*, 2017).

The Indonesian Meteorological, Climatological, and Geophysical Agency stated that there had been a change in the extreme rainfall period. Besides, weather phenomena occur faster than expected, from 10 to 20 years into five years (Kadarsah *et al*, 2020). Changes in the climate zone can affect water quality and quantity as well as the ecology of vectors and microorganisms related to diarrhea (WHO, 2016).

Access to basic sanitation such as a proper latrine, an increased usage of lavatories, and proper handwashing behavior will trigger the community to create a healthy life. Intervention research in South Western Ethiopia on implementing community-led total sanitation and handwashing behavior tends to reduce diarrhea cases (Bushen *et al*, 2022).

Presently, childhood diarrhea is still a health problem in South Kalimantan. During extreme weather conditions, the affected population can

be at risk of various diseases, such as diarrhea (WHO, 2016). Therefore, it is necessary to analyze the relationship between climatic factors and hygiene behavior with diarrhea incidence in this province to assist the government in control interventions.

MATERIALS AND METHODS

In the analysis conducted, several sources of secondary data were used, namely childhood diarrhea cases for 48 months (2017-2020) collected from the Ministry of Health. Rainfall, temperature, and humidity data in districts/cities were obtained from the Indonesian Meteorological, Climatological, and Geophysical Agency. As cited from 2007, 2013, and 2018 Basic Health Research (Riskesdas) reports, other data were based on good handwashing behavior, ie washing hands with soap before eating and preparing food, as well as after defecating, cleaning children's feces, and handling poultry or animals. These also included defecation behavior, namely using latrines. The hygiene behavior is a continuous variable by districts/cities from the results of categorical data calculations that has a range between zero to 100%.

The data were analyzed in several stages, where the descriptive analysis measured the average temperature, rainfall, and humidity, and the cumulative number of childhood diarrhea. These results were employed in estimating climate patterns and diarrhea incidence per month. The bivariate analysis used the Pearson correlation test to assess the relationship between climate variables and hygiene behavior with diarrhea incidence. The multivariable analysis applies negative binomial (NB) regression to calculate over-dispersion data when the variance exceeds the dependent mean (Weaver *et al*, 2015). Therefore, a negative binomial regression was performed to examine the relationship between climate factors and diarrhea in children under five years. Multicollinearity between climate variables using the Variance Inflation Factor (VIF) was tested before the multivariable regression analysis. The VIF of climate variables including temperature, rainfall, and relative humidity, had variance inflation factors of 1.68, 7.22, and 6.06, respectively. The recommendation for acceptable levels of VIF is 10. The multivariable negative binomial regression model was employed

to estimate the climate and behavioral factors that simultaneously relate to diarrhea incidence.

Ethical consideration

Ethical approval was obtained from the Health Research Ethics Committee of the National Institute of Research and Development, Ministry of Health of the Republic of Indonesia (Ethical approval number: LB 02.01./2/ KE.551/2021).

RESULTS

In the secondary data usage, there were several unavoidable limitations, such as the lack of several variables and data completeness. These data were related to the COVID-19 pandemic occurrence in Indonesia in early 2020. It was estimated that a decrease in diarrhea cases in 2020 does not correlate to a reduction in the disease's incidence, because communities failed to report the illness since they had limited access to health facilities.

The descriptive statistical information from 13 districts/cities in South Kalimantan is presented in Table 1. Childhood diarrhea incidence in this province was monitored and documented in disease surveillance, with 97,918 cases from 2017 to 2020. The average number of diarrhea cases in children under five years from 2017 to 2019 appears stagnant.

In general, about 70-82% of household members have defecated in the latrine, while handwashing behavior is still lacking, as demonstrated in Table 2.

A description of the climate for four years (2017-2020 period) showed the average temperature value increases slightly each year. Meanwhile, the averages of rainfall and relative humidity decreased slightly and were almost stagnant. The average temperature, rainfall, and relative humidity in 2020 have a slightly different pattern from previous years (Table 3).

Based on the seasonal pattern in South Kalimantan, the rainy season (rainfall over 100 mm/month) is from October to May of the following year. The dry season (precipitation less than 100 mm/month) ranges from June to August, which is the dry season peak.

Fig 1 shows the monthly average of climate variables over four years. There was no significant increase in temperature, as seen from the trendline, which stagnated with the coefficient of determination (R2) value below 0.1. The highest monthly average temperature was 28.97^{o}C in the pre-rainy season (September 2019), and the lowest was 26.5^{o}C in the

Table 1
Descriptive statistic of childhood diarrhea collected from 13 districts/cities in South Kalimantan in 2017-2020

Variable	Year			
	2017	2018	2019	2020
Childhood diarrhea (cases)				
Mean	188.14	177.69	176.49	85.36
Standard deviation	111.07	95.21	100.74	60.52
Minimum	7	45	51	15
Maximum	636	554	480	360
Incidence rate of childhood diarrhea (%)	6.40	6.05	6.02	2.96

Table 2
Descriptive statistic of hygiene factors in South Kalimantan

Hygiene factors(%)	Year		
	2007*	2013†	2018
Defecation in latrine	69.9	75.5	82.1
Handwashing	17.9	32.3	51.7

*Data from MOH RI (2008); †Data from MOH RI (2013)

Table 3
Descriptive statistic of climatic factors in South Kalimantan in 2017-2020

Climatic variable	Year			
	2017	2018	2019	2020
Temperature (Degree Celsius)				
Mean	27.08	27.24	27.71	27.27
Standard deviation	1.10	1.29	1.47	1.13
Minimum	25.60	25.60	25.90	25.40
Maximum	31.48	33.05	34.26	31.57
Rainfall (millimeter)				
Mean	213.89	201.83	166.95	232.23
Standard deviation	67.24	97.59	101.28	89.30
Minimum	87.40	49.10	18.00	75.00
Maximum	480.50	449.10	362.10	596.40
Relative humidity (Percent)				
Mean	82.93	81.40	79.04	82.62
Standard deviation	4.03	5.81	7.74	4.42
Minimum	63.35	53.26	42.50	60.00
Maximum	86.70	86.20	86.60	86.10

dry season (July 2020). The rainfall decreased in the middle of the year and then increased towards the end, until the beginning of the following year. Rainfall above the monthly average in the rainy season was 336.29 mm in January 2020, but the lowest value observed during the dry season in August 2019 was 32.03 mm. There was no decrease in rainfall, as evidenced by the trendline which stagnated, and the R2 value was below 0.01. The relative humidity slightly changed from January 2017 to December 2020. The average monthly humidity was a maximum of 84.6% in the rainy season (December 2018) and 68.6% in the pre-rainy season (September 2019).

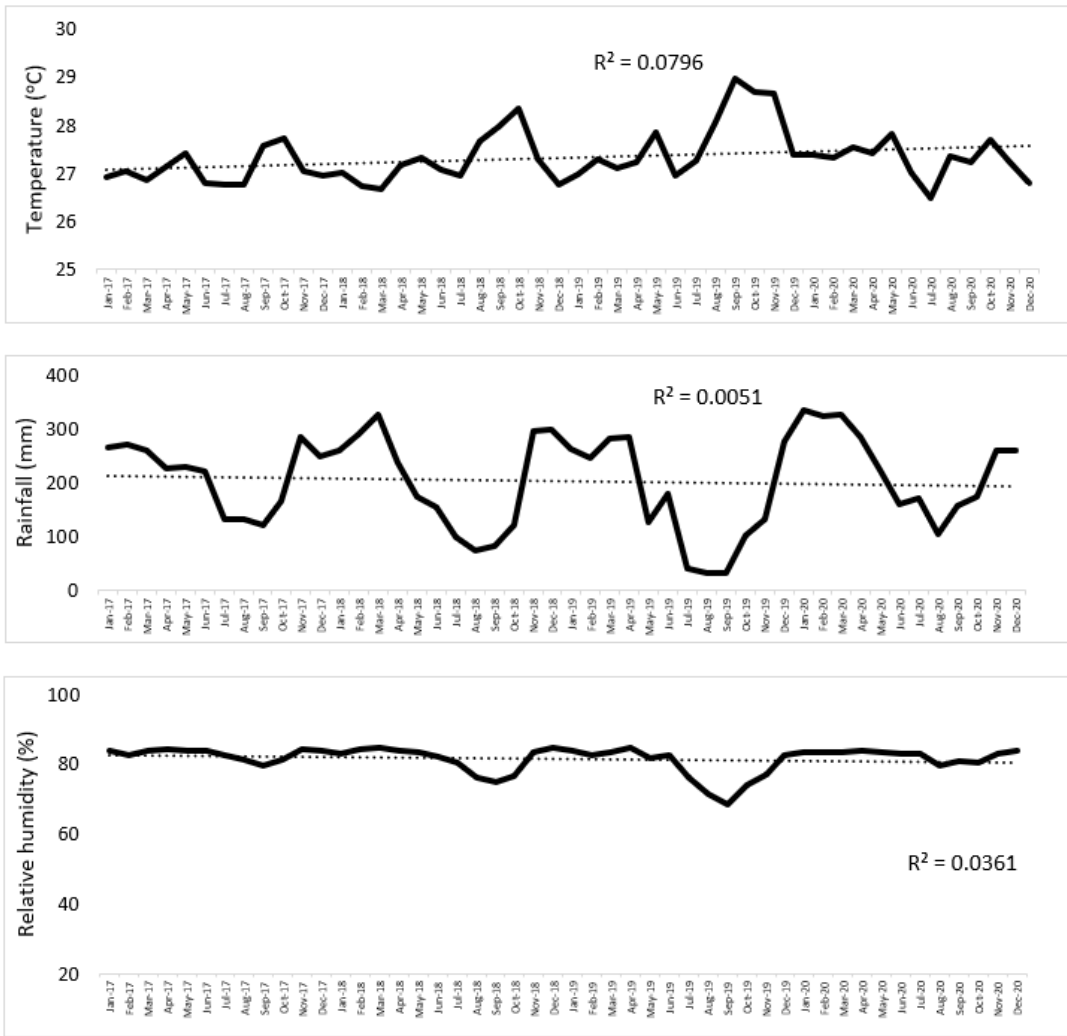

Fig 1 - Trends of monthly temperature, rainfall, and relative humidity in South Kalimantan in 2017 – 2020

R2: coefficient of determination

In Table 4, the Pearson analysis results showed a significant correlation between climatic factors and childhood diarrhea incidence. The temperature had a positive correlation value of 0.483, meaning temperature rise tends to

increase diarrhea incidence. The rainfall and humidity variables had negative correlation values of 0.204 and 0.517. This means the decline of rainfall and/or humidity will increase the number of cases. The hygiene behavior factors with the aggregation coverage also had a negative correlation. The correlation values for defecation in the latrine and handwashing were 0.398 and 0.407, respectively. The more people defecate in the lavatory with proper handwashing, the incidence of diarrhea will decrease.

The results of negative binomial regression showed a statistically significant relationship between temperature and relative humidity with diarrhea incidence. There was a significant positive relation between monthly temperature incidence rate ratio (IRR) = 1.103; 95% confidence interval (CI): 1.009-1.206) and diarrhea in children. Additionally, a significant negative relationship occurred between relative humidity and diarrhea (IRR = 0.973; 95%CI: 0.953-0.994) (Table 5). This model also indicated an insignificant negative relationship between rainfall and diarrhea incidence.

Table 4
The correlation of climate and hygiene behavior with childhood diarrhea in South Kalimantan

Variables	Pearson's correlation coefficient (r)	*p*-value
Climatic factors		
Temperature (^{o}C)	0.483	<0.001
Rainfall (mm)	-0.204	<0.001
Relative humidity (%)	-0.517	<0.001
Hygiene factors		
Defecation in a latrine (%)	-0.398	0.004
Handwashing (%)	-0.407	0.003

^{o}C: degree Celsius; mm: millimeter; %: percent

Table 5

Negative binomial regression analysis of the effect of climate variability on childhood diarrhea in South Kalimantan in 2017 – 2020

Variable	Crude IRR (95% CI)	Adjusted IRRa (95% CI)
Monthly temperature (^{o}C)	1.230 (1.185 - 1.277)†	1.103 (1.009 - 1.206)*
Monthly rainfall (mm)	0.999 (0.998 - 0.999)†	0.999 (0.999 - 1.000)
Monthly relative humidity (%)	0.952 (0.944 - 0.960)†	0.973 (0.953 - 0.994)*

*p<0.05; †p<0.001

CI: confidence interval; ^{o}C: degree Celsius; IRR: incidence rate ratio; mm: millimeter; %: percent

[a]Adjusted IRR at 95% CI shows the final model with all the climatic factors included in the final model

DISCUSSION

Climate relation to childhood diarrhea

The results showed that over four years (2017-2020) there has been a decrease in rainfall and relative humidity, while the temperature in South Kalimantan tends to increase. The multivariate analysis also associated climatic factors with diarrhea incidence in children under five years old in this province. These results are consistent with global research that indicated a significant association between temperature, rainfall, and relative humidity with diarrhea incidence in several parts of the world (Carlton *et al*, 2016), as well as the research in Singapore and Nepal (Aik *et al*, 2020; Dhimal *et al*, 2022).

Changes in temperature due to global climate change tend to affect diarrhea incidence, with vulnerable populations suffering the most from the disease (Hashizume *et al*, 2007; Chou *et al*, 2010; Wang *et al*, 2022). High temperatures can increase the exposure to bacteria and diarrheal parasites, prolong the survival ability of Escherichia coli, and elevate the proliferation

of pathogens, particularly those found in food and water (Zhou *et al*, 2013). High temperatures can also cause insects to multiply more quickly (Levy *et al*, 2016). The research in Taiwan and China detected that an increase of 1°C in temperature can raise the risk of diarrhea by 4% and 3%, respectively (Chou *et al*, 2010; Zhou *et al*, 2013).

It was discovered that temperature influences diarrhea incidence with the impact of relative humidity. The rise in the cases of this disease in South Kalimantan followed the decrease in relative humidity. The role of relative humidity in increasing the incidence is through the life of diarrhea-causing microorganisms and their vectors (Chowdhury *et al*, 2018). These results are in line with previous research that reported an inverse relationship between relative humidity and diarrhea (Xu *et al*, 2014; Phung *et al*, 2015; Azage *et al*, 2017). Another source stated that relative humidity is significant in the extreme rainfall period. Therefore, its effect on childhood diarrhea morbidity depends on the increased heavy rainfall (Chou *et al*, 2010). The relationship between relative humidity and diarrhea is based on laboratory evidence, which found rotavirus to be capable of surviving at low relative humidity and lowest temperature (Sattar *et al*, 1984; Sattar *et al*, 1986).

Although the results of rainfall multivariate analysis did not contribute to diarrhea incidence in South Kalimantan, the correlation results showed an inverse relationship to the disease. According to research in Ethiopia, changes in temperature and heavy rainfall significantly influenced the risk factor for diarrhea (Singh *et al*, 2001). Floods and droughts were also discovered to be associated with an increased risk of temporal diarrhea. Heavy rainfall causes flooding and allows the pathogen to contaminate water supplies. Meanwhile, the lowest rainfall (dry season) initiates difficulty in providing clean water, which tends to cause diarrhea (Levy *et al*, 2016). This is similar to the research conducted in Bangladesh, stating that the beginning of heavy rainfall is liable to generate water contamination, leading to increased breeding environments for bacteria, viruses, and parasites. Similarly, the lowest precipitation can reduce the amount of clean water, causing increased contact between humans and contaminated water (Hashizume *et al*, 2007).

Relation of hygiene behavior to childhood diarrhea

Based on the graph of rainfall patterns, the highest incidence of childhood diarrhea occurs during the lowest rainfall period. The high incidence is caused by the lack of supply of adequate water used for handwashing and defecation in latrines.

Prüss-Ustün *et al* (2019) reported that the disease burden initiated by inadequate water, sanitation, and hygiene in low and middle-income countries caused 297,000 deaths because of diarrhea in children under five years old. Open defecation behavior can pollute the environment, soil, water, and air. Feces contain various pathogenic germs causing diseases, one of which is *E. coli*. To prevent the contamination of feces in drinking water facilities, defecating in the lavatory is the primary option. Another research showed that childhood diarrhea is more prevalent in open defecation areas than open defecation free areas in Ethiopia and Kenya (Njuguna 2016; Ayalew *et al*, 2018).

Handwashing behavior also has a significant relationship with the incidence of diarrhea. Simple activities such as washing hands with soap after defecating and cleaning children's feces tend to reduce the risk of diarrhea by up to 40% (Freeman *et al*, 2014). In Tanzania, Briceño *et al* (2017) stated that the disease can be prevented by hygiene behavior and sanitation intervention.

Personal hygiene explains health education related to clean living behavior, which is essential to healthy living. Furthermore, handwashing intervention can reduce diarrhea in daycare centers in high-income countries and among people living in low and middle-income countries by about 30% (Ejemot-Nwadiaro *et al*, 2015). The effect of community-led total sanitation tends to increase the use of lavatory and latrine ownership, which can reduce diarrhea (Bushen *et al*, 2022). Therefore, the promotion of personal hygiene as a tool for health education is required to reduce open defecation and increase handwashing with soap and running water.

In summary, the climate variables, namely temperature, humidity, and rainfall, play a role in childhood diarrhea incidence. An increase in temperature, a decrease in relative humidity, and a reduction in rainfall are three conditions causing an increase in diarrhea. This is related to clean water availability, which can also influence hygiene behavior as the basis for preventing infectious diseases. Based on the analysis, we conclude that there is a potential increase in the risk of diarrheal disease with climatic conditions in the future. Therefore, the priority of global actions is to adapt and prepare for the adverse effect of climate change.

ACKNOWLEDGMENTS

The authors are grateful to Athena Anwar from Research Center for Climate and Atmosphere, Earth Science and Maritime Organization, and National Research and Innovation Agency, for facilitating the climate data collection and all assistance rendered, as well as to the participants in this research.

CONFLICT OF INTEREST DISCLOSURE

The authors declare no conflicts of interest.

REFERENCES

Aik J, Ong J, Ng LC. The effects of climate variability and seasonal influence on diarrhoeal disease in the tropical city-state of Singapore - a time-series analysis. *Int J Hyg Environ Health* 2020; 227: 113517.

Ayalew AM, Mekonnen WT, Abaya SW, Mekonnen ZA. Assessment of diarrhea and its associated factors in under-five children among open defecation and open defecation-free rural settings of Dangla District, Northwest Ethiopia. *J Environ Public Health* 2018; 2018: 4271915.

Azage M, Kumie A, Worku A, C Bagtzoglou A, Anagnostou E. Effect of cli-

matic variability on childhood diarrhea and its high risk periods in Northwestern parts of Ethiopia. *PLoS One* 2017; 12: e0186933.

Briceño B, Coville A, Gertler P, Martinez S. Are there synergies from combining hygiene and sanitation promotion campaigns: evidence from a large-scale cluster-randomized trial in rural Tanzania. *PLoS One* 2017; 12: e0186228.

Bushen, G, Merga H, Tessema F. Effects of community-led total sanitation and hygiene implementation on diarrheal diseases prevention in children less than five years of age in South Western Ethiopia: a quasi-experimental study. *PLoS One* 2022; 17: e0265804.

Carlton EJ, Woster AP, DeWitt P, Goldstein RS, Levy K. A systematic review and meta-analysis of ambient temperature and diarrhoeal diseases. *Int J Epidemiol* 2016; 45: 117-30.

Chou WC, Wu JL, Wang YC, Huang H, Sung FC, Chuang CY. Modeling the impact of climate variability on diarrhea-associated diseases in Taiwan (1996-2007). *Sci Total Environ* 2010; 409: 43-51.

Chowdhury FR, Ibrahim QSU, Bari MS, *et al*. The association between temperature, rainfall and humidity with common climate-sensitive infectious diseases in Bangladesh. *PLoS One* 2018; 13: e0199579.

Dharmayanti I, Tjandrarini DH. The role of the environment and individual towards diarrhea problems in Java and Bali, 2020 \ [cited 2021 May 04]. Available from: URL: http://ejournal2.litbang.kemkes.go.id/index.php/jek/article/view/3192/1889 [in Indonesian]

Dhimal M, Bhandari D, Karki KB, *et al*. Effects of climatic factors on diarrheal diseases among children below 5 years of age at national and subnational levels in Nepal: an ecological study. *Int J Environ Res Public Health* 2022; 19: 6138.

Ejemot-Nwadiaro RI, Ehiri JE, Arikpo D, Meremikwu MM, Critchley JA. Hand washing promotion for preventing diarrhoea. *Cochrane Database Syst Rev* 2015; 2015: CD004265.

Freeman MC, Stocks ME, Cumming O, *et al*. Hygiene and health: systematic review of handwashing practices worldwide and update of health effects. *Trop Med Int Health* 2014; 19: 906-16.

GBD 2017 Diarrhoeal Disease Collaborators. Quantifying risks and interventions that have affected the burden of diarrhea among children younger than 5 years: an analysis of the Global Burden of Disease Study 2017. *Lancet Infect Dis* 2020; 20: 37-59.

Hashizume M, Armstrong B, Hajat S, *et al*. Association between climate variability and hospital visits for non-cholera diarrhoea in Bangladesh: effects and vulnerable groups. *Int J Epidemiol* 2007; 36: 1030-7.

Kadarsah, Hadi AS, Siswanto, Permana DS, Chandrasa GT, Supari. Climate change in Indonesia and flood analysis in a climate change perspective, 2020 [cited 2022 Aug 06]. Available from: URL: https://lingkunganhidup.jakarta.go.id/jakartaberketahanan/?p=17693 [in Indonesian]

Levy K, Woster AP, Goldstein RS, Carlton EJ. Untangling the impacts of climate change on waterborne diseases. *Environ Sci Technol* 2016; 50: 4905-22.

Malik, I, Anjayati S, Musdhalifa P, Binti D, Tosepu R. Impact of weather and climate on diarrhea incidence: a review, 2021 [cited 2022 Jun 30] Available from: URL: https://iopscience.iop.org/article/10.1088/1755-1315/755/1/012088/pdf

Ministry of Health of the Republic of Indonesia (MOH RI). Diarrhea situation in Indonesia, 2014 [cited 2022 Jun 25]. Available from: URL: https://www.kemkes.go.id/article/view/13010200028/diare.html [in Indonesian]

Ministry of Health of the Republic of Indonesia (MOH RI). Indonesia health profile 2020, 2021 [cited 2022 May 12]. Available from: URL: https://www.kemkes.go.id/downloads/resources/download/pusdatin/profil-kesehatan-indonesia/Profil-Kesehatan-Indonesia-Tahun-2020.pdf [in Indonesian]

Ministry of Health of the Republic of Indonesia (MOH RI). Report on Result of National Basic Health Research (Riskesdas), 2007, 2008 [cited 2018 Jan 26]. Available from: URL: http://labmandat.litbang.kemkes.go.id/images/download/laporan/RKD/2007/Riskesdas_2007_English.zip

Ministry of Health of the Republic of Indonesia (MOH RI). Report on National Basic Health Research (Riskesdas), 2013, 2013 [cited 2020 Mar 18]. Available from: URL: http://labmandat.litbang.kemkes.go.id/

images/download/laporan/RKD/2013/Laporan_riskesdas_2013_final.pdf [in Indonesian]

Njuguna J. Effect of eliminating open defecation on diarrhoeal morbidity: an ecological study of Nyando and Nambale sub-counties, Kenya. *BMC Public Health* 2016; 15: 712.

Onuoha UP. Influence of environmental factors and socioeconomic status of parents on the occurrence of under-five diarrhea disease among selected households in Abia State, Nigeria. *J Health Environ Res* 2018; 4: 97-104.

Phung D, Huang C, Rutherford S, *et al*. Temporal and spatial patterns of diarrhoea in the Mekong Delta area, Vietnam. *Epidemiol Infect* 2015; 143: 3488-97.

Prüss-Ustün A, Wolf J, Bartram J, *et al*. Burden of disease from inadequate water, sanitation and hygiene for selected adverse health outcomes: an updated analysis with a focus on low-and middle-income countries. *Int J Hyg Environ Health* 2019; 222: 765-77.

Sattar SA, Ijaz MK, Johnson-Lussenburg CM, Springthorpe VS. Effect of relative humidity on the airborne survival of rotavirus SA11. *Appl Environ Microbiol* 1984; 47: 879-81.

Sattar SA, Lloyd-Evans N, Springthorpe VS, Nair RC. Institutional outbreaks of rotavirus diarrhea: potential role of fomites and environmental surfaces as vehicles for virus transmission. *J Hyg* 1986; 96: 277-89.

Singh RBK, Hales S, de Wet N, Raj R, Hearnden M, Weinstein P. The influence of climate variation and change on diarrheal disease in the Pacific Islands. *Environ Health Perspect* 2001; 109: 155-9.

South Kalimantan Provincial Health Office. South Kalimantan Province Health Profile 2019, 2020 [cited 2022 Aug 26]. Available from: URL: http://dinkes.kalselprov.go.id/profil-kesehatan-tahun-2019.html [in Indonesian]

Sudasman FH, Bachtiar A, Laelasari E, Ciptaningtyas R. Factors associated with the risk of diarrhea in children under five in Bandung, West Java, 2019 [cited 2021 Nov 05]. Available from: URL: http://theicph.com/wp-content/uploads/2019/07/50.-Fuad-Hilmi-Sudasman-1.pdf

Wang P, Asare E, Pitzer VE, Dubrow R, Chen K. Associations between long-term drought and diarrhea among children under five in low-and middle-income countries. *Nature Commun* 2022; 13: 3661.

Weaver CG, Ravani V, Oliver MJ, Austin PC, Quinn RR. Analyzing hospitalization data: Potential limitations of poisson regression. *Nephrol Dial Transplant* 2015; 30: 1244-9.

World Health Organization (WHO). Protecting health from climate change: vulnerability and adaptation assessment of the health impacts of climate variability and change in Nepal, 2016 [cited 2022 Jan 13]. Available from: URL: https://cdn.who.int/media/docs/default-source/climate-change/protecting-health-from-climate-change.pdf?sfvrsn=b8334581_3&download=true

Xu Z, Hu W, Tong S. Temperature variability and childhood pneumonia: an ecological study. *Environ Health* 2014; 13: 51.

Zhou X, Zhou Y, Chen R, Ma W, Deng H, Kan H. High temperature as a risk factor for infectious diarrhea in Shanghai, China. *J Epidemiol* 2013; 23: 418-23.