ENVIRONMENTAL FACTORS INFLUENCING DIARRHEA INCIDENCE AMONG CHILDREN AGED 0–23 MONTHS

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ABSTRACT
Diarrhea remains a primary public health concern contributing to significant morbidity and mortality among children under five years of age, particularly in developing countries, including Indonesia. This study aimed to create a predictive model of environmental factors associated with the incidence of diarrhea among children aged 0–23 months. A cross-sectional design was employed, utilizing secondary data from the 2018 Indonesian Basic Health Research Survey (RISKESDAS—Riset *Kesehatan Dasar*). Data were collected through structured interviews utilizing household and individual questionnaires, encompassing responses from 27,280 mothers with children aged 0–23 months. Data were analyzed using ordinal logistic regression. The findings indicated that households with 5–7 members, use of unprotected drinking water sources, and feces disposal practices not involving toilets were significantly associated with increased risk of diarrhea among children aged 0–23 months. The predictive model accounted for only 0.02% of the variance in diarrhea incidence, suggesting that 99.98% of the variation is attributable to other unmeasured factors. It is recommended that public health stakeholders prioritize interventions aimed at improving water quality, promoting safe sanitation practices, and addressing household overcrowding to reduce the burden of diarrhea in this vulnerable age group.

Keywords: Diarrhea; Children aged 0-23 months; Environmental Factors.

INTRODUCTION

Diarrhea remains a primary public health concern contributing to significant morbidity and mortality among children under five years of age, particularly in developing countries, including Indonesia. (Al-Mubarokah & Sartika, 2022; Soelaeman et al., 2023a). Based on the results of a household health survey, there was an increasing prevalence of diarrhea in Indonesia from 7% in 2013 to 8% in 2018 (Ministry of Health of the Republic of Indonesia, 2018). According to the 2018 Indonesian Basic Health Research Survey, the highest prevalence of diarrhea was observed among children aged 12 to 23 months, reaching 7.9 percent. The prevalence was higher in urban areas, at 5.2%, and among children from low socioeconomic households, at 6.0%. In addition, the prevalence among male children was 5.2%, slightly higher than that among female children, which was 4.7%. Furthermore, data from the 2019 Indonesian Health Profile indicated that the highest age-specific prevalence of diarrhea occurred in the one to four age group, at 11.5%, followed by infants, at 9% (Ministry of Health of the Republic of Indonesia, 2023).

According to the World Health Organization's Disability-Adjusted Life Years (DALYs) measure, the overall burden of diarrhea is higher than that of any other gastrointestinal neoplasm. The DALY value for diarrhea is 2.69, significantly higher than for colorectal neoplasms (0.43), liver neoplasms (0.38), or even esophageal neoplasms, which are only 0.06 (WHO, 2021). Diarrhea in toddlers, if not treated further, can cause dehydration, which can result in death. One of the risk factors for diarrhea is environmental factors, including basic ecological sanitation, such as access

to clean water facilities, healthy toilets, and proper waste disposal facilities (Paul, 2020). Sanitation plays a crucial role in creating healthy homes and as a means to prevent environmentally based diseases (Kurniawati & Abiyyah, 2021). Globally, about 90% of diarrhea-related deaths in children under five are caused by inadequate access to clean water, sanitation, and hygiene. Each year, more than 297,000 children under the age of five die from diarrheal diseases linked to poor water, sanitation, and hygiene (CDC, 2021; UNICEF, 2009; WHO, 2020). Several environmental factors also contribute to the incidence of diarrhea in young children (Soelaeman et al., 2023b). Previous studies have shown that factors such as large household size, a high number of children under five, limited access to healthcare services, improper fecal waste disposal, and unsafe drinking water sources increase both the risk and impact of diarrhea in children (CDC, 2021; UNICEF, 2009; WHO, 2020).

The number of family members reflects household population density, which can create unhygienic conditions and increase the risk of food and water contamination. Crowded living spaces can significantly affect the health of occupants and contribute to the spread of disease. In households with a larger number of family members, the likelihood of direct contact between individuals increases, facilitating the transmission of infectious diseases. A household density of more than four people is particularly associated with a higher risk of diarrhea in toddlers. This is because diarrhea is a contagious disease that can affect both children and adults. When adults in the household experience diarrhea, toddlers living in the same environment are also at greater risk of infection (Sari & Sartika, 2021).

In addition to household size and the number of toddlers, sanitation factors such as the source of drinking water are also key risk factors for diarrhea. Unprotected water sources located near toilets or septic tanks are easily contaminated. *Escherichia coli* (*E. coli*), a bacterium that causes diarrhea and is transmitted via the fecal-oral route, can enter water supplies during rainfall, carrying human or animal waste into the ground or nearby springs. When water sources do not meet safety standards, the risk of diarrhea in toddlers increases. Contamination may occur at the source, during distribution, or in household storage. (Irjayanti et al., 2024).

Additionally, the availability of feces disposal facilities is also suspected of influencing the incidence of diarrhea in children. There are still people who lack access to feces disposal facilities that meet the necessary criteria. (Irjayanti et al., 2024; Yulda & Fitriani, 2023). Having a healthy and good family toilet can be believed to prevent the transmission of chronic diarrheal diseases caused by infection pathways. Sanitary feces disposal aims to accommodate and isolate feces, preventing direct or indirect contact with humans, disease transmission, and environmental pollution. (Kurniawati & Abiyyah, 2021).

Thus, the study aims to analyze the environmental factors that influence the incidence of diarrhea in children aged 0-23 months in Indonesia using the proportional odds model in ordinal regression. This study is essential because the ordinal logistic regression method used provides a more in-depth analysis of the relationship between environmental characteristics and the severity of diarrhea. This approach has not been widely explored in previous studies. The results of this study provide new and more specific information that could help in developing more effective diarrhea prevention strategies for the under-five age group, which is vulnerable to this disease.

METHOD

This study is a secondary data analysis based on the 2018 Basic Health Research Survey (RISKESDAS) conducted by the Indonesian Ministry of Health. The RISKESDAS employed a cross-sectional design and was implemented at the national level, covering households across all 34 provinces, 416 districts, and 98 cities in Indonesia. The analysis focused on data from 27,280 women with children aged 0 to 23 months who completed the questionnaire in full. The research instruments and data collection procedures followed the standardized protocol of the 2018

RISKESDAS, using structured questionnaires administered through interviews and physical measurements conducted by the RISKESDAS research team.

The dependent variable in this study is the diarrhea status of toddlers aged 0 to 23 months, classified into three categories: experiencing diarrhea within the past two weeks, experiencing diarrhea between one and two months ago, and never experiencing diarrhea. The independent variables include environmental factors such as the number of household members, categorized as more than three adults or three or fewer adults; the number of children under five in the household, categorized as two or more toddlers or fewer than two toddlers; access to health services, considered limited if there is no transportation available to health facilities; disposal of toddler feces, categorized as inappropriate if feces are not disposed of via a septic tank; and the source of drinking water, classified as poor if the water source is uncovered.

The analysis employed ordinal logistic regression with a proportional odds model to investigate the relationship between diarrhea incidence and predictor variables, including the number of toddlers in the household, the number of household members, access to health services, drinking water sources, and feces disposal methods.

RESULTS

Based on univariate, bivariate, and multivariate analysis, the following results were obtained:

Table 1. Characteristic of Research Respondents and Bivariate Analysis

Category	History of Diarrhea						p-value
	Yes, in < 2 Weeks		Yes, in > Weeks – 1 month		Never		
	n	%	n	%	n	%	
Number of Toddlers in the House							
More than three toddlers	53	6.4	33	4.0	743	89.6	0.063
2 toddlers	500	7.4	225	3.3	6,072	89.3	
1 toddler	1,486	7.6	799	4.1	17,369	88.4	
Number of Household Members							
More than 8	183	7.2	104	4.1	2,272	88.8	0.001
5-7	980	7.1	485	3.5	12,430	89.5	
1-4	876	8.1	468	4.3	9,482	87.6	
Access to Health Services							
Unreachable	114	8.7	59	4.5	1,135	86.8	0.036
Reachable	1,925	7.4	998	3.8	23,049	88.7	
Drinking Water Source							
Unprotected water	371	8.3	171	3.8	3,927	87.9	0.033
Protected water	1,668	7.3	886	3.9	20,257	88.8	
Disposal of Feces							
Besides the toilet	1,300	7.8	676	4.1	14,698	88.1	0.002
The toilet	739	7.0	381	3.6	9,486	89.4	

Source: Secondary data from RISKESDAS (2018)

Table 1 shows a significant relationship between the number of household members, access to health services, drinking water sources, feces disposal, and a history of diarrhea in toddlers, with p-values of 0.001, 0.036, 0.033, and 0.002, respectively. The number of toddlers in the house did not show a significant relationship with a history of diarrhea in toddlers (p-value 0.063).

Table 2. Simultaneous Parameter Estimation Test

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	287.674			
Final	249.9	37.775	5	0.000

Source: Author's Calculation (2024)

Table 2 shows the comparison results between the model with only an intercept and the final model. The -2 Log Likelihood value decreased from 287.674 in the intercept-only model to 249.9 in the final model, indicating an improvement in model fit. This suggests that when intercept modeling was carried out, the model fit value increased, making the intercept model the most suitable model for this research. The chi-square test yielded a value of 37.775 with 5 degrees of freedom and a p-value of 0.000, indicating that the addition of predictor variables in the final model significantly improved the model fit compared to the intercept-only model.

Table 3. Partial Parameter Estimation Test

Variable	Estimate	Wald	df	p-value	OR	CI 95% Lower	CI 95% Upper
Constants 1	-2.511	3741.3	1				
Constants 2	-2.05	2765.5	1				
The number of family members is more than 8 (X1)	0.132	3.6	1	0.057	1.141	1.004	1.306
Number of family members 5-7 (X2)	0.183	20.9	1	0.000	1.201	1.111	1.300
Access to Health Services unreachable (X3)	-0.161	3.6	1	0.058	1.175	1.387	1.005
Drinking water sources are not protected (X4)	-0.076	2.2	1	0.136	1.079	1.191	1.024
Disposal of feces other than to the toilet (X5)	-0.122	9.4	1	0.002	1.130	1.221	1.045

Source: Author's Calculation (2024)

Table 3 shows that having more than eight family members increases the odds of diarrhea in children aged 0-23 months; however, this result is not statistically significant (OR = 1.141, 95% CI [1.004, 1.306], p = 0.057). The number of family members, 5-7, also significantly increases the odds of diarrhea (OR = 1.201, 95% CI [1.111, 1.300], p = 0.000). Inaccessible access to health services tends to reduce the odds of diarrhea, but the results are not significant (OR = 1.175, 95% CI [1.005, 1.387], p = 0.058). Unprotected drinking water sources are associated with a higher odds of diarrhea, but the results are not statistically significant (OR = 1.079, 95% CI [1.024, 1.191], p = 0.136). Disposal of feces other than to the toilet significantly increased the chance of diarrhea in children aged 0-23 months (OR = 1.130, 95% CI [1.045, 1.221], p = 0.002). The ordinal regression equation with its threshold is as follows:

$$\text{Logit } (Y_1) = -2{,}511 = 0{,}132_{x1} + 0{,}183_{X2} - 0{,}161_{X3} - 0{,}076_{x4} - 0{,}122_{x5}$$
$$\text{Logit } (Y_2) = -2{,}05 = 0{,}132_{x1} + 0{,}183_{X2} - 0{,}161_{X3} - 0{,}076_{x4} - 0{,}122_{x5}$$

Table 4. Model Fit Test and Parameter Estimation

Goodness-of-Fit			Nagelkerke
Chi-Square	df	Sig.	
25.624	41	0.971	0.002

Source: Author Calculation (2024)

Table 4 shows the results of the model fit test, indicating that the model has a good fit with the data, based on the very high chi-square p-value (0.971). However, the very low Nagelkerke R^2 value (0.2%) indicates that the model explains only a small portion of the variation in the data. This means that environmental characteristic factors, such as the number of toddlers in the house, the number of household members, access to health services, drinking water sources, and feces disposal, affect the incidence of diarrhea in children aged 0-23 months in general by only 0.2%. In contrast, 99.8% is influenced by other factors not included in this model test.

DISCUSSION

Diarrhea remains a significant public health problem, especially in developing countries, where it is a major cause of morbidity and mortality in children under two years of age. Diarrhea is the leading cause of death in toddlers besides pneumonia. Diarrhea in toddlers occurs when the excretion of abnormal liquid stools, where children can defecate frequently or more than 3 times a day in children and 4 times a day in infants, with a water content of more than 100- 200ml (Rokhmiati et al., 2024). Several studies have investigated the risk factors contributing to diarrhea, with a focus on environmental, demographic, and behavioral aspects. (Rahmat et al., 2023; Syukrilla et al., 2023; WHO, 2020). This study highlights the findings of environmental factor characteristics that have a significant relationship with the incidence of diarrhea in children aged 0-23 months in Indonesia, namely the number of family members, quality of water sources, and sanitation practices on the incidence of diarrhea (p value <0.005), while insignificant factors such as the number of toddlers and access to health services.

Research results consistently show that larger family sizes, especially those with 5-7 members, are associated with a higher prevalence of diarrhea in children aged 0– 23 months. A study in Ethiopia found that the odds of diarrhea in children under five years of age were 5.2 times higher in families with more than five family members compared to those with ≤5 family members (AOR [95% CI] = 3.4 [1.7–17.6]) (Bekele et al., 2021a). Households with more than four members are at significantly higher risk of diarrhea due to increased person-to-person contact and potential poor household hygiene. (Ayalew et al., 2018; Hashi et al., 2016). Household density increases the risk of transmission of diseases that cause diarrhea in children through contaminated water, food, and poor hygiene, but family size is not associated with diarrhea in children under five years of age if other risk factors remain constant and family life is (Bekele et al., 2021b). A research report in Wonago District, Southern Ethiopia, showed results that children in households with more than five family members were about three times more likely to experience moderate to severe diarrhea than those living in smaller families. (Tesfaye et al., 2020). Another study found that the likelihood of diarrhea among children under five was 5.2 times higher in families with more than five members compared to those with five or fewer members. (Bekele et al., 2021c).

Another factor associated with diarrhea in children aged 0-23 months is the quality of drinking water sources. Research in Northern Nigeria showed that children were 1.2 times more likely to experience diarrhea in families with unsafe water sources than in families with safe water sources. (Berhe & Berhane, 2014a). Research in Medebay Zana District, Northwest Tigray, reported that diarrhea was 1.8 times more likely to occur in families with unsafe water sources compared to families with safe water sources. This suggests that children who consume water from wells, rivers, or other unprotected sources are at a significantly higher risk of contracting pathogens that cause gastrointestinal infections. (Asfaha et al., 2018; Berhe & Berhane, 2014b). The lack of proper water treatment and safe storage practices further exacerbates these risks. The availability of

clean water sources is one key effort to improve community health. Environmental health is organized to create a healthy environment, namely a condition that is free from risks that endanger human health and safety (Harsa, 2019).

The quality of drinking water sources plays a crucial role in the incidence of diarrhea, particularly among children under the age of five. Unprotected water sources are vulnerable to contamination by bacteria, viruses, and parasites that cause diarrhea. Notably, E. coli, a standard indicator of fecal contamination, is frequently detected in unprotected water and is strongly linked to an increased risk of diarrhea in young children. Research indicates that children consuming water contaminated with *E. coli* have approximately a 22% higher likelihood of developing diarrhea compared to those who drink uncontaminated water. (Luby et al., 2015; Parvin et al., 2021).

In addition to the quality of drinking water sources, other sanitation practices, especially feces disposal, have also been identified as critical determinants of diarrhea prevalence in children. Research by Bekele et al. (2021) Emphasized that improper feces disposal, such as open defecation or using unauthorized places other than toilets, significantly increases the likelihood of contracting diarrheal diseases. Open defecation is defined as human feces that are released carelessly, not disposed of in a septic tank, resulting in contamination (e.g., disposal of human feces in fields, forests, bushes, ditches, water channels, terraces, pastures, backyards, or other spaces), leading to potential exposure to enteric pathogens. Each gram of fresh human feces contains 101 helminth eggs, 106 bacteria, 106 viruses, and 104 protozoan cysts. (Irawaty, 2022; Hajj-Mohamad et al., 2019). WHO reports that toilet use is an independent predictor of diarrheal disease, with families without toilets six times more likely to experience diarrhea than families with toilets. These practices contribute to environmental contamination and facilitate the transmission of infectious agents to children through various routes, including contaminated hands, food, and water. Open defecation can serve as a breeding ground for flies. If these insects land on food, they can transfer bacteria to food consumed by humans. (Suryaningsih & Wijayanti, 2020).

Based on the Indonesian Minister of Health Regulation Number 3 of 2014 concerning Community-Based Total Sanitation, one way to break the chain of disease transmission is by using healthy toilets. Every family is required to have and use a healthy toilet that is accessible to every family member. The upper structure of the bathroom, consisting of walls and a roof, must be able to protect its users from weather and other disturbances. The middle part of the toilet must have a waste disposal hole with a gooseneck type. For buildings that do not use gooseneck construction, a cover must be equipped. The toilet floor must be made of a waterproof material, non-slip, and must be connected to the Sewage Drainage Channel (*SPAL*). The lower structure of the toilet must be equipped with a septic tank or *septic system* that can prevent pollution. (Fauziyah & Siwiendrayanti, 2023).

The results of this study also highlight several factors that were found to have no significant association with diarrhea in the analyzed models. The number of toddlers in the household did not show a substantial impact on the incidence of diarrhea. These results observe that the presence of several young children does not independently increase the risk of diarrhea, suggesting that other factors, such as maternal hygiene practices and education, may play a more critical role. Furthermore, access to health services was not significantly associated with the prevalence of diarrhea in this study. The WHO report states that although access to health services is essential for treatment, it does not necessarily prevent diarrhea from occurring, highlighting the importance of preventive measures and education. (WHO, 2019). The study methodology has several shortcomings, including reliance on secondary data, which results in a narrow selection of variables, limitations of the cross-sectional survey design, and a low explanatory power of the statistical model. These issues underscore the need for a more comprehensive approach, potentially involving longitudinal data collection, a broader range of variables, and more robust statistical methods to understand better the factors influencing diarrheal disease incidence in children.

CONCLUSION

This article examines the environmental factors that influence the incidence of diarrhea among children aged 0–23 months in Indonesia, using ordinal logistic regression. The findings indicate that households with 5–7 members, the use of unprotected drinking water sources, and improper disposal of feces significantly increase the risk of diarrhea. However, the constructed model explains only 0.02% of the variation in diarrhea incidence, suggesting that 99.98% of contributing factors (such as behavioral, nutritional, or specific infectious factors) remain unmeasured. Key recommendations include environmental-based interventions, such as improving access to clean water, promoting safe sanitation practices, and reducing household overcrowding. Additionally, education on personal hygiene and domestic waste management should be enhanced to prevent the transmission of diseases.

This study has several limitations, including the use of secondary data, which restricts the variables that can be analyzed; a cross-sectional design that cannot establish causal relationships; and a low Nagelkerke R^2 value, indicating the model's limited explanatory power. Future research should adopt longitudinal or qualitative designs to understand better the dynamics of risk factors associated with diarrhea. Additional variables, such as child nutritional status, breastfeeding practices, and maternal education levels, should also be included. Collaboration with policymakers is essential to implement these findings into more comprehensive public health programs, such as the development of sanitation infrastructure and community-based behavioral change campaigns.

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