RESEARCH ARTICLE Open Access

Gema Lingkungan Kesehatan
Vol. 23, No. 4 (2025), pp 512-522
e-ISSN 2407-8948 p-ISSN 16933761
doi: https://doi.org/10.36568/gelinkes.v23i4.363 Journal Homepage: https://gelinkes.poltekkesdepkes-sby.ac.id/

Association Between Community-Based Total Sanitation (CLTS) Pillars and Diarrhea Incidence in Wetland Communities of South Indralaya

Inoy Trisnaini[1], Widya Ayu Pratiningsih[1*], Dini Arista Putri[1], Annisa Juniarni[2], Dwita Febriana[2], Hanifaus Safana[2], Amirarosa Firdaus[2]

[1] Department of Environmental Health, Public Health Faculty, Universitas Sriwijaya, Indralaya, Indonesia
[2] Department of Public Health, Public Health Faculty, Universitas Sriwijaya, Indralaya, Indonesia

*Correspondence: widyaayupratiningsih@fkm.unsri.ac.id

Diarrhea remains a major global health problem and a leading cause of mortality among children under five, often exacerbated by inadequate sanitation and limited access to clean water. Community-Led Total Sanitation (CLTS) represents a national strategy for preventing environment-based diseases, including diarrhea. However, researchers have not comprehensively studied the effectiveness of each CLTS pillar within specific geographical contexts, such as wetland areas. This study aims to identify the relationship between sanitation factors of Community-Led Total Sanitation (CLTS) pillars and diarrhea incidence in the South Indralaya wetland community. This quantitative research employed a cross-sectional design and selected 100 respondents using a purposive sampling technique. Data were collected through questionnaires and analyzed using chi-square test for bivariate analysis and logistic regression for multivariate analysis. Our results indicated a diarrhea prevalence of 45% among total respondents. Multivariate analysis revealed that two CLTS pillars significantly associated with diarrhea incidence. Pillar 1, concerning latrine availability, showed that households without latrines had a 3.4 times higher risk of experiencing diarrhea (OR = 3.400; 95% CI: 1.037–11.155). Pillar 4, regarding unsafe waste management, also served as a strong predictor, increasing diarrhea likelihood up to 3.296 times (P-value = 0.008; Exp(B) = 3.296; 95% CI: 1.359–7.996). We found that latrine type (P = 0.053) acted as a confounder, which influenced the risk estimation of the main variables in the model. This study concludes that CLTS pillars 1 and 4, related to feces and solid waste management, are key determinants of diarrhea incidence in South Indralaya. Interventions focusing on improving access to and quality of latrines, as well as safe waste management practices, are crucial for reducing diarrhea incidence in the region.

Keywords: Diarrhea, Sanitation, Latrine, Waste Management

INTRODUCTION

Global health challenges are becoming increasingly complex, encompassing the impacts of climate change, antibiotic resistance, and inequitable access to healthcare services that can significantly affect public health levels, even leading to mortality. One of the major health problems that remains a global concern is diarrhea, which continues to be the leading cause of death in children under five years of age, particularly in developing countries. This condition is often exacerbated by poor access to clean water and adequate sanitation (UNICEF, 2021). According to the World Health Organization (WHO) report for 2024, there were approximately 1.7 billion cases of diarrhea in children worldwide with 443,832 deaths in children under five years of age (WHO, 2024).

In Indonesia, diarrhea also remains a significant health problem. The results of the Indonesian Nutritional Status Survey (SSGI) in 2024 showed that the prevalence of diarrhea in children under five reached 5.8% (Kementerian Kesehatan, 2025). Regionally, South Sumatra Province recorded 109,033 cases of diarrhea in 2023, making it one of the provinces with the highest diarrhea cases. Ogan Ilir Regency is the regency with the highest percentage of treated diarrhea cases in South Sumatra Province, including the South Indralaya area, Ogan Ilir Regency, which demonstrates the close relationship between health problems at global, national, and regional levels (Dinas Kesehatan Provinsi Sumatera Selatan, 2024).

Medically, diarrhea is defined as an abnormal condition of stool discharge, characterized by increased volume, liquidity, and frequency of defecation more than three times a day, or more than four times a day which may be accompanied by mucus or blood (Juliansyah et al., 2021). This disease occurs due to bacterial, viral, or parasitic infections in the stomach or intestines (Muhammad Hilmi Mahmud & Md. Isa, 2022). The types of pathogens causing diarrhea vary depending on geographical area as well as the level of sanitation and environmental hygiene.

The impact of diarrhea is very serious, especially in children under five years of age as a vulnerable group. This condition can cause malnutrition, severe dehydration, and even death if not treated properly (Warseno et al., 2024). Dehydration, resulting from fluid and electrolyte loss, is the main cause of death in diarrhea cases. Data show that morbidity and mortality in children under 5 years of age remain high in developing countries, including Indonesia, with approximately 60 million cases annually, of which 70-80% occur in children under five (Grafika et al., 2017).

Several key factors causing diarrhea involve complex interactions between pathogens, hosts, and the environment. Inadequate environmental conditions, such as lack of healthy latrines, waste management facilities, and drinking water quality, significantly increase the risk of diarrhea (Azis et al., 2021; Putri & Susanna, 2020). This fact is reinforced by data from Kemenkes RI (2022), which shows that clean water coverage in Indonesia is only 84.8%, in South Sumatra 68.7%, and in Ogan Ilir Regency even lower at 59%. Several other key factors affecting sanitation include household waste management, such as used bathing water, washing water, toilet waste, as well as the availability of adequate sanitation facilities (Hargono et al., 2022). In general, inappropriate environmental sanitation, including the provision and condition of clean water facilities, drinking water sources, latrine conditions, wastewater disposal systems, and waste management facilities, are dominant factors causing diarrhea (Farkhati, 2021; Mulatu et al., 2022).

In a comprehensive effort to address sanitation problems and environment-based diseases, the Ministry of Health of the Republic of Indonesia has developed the Community-Led Total Sanitation (CLTS) program (Kemenkes, 2014). This program is designed to prevent various sanitation-related diseases, including diarrhea, through five key behavioral pillars: Open Defecation Free (ODF), Handwashing with Soap (HWWS), Household Water and Food Management, Household Waste Security, and Household Liquid Waste Security. Various studies have proven the effectiveness of implementing CLTS pillars in reducing diarrhea incidence (Indah et al., 2021; Kamiludin & Azizah, 2025). This demonstrates that CLTS is a relevant and effective strategy for preventing environment-based diseases, including diarrhea.

Although the Community-Led Total Sanitation (CLTS) approach has long been implemented in Indonesia, most studies tend to assess the five pillars not in an integrated manner within a comprehensive analytical model. Previous studies, such as those by Khasanah & Setiyabudi, (2023) and Paramastri et al. (2021), showed that CLTS pillars can reduce diarrhea incidence, but are still limited to descriptive approaches or do not adjust to specific geographical conditions. Meanwhile, wetland areas such as South Indralaya have distinctive environmental challenges, such as water-saturated soil conditions that are prone to flooding, the presence of rivers as water sources as well as waste channels resulting in groundwater contamination, and limited technical sanitation infrastructure. To date, there is still minimal research examining the relationship of all five CLTS pillars simultaneously using a multivariate approach in the context of wetland communities. Some studies use descriptive approaches or simple bivariate tests without considering interactions between pillars or other confounding variables.

South Indralaya was selected as the research location due to its regional characteristics that support the spread of diarrheal diseases. The topography of this area consists of low-lying swampland with the Ogan River flow serving as the main water source for the community. Alluvial soil conditions around the Ogan River Basin that tend to be moist and sandy can increase the risk of bacterial contamination (Maksuk & Mardianti, 2023). Rivers and wetlands in South Indralaya function as natural filters; however, if their management is not optimal, both can become sources of contamination that increase the risk of disease spread (Febrianti & Anggraini, 2018). The complexity of various risk factors, including environmental quality and limited access to health infrastructure, creates conditions that support high diarrhea prevalence in the area. Additionally, according to the Ogan Ilir District Health Office Report (2021), South Indralaya has already implemented CLTS.

This research fills a scientific gap, considering that areas with swamp and river characteristics potentially have different pathogen transmission pathways compared to urban or mountainous areas. This research contributes scientifically by analyzing the determinants of diarrhea incidence based on the five CLTS pillars in the context of wetland environments, using a quantitative approach with logistic regression models. By considering environmental complexity and stronger statistical approaches, this study is expected to produce more relevant and contextual sanitation intervention recommendations.

This research aims to understand the extent to which environmental sanitation condition factors reflected by CLTS pillars play a role in influencing community health in the local area. It is hoped that the results of this research can provide benefits for local governments as a reference for improving health infrastructure, sanitation, and developing more effective community health education programs to reduce diarrhea prevalence, particularly in areas with similar environmental conditions.

METHOD

This study employed a quantitative method with a cross-sectional design to evaluate the relationship between environmental sanitation factors and the incidence of diarrheal disease among families in South Indralaya, Ogan Ilir. The population in this study included all families residing in the wetland area of South Indralaya. A sample size of 100 respondents was determined using the purposive sampling method. To ensure statistical validity, this sample size was calculated based on the Lemeshow et al. (1990) formula for estimating a population proportion. The inclusion criteria used were that respondents must: (1) have resided in the South Indralaya District's wetland area for five years or more; (2) be located in a region where the CLTS program has been implemented; (3) be 18 years of age or older; and (4) be willing to be interviewed and participate in the study.

The instrument used was a structured questionnaire consisting of two main parts: respondent characteristics and indicator variables of CLTS pillars. The questionnaire was developed based on the indicators of Indonesian Ministry of Health Regulation No. 3 of 2014. All data were collected through face-to-face interviews and direct observation of household sanitation facilities. The data collection procedure began with providing explanations about the research objectives and benefits to respondents, followed by presenting informed consent forms to ensure their participation agreement, along with a digital questionnaire in Google Form format. This research has obtained ethical approval from the Health Research Ethics Committee, Faculty of Public Health, Sriwijaya University, with number: 351/UN9.FKM/TU.KKE/2024. Data confidentiality and anonymity were maintained in accordance with health research ethical principles.

The independent variables measured in this study included several aspects of sanitation. Latrine availability was defined as a household's ownership of a private latrine. A latrine type was considered safe if it had complete upper, middle, and lower structures. Handwashing with soap (HWWS) habits were assessed based on whether respondents regularly washed their hands with soap at five critical times (before eating, after defecating, after cleaning a baby, before preparing food, and after touching animals). The physical quality of clean water was considered good if the water was tasteless, colorless, and odorless. Clean water availability was measured by whether the water was accessible at all times. The type of drinking water considered safe was refilled water or bottled drinking water. Drinking water storage was considered safe if the water was kept in a covered container. Waste management was defined as safe when household waste was processed domestically and not disposed of indiscriminately. The frequency of waste disposal from the house was measured based on how often it was done (daily or not daily).

Regarding liquid waste, safe blackwater disposal was defined as the disposal of wastewater from the toilet into a watertight septic tank. Meanwhile, safe greywater disposal was when other domestic wastewater was channeled into a closed drainage system. Finally, water stagnation around the house environment was defined as the presence of standing water around the house at certain times. The dependent variable, the incidence of diarrhea, was defined as a family member experiencing loose, watery stools three or more times in a single day within the last six months.

Data were processed using SPSS software through several stages, starting from univariate analysis, then bivariate analysis to test relationships between variables using Chi-Square test, and multivariate analysis using logistic regression when necessary to identify dominant factors affecting diarrhea incidence. Through this analysis, it is expected that the research results can provide valuable insights for community-based health interventions in the study area. With 95% significance level ($\alpha \leq 0.05$), if the test results show $p \leq 0.05$, it means there is a relationship, but if the test results show $p > 0.05$, it means there is no relationship. Goodness-of-fit testing was performed using the Hosmer-Lemeshow test.

RESULT AND DISCUSSION

The results of this study are presented through univariate, bivariate, and multivariate analyses, which are displayed in tabular form.

Univariate Analysis

Tabel 1

Diarrhea Incidence in South Indralaya

Diarrhea Incidence	n	%
Yes	45	45
No	55	55

Of the total 100 respondents involved, 45% (n=45) were reported to have experienced diarrhea, while 55% (n=55) did not experience diarrhea, indicating a relatively high prevalence of diarrhea in the South Indralaya study area. Diarrhea was defined as loose stools three times or more within a day and night (24 hours) as inquired to respondents within the last 6 months. The elevated prevalence suggests that wetland environmental conditions in South Indralaya create multiple pathogen transmission pathways that amplify diarrheal disease risk beyond typical rural settings.

Bivariate Analysis

Bivariate analysis was conducted to determine the relationship between each independent variable and the dependent variable, namely diarrhea incidence. The statistical test used was the chi-square test, with the significance level set at $p < 0.05$.

Tabel 2
Relationship Between Sanitation Variables and Diarrhea Incidence

Variables	**Diarrhea Incidence**				***p-Value***
	Yes		No		
	n	%	N	%	
Pillar 1					
Latrine Availability					
Not available	13	59.1	9	40.9	0.133
Available	32	41.0	46	59.0	
Latrine Type					
Does not meet requirements	22	39.3	34	60.7	0.195
Meets requirements	23	52.3	21	47.7	
Pillar 2					
HWWS Habits					
Poor	15	35.7	27	64.3	0.112
Good	30	51.7	28	48.3	
Physical Quality of Clean Water					
Does not meet requirements	6	60.0	4	40.0	0.339
Meets requirements	39	43.3	51	56.7	
Clean Water Availability					
Part of the time	11	57.9	8	42.1	0.209
All the time	34	42.0	47	58.0	
Pillar 3					
Type of drinking water					
Boiled water	30	50.0	30	50.0	0.218
Refilled water	15	37.5	25	62.5	
Drinking water storage					
Open container	21	50.0	21	50.0	0.392
Closed container	24	41.4	34	58.6	
Pillar 4					
Waste management					
Unsafe	24	63.2	14	36.8	0.004*
Safe	21	33.9	41	66.1	
Waste disposal frequency					
Not Daily	40	44.0	51	56.0	0.728
Daily	5	55.6	4	44.4	
Pillar 5					
Blackwater disposal					
Unsafe	41	44.1	52	55.9	0.698
Safe	4	57.1	3	42.9	
Greywater disposal					
Unsafe	23	50.0	23	50.0	0.354
Safe	22	40.7	32	59.3	
Water stagnation around house environment					
Present	33	45.2	40	54.8	0.946
Absent	12	44.4	15	55.6	

Bivariate analysis conducted to identify the relationship between CLTS pillar sanitation factors and diarrhea incidence in South Indralaya, Ogan Ilir Regency, shows that waste management is the only factor that has a statistically significant relationship with diarrhea incidence (P-value = 0.004) (Table 2). Descriptively, diarrhea incidence was recorded substantially higher in the household group with unsafe waste management (63.2%) compared to those with safe waste management (33.9%).

For other sanitation factors, most did not show statistically significant relationships with diarrhea incidence in this study. In Pillar 1 (Open Defecation Free), both latrine availability (P-value = 0.133) and latrine type (P-value = 0.195) did not show significant relationships.

Similarly, for Pillar 2 (Handwashing with Soap), HWWS habits (P-value = 0.112) were not significantly associated with diarrhea incidence.

In Pillar 3 (Household Drinking Water Management), the variables of physical quality of clean water (P-value = 0.339), clean water availability (P-value = 0.209), type of drinking water (P-value = 0.218), and drinking water storage (P-value = 0.392) also did not show statistically significant relationships.

Furthermore, in Pillar 4 (Household Waste Management), besides waste management, waste disposal habits (P-value = 0.728) were not proven to have a significant relationship with diarrhea incidence. Finally, for Pillar 5 (Household Wastewater Management), blackwater disposal (P-value = 0.698), greywater disposal (P-value = 0.354), and water stagnation around the house environment (P-value = 0.946) also did not show significant relationships with diarrhea incidence.

Overall, the results of this bivariate analysis indicate that in South Indralaya, household waste management aspects are the most prominent sanitation factors related to diarrhea incidence. Nevertheless, it is important to conduct multivariate analysis to control for potential confounding factors and identify the actual determinants of diarrhea in this complex context.

Multivariate Analysis

As an initial step in multivariate analysis, variable selection was performed based on bivariate analysis results. Variables with p-value < 0.25 were entered into the multivariate model. Variables considered for inclusion in the multivariate model were waste management, latrine availability, latrine type, handwashing with soap (HWWS) habits, clean water availability, and type of drinking water (Table 3).

Subsequently, these variables were further filtered for the multivariate model based on their significance values. Variables with P-value > 0.05 would be removed gradually from the model. However, it is important to consider the potential presence of confounding variables. If after a variable is removed from the model there is a change in odds ratio (OR) of 10% or more in other independent variables, then the removed variable is categorized as a confounder. A confounder is a variable that can cause bias in model interpretation because it influences the relationship between independent and dependent variables. Therefore, variables identified as confounders will still be retained in the multivariate model to ensure more accurate analysis results.

Table 3

Initial Multivariate Analysis Model from Bivariate Selection

Variables	***P-value***
Waste management	0.004
Latrine Availability	0.133
Latrine Type	0.195
HWWS Habits	0.112
Clean Water Availability	0.209
Type of drinking water	0.218

The process of eliminating variables with significance values (P-value) > 0.05 was performed one by one, starting from the variable with the highest significance value, using the Enter method. This method ensures that each variable removed does not have a significant impact on model stability, so that only variables that truly contribute to the final model are retained.

Table 4

Final Multivariate Model

Variable	**B**	**Exp (B)**	**P-value**	**95% CI**	
				Lower	**Upper**
Waste management	1.193	3.296	0.008	1.359	7.996
Latrine Availability	1.224	3.400	0.043	1.037	11.155
Latrine Type	-1.178	0.308	0.053	0.112	0.842

In the bivariate analysis stage, of all sanitation factors evaluated (Table 2), only waste management showed a statistically significant relationship with diarrhea incidence (P-value = 0.004). Subsequently, after controlling for potential confounding variables, the final multivariate model results showed two sanitation factors related to diarrhea incidence (Table 4).

Waste management was proven to be significantly associated with diarrhea incidence (P-value = 0.008). Respondents who performed "unsafe" waste management had a 3.296 times higher likelihood (Exp(B)=3.296; 95% CI: 1.359–7.996) of experiencing diarrhea compared to those who managed waste "safely," after adjusting for other variables in the model. This finding is consistent with bivariate results that highlighted waste management as a prominent risk factor.

Latrine availability was also found to have a statistically significant relationship with diarrhea incidence (P-value = 0.043). Respondents who reported latrine availability as "not available" had a 3.400 times higher likelihood (Exp(B)=3.400; 95% CI: 1.037–11.155) of experiencing diarrhea compared to those with latrine access, after controlling for other variables. Interestingly, although not significant in the initial bivariate analysis (P-value = 0.133), this variable became significant in the multivariate model, indicating that its effect became clearer after being controlled by other factors. Furthermore, although waste management is also a strong risk factor, inadequate latrine availability becomes the most dominant factor in increasing the likelihood of diarrhea occurrence in children in South Indralaya, based on the highest Exp(B) value (Exp(B) = 3.400) in the final multivariate model.

Latrine type showed a relationship that was statistically at the borderline of significance (P-value = 0.053) with an Exp(B) value of 0.308 (95% CI: 0.112–0.842). Nevertheless, further exploratory results showed that removing latrine type from the model caused meaningful changes (OR ≥10%) in the odds ratio values of other variables, so this variable was retained in the multivariate model because it was proven to have a role as a confounder. Therefore, latrine type is retained to improve the internal validity of the logistic regression model built in this study.

Relationship Between CLTS Pillar 1 and Diarrhea Incidence

This study confirms that inadequate latrine availability, representing CLTS Pillar 1, is a significant determinant of diarrhea incidence in South Indralaya's wetland communities. The emergence of latrine availability as the strongest predictor (OR=3.400) in multivariate analysis, despite non-significance in bivariate testing, illustrates the complex interaction effects characteristic of wetland sanitation systems. Households without access to latrines were almost four times more likely to experience diarrhea compared to those with latrines. This finding highlights the central role of feces containment in interrupting transmission pathways, which is the core principle of the CLTS approach (Kemenkes, 2014). This phenomenon occurs because the protective effect of latrines becomes more apparent when other confounding factors are statistically controlled, particularly latrine type quality.

The association observed in this study is consistent with previous evidence that open defecation remains one of the strongest risk factors for diarrheal disease (Muga et al., 2023; Prüss-Ustün et al., 2014). In wetland areas such as South Indralaya, the risk is further amplified due to high groundwater levels, frequent flooding, and the reliance on river water for daily use. These conditions facilitate the rapid spread of pathogens from exposed feces to the surrounding environment, contaminating water, soil, and food (Maksuk & Mardianti, 2023; Mara et al., 2010). Therefore, government efforts through the first pillar of CLTS, namely "Stop Open Defecation," are highly relevant and urgent to be intensified.

Furthermore, this study also found that latrine type (p=0.053) acted as a confounding factor, suggesting that not all latrines provide the same level of protection. The role of latrine type as a confounder can be explained through the mechanism that not all latrines have the same effectiveness in preventing pathogen spread especially in wetland settings. This is very crucial because not only the presence of latrines, but also how these latrines are designed and managed affects their effectiveness in preventing disease transmission (Jenkins et al., 2015). Low-quality latrines or those that do not meet standards can still be sources of contamination despite being technically "available." Latrines that meet requirements, such as those equipped with water seals, good drainage systems, and covers, can effectively isolate feces from the environment, reduce exposure to vectors such as flies, and prevent soil and water contamination (WHO, 2018).

Based on research results by Setiawaty et al. (2022), family latrines are an important part of households because they can prevent the development of infectious diseases originating from human feces. The use of latrines has a great effect on reducing disease transmission risk, and every family member must defecate in latrines. This indicates that CLTS interventions should not only target facility provision, but also need to ensure that constructed latrines truly meet the technical and functional requirements established in national sanitation standards.

This finding underscores the need for wetland-adapted sanitation standards that consider seasonal inundation and soil saturation patterns. The multivariate model's revelation that latrine availability becomes the dominant factor when other variables are controlled indicates that CLTS Pillar 1 implementation in South Indralaya should prioritize both facility provision and technical quality assurance. This dual approach differs from standard CLTS protocols that often emphasize behavior change over infrastructure specifications.

Relationship Between Pillar 2 and Diarrhea Incidence

CLTS Pillar 2 relates to Handwashing with Soap (HWWS). The non-significance of handwashing with soap (HWWS) habits (p=0.112), clean water availability (p=0.209), and physical water quality (p=0.339) presents an apparent contradiction to established hygiene literature. The scientific consensus has long identified HWWS as a highly effective and fundamental intervention in preventing diarrhea and other infectious diseases (Ejemot-nwadiaro et al., 2015). However, this pattern can be understood through the lens of environmental contamination saturation theory, where overwhelming pathogen loads from dominant sources (open defecation, waste accumulation) may mask the protective effects of individual hygiene practices.

HWWS may be compromised by several factors unique to these settings. First, the reliance on surface water sources that are simultaneously used for waste disposal creates a contamination cycle where clean water for handwashing may itself be compromised. Generally, access to adequate and safe clean water is a prerequisite for hygiene and sanitation, which is essential in diarrhea prevention (WHO/UNICEF/JMP, 2020). Second, the measurement of HWWS through self-reporting may not capture the actual quality and consistency of handwashing practices, particularly regarding water quantity, soap effectiveness, and critical timing. The measurement of HWWS habits often relies on self-reporting, which is susceptible to social desirability bias, where respondents tend to report ideal practices rather than actual behaviors (Biran et al., 2014).

The non-significant relationship with clean water physical quality (p=0.339) reflects the limitation of organoleptic assessment in predicting microbiological safety. However, the presence of *E. coli* bacteria as an indicator that plays a more significant role in pathogen transmission related to diarrhea risk (Gruber et al., 2014). Water that appears physically acceptable may harbor significant pathogenic bacterial loads, particularly in environments where fecal contamination and organic waste decomposition occur in close proximity to water sources. This finding suggests that future interventions should incorporate microbiological water quality testing to better understand the relationship between water safety and health outcomes.

Furthermore, although water sources may meet availability and physical quality standards, contamination can occur during transportation, storage, or household water handling, known as point-of-use contamination (Clasen, 2015). Unhygienic water storage containers can become sources of secondary contamination that reduce HWWS effectiveness. Regarding water availability, this study did not measure the amount of water used and techniques employed in HWWS practice. Therefore, although water availability may be sufficient, HWWS practices using minimal water quantities and incorrect techniques can affect the effectiveness of HWWS..

The environmental context of South Indralaya, with its complex hydrology and multiple contamination sources, may require HWWS promotion strategies that address both behavior change and environmental modification. Simply promoting handwashing without simultaneously addressing primary contamination sources may provide limited health benefits in such heavily contaminated environments.

Relationship Between Pillar 3 and Diarrhea Incidence

The non-significant relationships observed for drinking water type (p=0.218) and storage practices (p=0.392) reflect the complexity of household water management in wetland communities. These findings suggest that in environments with multiple contamination pathways, traditional approaches to drinking water safety may provide insufficient protection against diarrheal disease.

The balanced distribution of drinking water practices between diarrhea and non-diarrhea groups indicates that point-of-use water treatment and storage, while important, may not be the primary determinant of health outcomes when environmental contamination is pervasive. Although boiling water is generally effective in killing pathogens, and closed storage can reduce recontamination, these data may not fully reflect actual risks. The primary issue often lies in the microbiological quality of consumed water, not merely the initial processing type or physical quality (Clasen, 2015). Even boiled water can become recontaminated if stored in unclean containers or handled with dirty hands. This study does not present data regarding microbiological contamination of drinking water at the point of use, which is a more direct predictor of diarrhea risk (Clasen, 2015). This pattern is consistent with research demonstrating that household water treatment effectiveness diminishes in environments with high background contamination levels.

Furthermore, although water may be properly processed (e.g., boiled) or stored correctly, contamination can occur during the process of water collection, pouring, or household use (WHO/UNICEF/JMP, 2020). Poor hand hygiene practices when collecting water, use of dirty containers or cups, or even insects falling into open containers can recontaminate initially safe water. If household water handling behaviors remain vulnerable, initial processing or storage efforts alone may be insufficient to prevent diarrhea.

The wetland context presents unique challenges for drinking water management that may explain these non-significant relationships. Seasonal flooding can compromise water storage systems, while high humidity and temperature conditions may reduce the effectiveness of certain treatment methods. Additionally, the community's adaptive practices, developed over generations of living in wetland environments, may have created relatively uniform exposure patterns that mask statistical differences between "safe" and "unsafe" practices.

The research results showing no significant relationship between drinking water type and storage with diarrhea do not diminish the importance of implementing CLTS Pillar 3. The CLTS program is designed as a holistic approach where CLTS constitutes an approach to change hygienic and sanitary behaviors through community empowerment via triggering methods. The success of this program lies in the synergy among all five pillars, not just one pillar in isolation.

Relationship Between Pillar 4 and Diarrhea Incidence

Household Waste Management in Pillar 4 encompasses activities from sorting and collecting to processing waste (Kemenkes, 2014). Waste management emerges as the most consistent predictor of diarrhea incidence across both bivariate (p=0.004) and multivariate (OR=3.296, p=0.008) analyses. These findings are strongly consistent with environmental health literature that emphasizes how poor solid waste management creates environments conducive to disease vector proliferation such as flies and rodents, and can cause soil and water contamination (Daniel Hoornweg & Perinaz Bhada-Tata, 2012; WHO, 2018). This prominence reflects the particular vulnerability of wetland environments to solid waste contamination due to limited drainage, seasonal flooding, and high organic matter decomposition rates.

The significant association between unsafe waste processing and diarrhea incidence (63.2% vs 33.9%) demonstrates how poor solid waste management creates multiple disease transmission pathways in wetland settings. Organic waste accumulation in water-saturated environments provides ideal breeding conditions for disease vectors, while leachate from improperly managed waste contaminates both surface and groundwater sources used by the community (Utami et al., 2023). Therefore, safe waste processing constitutes a crucial pillar in diarrhea prevention, with overall waste management impact being the largest among all household features, even greater than other sanitation components (Juvakoski et al., 2023).

The non-significance of disposal frequency (p=0.728) versus processing method significance provides important insights for intervention design. This pattern indicates that the quality of waste treatment, rather than removal schedule, determines health outcomes. Even daily waste removal may provide limited health benefits if final disposal methods involve open dumping, uncontrolled burning, or disposal in waterways that subsequently contaminate community water sources.

In wetland environments, the impact of solid waste extends beyond direct pathogen transmission to include ecosystem disruption that indirectly affects health outcomes. Waste accumulation can alter local hydrology, create stagnant water conditions that favor vector proliferation, and disrupt natural water filtration processes that communities depend upon for environmental protection (Krystosik et al., 2020; Yu et al., 2023).

These findings suggest that CLTS Pillar 4 interventions in South Indralaya should emphasize integrated waste management systems that address both household-level processing and community-level disposal infrastructure. The focus should shift from waste removal frequency to developing environmentally appropriate processing methods that account for wetland ecosystem characteristics.

Relationship Between Pillar 5 and Diarrhea Incidence

The non-significant relationships observed for liquid waste management variables (blackwater p=0.698, greywater p=0.354, water stagnation p=0.946) require interpretation within the broader context of wetland hydrology and community adaptation patterns. These results differ from several previous studies demonstrating that unsafe liquid sanitation, such as direct domestic wastewater discharge to open environments or untreated drainage systems, can increase contamination risk and spread of water-based diseases like diarrhea, consistent with the CLTS Program (Kemenkes, 2014; Prüss-Ustün et al., 2019). These findings may reflect the natural water treatment capacity of wetland environments, where dilution and biological processing can mitigate the health impacts of liquid waste discharge under certain conditions.

However, the non-significance should not be interpreted as evidence that liquid waste management is unimportant in wetland communities. Rather, it may indicate that current waste loads remain within the natural treatment capacity of the local ecosystem, or that community exposure patterns have developed adaptive tolerance mechanisms. Additionally, the seasonal nature of wetland hydrology means that liquid waste impacts may vary substantially throughout the year, with health effects potentially concentrated during specific periods not captured by this cross-sectional study design. These findings align with research by (Hutton & Chase, 2017), stating that liquid waste management's health effects can be highly dependent on local context, including population density, geographical conditions, and other sanitation interventions.

The finding that water stagnation around homes (p=0.946) shows no relationship with diarrhea incidence is particularly noteworthy given the established relationship between standing water and vector-borne disease transmission. This may reflect effective community management practices that minimize health risks from stagnant water, or it may indicate that other contamination sources overwhelm any effects from household-level water stagnation.

For CLTS Pillar 5 implementation in South Indralaya, these findings suggest that liquid waste interventions should be designed with careful consideration of natural ecosystem capacity and seasonal variation patterns. Interventions should focus on protecting and enhancing natural treatment processes rather than implementing infrastructure that may be inappropriate for wetland conditions.

Implication

The overall pattern of results reveals a wetland-specific hierarchy of sanitation risks where infrastructure factors (latrines, solid waste management) dominate hygiene behavior factors (handwashing, water treatment). This hierarchy differs from typical CLTS implementation models and suggests the need for environment-adapted intervention strategies (Torlesse et al., 2016). Evidence from Indonesian settings demonstrates that improved sanitation coverage shows stronger associations with reduced diarrhea prevalence than improved water coverage alone, particularly in environmentally challenging contexts (Cameron et al., 2019).

The dominance of Pillars 1 and 4 in predicting diarrhea incidence reflects the interconnected nature of fecal and solid waste contamination in wetland environments. Poor solid waste management can compromise latrine effectiveness, while inadequate fecal containment can contaminate waste management systems. This interconnection suggests that successful interventions must address both pillars simultaneously rather than sequentially.

The study's findings have important implications for CLTS implementation in environmentally vulnerable communities. Standard CLTS protocols, developed primarily in diverse geographical contexts, may require substantial adaptation for wetland environments where environmental factors can overwhelm individual behavior change efforts. Successful programs in such settings may need to prioritize infrastructure development and environmental modification alongside community mobilization activities.

CONCLUSION

This study successfully identified dominant sanitation factors associated with diarrhea incidence among children in South Indralaya, Ogan Ilir Regency, with a diarrhea prevalence of 45% among total respondents. Multivariate analysis results significantly demonstrate that unavailability of latrines proved to be the most dominant risk factor, with a 3.400-fold increase in diarrhea odds (p-value = 0.043). Furthermore, unsafe waste management emerged as a strong predictor, increasing diarrhea odds by up to 3.296 times (p-value = 0.008). Qualified latrine types showed not statistically significant (p = 0.053) and served as a confounder in the relationship between latrine availability and waste processing on diarrhea risk. These findings confirm that CLTS pillars related to fecal and solid waste management are key determinants of diarrhea incidence in the study area, consistent with inadequate environmental conditions such as minimal access to healthy latrines and waste management facilities that can increase diarrhea risk.

Although other important aspects of CLTS did not demonstrate statistically significant relationships in this study, this indicates that in the context of South Indralaya, diarrhea transmission pathways are most likely dominated by fecal exposure and contamination from solid waste. Low community knowledge regarding hygiene and sanitation, which may be related to educational levels, can impact health behaviors that subsequently influence diarrhea incidence. Thus, the success of diarrhea prevention programs in this region heavily depends on interventions targeting fundamental improvements in sanitation access and safe waste management.

SUGGESTION

Based on the discussed findings, it is recommended that local government and health stakeholders in South Indralaya prioritize efforts to implement CLTS Pillar 1 (Stop Open Defecation) and Pillar 4 (Household Waste Security) more intensively. Interventions should focus on improving household access to healthy latrines, including education regarding qualified latrine standards and safe fecal disposal practices. Concurrently, community education and facilitation to transition from unsafe waste processing practices to sanitary methods, such as household-based or community-based waste management, becomes crucial for breaking disease transmission chains. Continuous education and socialization enhancement regarding the importance of CLTS implementation in daily life by health workers is required to build awareness and sustainable behavioral change. For subsequent research, it is highly recommended to conduct further investigation into factors that were not significant in this study, particularly handwashing with soap (HWWS) and water management aspects. This can be achieved through the use of more objective measurement methods, such as direct behavioral observation or microbiological water quality testing at point-of-use, to obtain more accurate representations of actual practices and risks. Additionally, future research may consider longitudinal study designs to establish stronger causal relationships, as well as exploration of other sociodemographic factors or interaction variables that may moderate the relationship between sanitation and diarrhea incidence in communities with similar characteristics.

REFERENCE

Azis, W. A., Hudayah, N., & Ardi. (2021). Hubungan Sanitasi Dasar Dengazn Kejadian Diare Pada Balita Di Desa Sandi Kecamatan Kaledupa Selatan Kabupaten Wakatobi. *Jurnal Medika Hutama*, *02*(03), 834–848. [Publisher]

Biran, A., Schmidt, W. P., Varadharajan, K. S., Rajaraman, D., Kumar, R., Greenland, K., Gopalan, B., Aunger, R., & Curtis, V. (2014). Effect of a behaviour-change intervention on handwashing with soap in India (SuperAmma): A cluster-randomised trial. *The Lancet Global Health*, *2*(3), e145–e154. [Crossref] [Publisher]

Cameron, L., Olivia, S., & Shah, M. (2019). Scaling up sanitation: Evidence from an RCT in Indonesia. *Journal of Development Economics*, *138*, 1–16. [Crossref] [Publisher]

Clasen, T. (2015). Household Water Treatment and Safe Storage to Prevent Diarrheal Disease in Developing Countries. *Current Environmental Health Reports*, *2*(1), 69–74. [Crossref] [Publisher]

Daniel Hoornweg, & Perinaz Bhada-Tata. (2012). A Global Review of Solid Waste. *Worldbank*, *15*(January 2012), 10. [Publisher]

Dinas Kesehatan Kabupaten Ogan Ilir. (2021). Profil Kesehatan Kabupaten Ogan Ilir 2021. *Dinas Kesehatan Kabupaten Ogan Ilir*, 101. [Publisher]

Dinas Kesehatan Provinsi Sumatera Selatan. (2024). *Profil Kesehatan Provinsi Sumatera Selatan Tahun 2023*. [Publisher]

Ejemot-nwadiaro, R. I., Ehiri, J. E., Arikpo, D., Meremikwu, M. M., & Critchley, J. A. (2015). Hand washing promotion for preventing diarrhoea (Systematic Review). *Cochrane Library*, 81. [Crossref] [Publisher]

Farkhati, D. U. (2021). Kajian Literatur: Gambaran Kondisi Sanitasi Lingkungan Rumah Tangga denagn Kejadian Diare pada Balita. *Muhamadiyah Public*

Health Journal (MPHJ), *1*(2), 115–128. [Crossref] [Publisher]

Febrianti, A., & Anggraini, D. (2018). Perawatan Kulit Pada Anak Umur 0-3 Tahun Yang Menderita Diare Di Wilayah Kerja Puskesmas Pemulutan Kabupaten Ogan Ilir Tahun 2018. *Masker Medika*. [Publisher]

Grafika, D., Sabilu, Y., & Munandar, S. (2017). Faktor risiko kurangnya perilaku hidup bersih dan sehat (phbs) tatanan rumah tangga terhadap kejadian diare pada balita di wilayah kerja puskesmas benu-benua kota kendari tahun 2017. *Jurnal Ilmiah Kebidanan (Scientific Journal of Midwifery)*, *56*, 1–10. [Publisher]

Gruber, J. S., Ercumen, A., & Colford, J. M. (2014). Coliform bacteria as indicators of diarrheal risk in household drinking water: Systematic review and meta-analysis. *PLoS ONE*, *9*(9). [Crossref] [Publisher]

Hargono, A., Waloejo, C., Pandin, M. P., & Choirunnisa, Z. (2022). Penyuluhan Pengolahan Sanitasi Air Bersih untuk Meningkatkan Kesehatan Masyarakat Desa Mengare, Gresik. *Abimanyu: Journal of Community Engagement*, *3*(1), 1–10. [Crossref] [Publisher]

Hutton, G., & Chase, C. (2017). Injury Prevention and Environmental Health. 3rd edition. In *Injury Prevention and Environmental Health. 3rd edition*. International Bank for Reconstruction and Development / The World Bank. [Crossref] [Publisher]

Indah, F. P. S., Ismaya, N. A., Puji, L. K. R., Hasanah, N., & Jaya, F. P. (2021). Penerapan Program Sanitasi Total Berbasis Masyarakat (STBM) dengan Kejadian Diare pada Balita. *Jurnal Ilmiah Kesehatan*, *20*(1), 10–15. [Crossref] [Publisher]

Jenkins, M. W., Cumming, O., & Cairncross, S. (2015). Pit latrine emptying behavior and demand for sanitation services in Dar Es Salaam, Tanzania. *International Journal of Environmental Research and Public Health*, *12*(3), 2588–2611. [Crossref] [Publisher]

Juliansyah, E., Haryanti, Y., Masan STIKes Kapuas Raya Sintang, L., & Barat, K. (2021). Faktor yang Berhubungan dengan Pencegahan Penyakit Diare pada Balita di Puskesmas Tempunak Kabupaten Sintang Factors Associated with Prevention of Diarrhea in Toddlers at Temunak Health Center, Sintang District. *Gorontalo Journal of Public Health*, *4*(2), 78–89. [Crossref] [Publisher]

Juvakoski, A., Rantanen, H., Mulas, M., Corona, F., Vahala, R., Varis, O., & Mellin, I. (2023). Evidence of waste management impacting severe diarrhea prevalence more than WASH: An exhaustive analysis with Brazilian municipal-level data. *Water Research*, *247*(July), 120805. [Crossref] [Publisher]

Kamiludin, K. S., & Azizah, R. (2025). *Implementasi Pilar Sanitasi Total Berbasis Masyarakat (STBM) dengan Insiden Diare pada Balita : Kajian Literatur*. *9*(1). [Crossref] [Publisher]

Kemenkes. (2014). *Peraturan Menteri Kesehatan Republik Indonesia Nomor 3 Tahun 2014*. 1–40. [Publisher]

Kemenkes RI. (2022). Profil Kesehatan Indonesia 2021. In *Pusdatin.Kemenkes.Go.Id*. [Publisher]

Kementerian Kesehatan. (2025). Survei Status Gizi Indonesia 2024. In *Badan Kebijakan Pembangunan Kesehatan Kementerian Kesehatan RI*. [Publisher]

Khasanah, K., & Setiyabudi, R. (2023). The The Relationship of STBM with the Event of Diarrhea Children in Maos Health Centre, Cilacap Regency. *Pancasakti Journal Of Public Health Science And Research*, *3*(1), 55–61. [Crossref] [Publisher]

Krystosik, A., Njoroge, G., Odhiambo, L., Forsyth, J. E., Mutuku, F., & LaBeaud, A. D. (2020). Solid Wastes Provide Breeding Sites, Burrows, and Food for Biological Disease Vectors, and Urban Zoonotic Reservoirs: A Call to Action for Solutions-Based Research. *Frontiers in Public Health*, *7*(January), 1–17. [Crossref] [Publisher]

Maksuk, & Mardianti. (2023). Faktor risiko kejadian diare pada balita yang tinggal di sekitar sungai Kabupaten Ogan Ilir Sumatera Selatan. *TELKOMNIKA*, *19*(1), 35–42. [Publisher]

Mara, D., Lane, J., Scott, B., & Trouba, D. (2010). Sanitation and health. *PLoS Medicine*, *7*(11). [Crossref] [Publisher]

Muga, M. A., Tarus, M. C., & Bor, W. (2023). Relationship Between Hygiene Practices and Occurrence of Diarrhea among Under-Five Children: A Case of East Pokot Sub County. *African Journal of Nutrition and Dietetics*, *1*(1), 26–37. [Crossref] [Publisher]

Muhammad Hilmi Mahmud, & Md. Isa, Z. (2022). Environmental Risk Factors of Diarrhoea Among Vulnerable Population: a Narrative Review. *Malaysian Journal of Public Health Medicine*, *22*(2), 165–175. [Crossref] [Publisher]

Mulatu, G., Ayana, G. M., Girma, H., Mulugeta, Y., Daraje, G., Geremew, A., & Dheresa, M. (2022). Association of drinking water and environmental sanitation with diarrhea among under-five children: Evidence from Kersa demographic and health surveillance site, eastern Ethiopia. *Frontiers in Public Health*, *10*. [Crossref] [Publisher]

Paramastri, N., Nurjazuli, N., & Setiani, O. (2021). Hubungan Antara Penerapan Program Sanitasi Total Berbasis Masyarakat (STBM) dengan Kejadian Diare di Tingkat Rumah Tangga (RT) Studi di Wilayah Kerja Puskesmas Kebasen Kecamatan Kebasen Kabupaten Banyumas. *Jurnal Riset Kesehatan Masyarakat*, *1*(2), 1–9. [Crossref] [Publisher]

Prüss-Ustün, A., Bartram, J., Clasen, T., Colford, J. M., Cumming, O., Curtis, V., Bonjour, S., Dangour, A. D., De France, J., Fewtrell, L., Freeman, M. C., Gordon, B., Hunter, P. R., Johnston, R. B., Mathers, C., Mäusezahl, D., Medlicott, K., Neira, M., Stocks, M., … Cairncross, S. (2014). Burden of disease from inadequate water, sanitation and hygiene in low- and middle-income settings: A retrospective analysis of data from 145 countries. *Tropical Medicine and International Health*, *19*(8), 894–905. [Crossref] [Publisher]

Prüss-Ustün, A., Wolf, J., Bartram, J., Clasen, T., Cumming, O., Freeman, M. C., Gordon, B., Hunter, P. R., Medlicott, K., & Johnston, R. (2019). 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. *International Journal of Hygiene and Environmental Health*, *222*(5), 765–777. [Crossref] [Publisher]

Putri, S. R., & Susanna, D. (2020). Kondisi Sanitasi Dasar dengan Kejadian Diare di Kawasan Pesisir Pantai Desa Sedari, Kabupaten Karawang, Jawa Barat Tahun 2018. *Jurnal Nasional Kesehatan Lingkungan Global*, *1*(2). [Crossref] [Publisher]

Setiawaty, E., Alfian, & Fauzi, M. (2022). Pengaruh Penggunaan Jamban Sehat terhadap Kejadian Penyakit Diare di Desa Ropang Kecamatan Ropang. *Jurnal Kesehatan Samawa*, *2*(1), 15–22. [Crossref] [Publisher]

Torlesse, H., Cronin, A. A., Sebayang, S. K., & Nandy, R. (2016). Determinants of stunting in Indonesian children: Evidence from a cross-sectional survey indicate a prominent role for the water, sanitation and hygiene sector in stunting reduction. *BMC Public Health*, *16*(1). [Crossref] [Publisher]

UNICEF. (2021). *Progress on household drinking water, sanitation and hygiene, 2000-2020: Five years into the SDGs*. [Publisher]

Utami, A. P., Pane, N. N. A., & Hasibuan, A. (2023). Analisis Dampak Limbah Sampah Rumah Tangga Terhubung Pencemaran Lingkungan Hidup. *Cross-Border*, *6*(2), 1107–1112. [Crossref] [Publisher]

Warseno, P. R., Sudarmanto, Maslahah, S. F. N., & Jati, I. T. (2024). Anak Usia 5 Tahun Dengan Diare Akut Dehidrasi Ringan Sedang : Laporan Kasus. *Contiunuing Medical Education*, 74–84. [Publisher]

WHO/UNICEF/JMP. (2020). Progress on household drinking water, sanitation and hygiene 2000-2020: five years into the SDGs. In *Launch version July 12 Main report Progress on Drinking Water , Sanitation and Hygiene*. [Publisher]

WHO. (2018). Guidelines On Sanitation and Health. In *World Health Organization* (Issue December). [Publisher]

WHO. (2024). *Diarrhoeal disease*. World Health Organization. [Publisher]

Yu, R., Zhang, C., Gao, X., & Daly, K. (2023). Stagnant water environmental management in urban river networks: An integrated risk analysis involving hydraulic potential dissipation. *Journal of Hydrology*, *622*, 129652. [Crossref] [Publisher]