**Indonesian Journal of Environment & Health**
*e*-ISSN : 3124-8500
Vol. 1, No. 3, December 2025
https://jenhjournal.com | https://doi.org/10.xxxxx/jenh.2025.1.3.76-83



Research Paper

# Analysis of Water Quality in Flood-Prone Areas Based on E. Coli Levels and The Incidence of Diarrhea Among Toddlers in The Service Area of The Nagaswidak Community Health Center Palembang City

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Article History: Received: September 15, 2026, Accepted: November 02, 2026

**Abstract**
Diarrhea remains a major health problem for toddlers, especially in flood-prone areas with a high risk of environmental pollution to household water sources. Flood conditions have the potential to bring fecal contaminants into water sources, thereby increasing the presence of E. coli bacteria that can cause diarrhea. Based on these conditions, this study aims to analyze the relationship between water quality in flood-prone areas based on E. coli content and the incidence of diarrhea in toddlers in the working area of the Nagaswidak Community Health Center in Palembang City. The study used an observational analytical design with a cross-sectional approach. The sample in the study consisted of 92 mothers with toddlers aged 0-60 months who were selected using a proportional random sampling technique. Water quality examination was carried out through analysis of E. coli content in household water sources. Data were analyzed bivariately using the chi-square test and the Prevalence Ratio value was calculated. The results showed a significant relationship between the age of toddlers 0-60 months (p-value = 0.000), water quality based on E. coli content (p-value = 0.000), and household water storage containers (p-value = 0.001) with the incidence of diarrhea in toddlers. Meanwhile, clean water sources were not significantly related (p-value = 0.009), and household clean water treatment was not significantly related (p-value = 0.117). The potential for recontamination, hygiene practices, and flood-prone environmental conditions are suspected to be factors causing diarrhea. It was concluded that there was a significant relationship between toddler age, water quality based on E. coli content, and storage container conditions with the incidence of diarrhea in toddlers. The presence of E. coli in water storage containers indicates fecal contamination that has the potential to increase the risk of diarrhea. It is recommended to prevent diarrhea by improving environmental sanitation and increasing public education regarding safe water treatment and storage, especially in flood-prone areas.

**Keywords**
*diarrhea, e. coli, prone to food, toddler, water quality*

## 1. INTRODUCTION

Diarrhea is the third leading cause of death and morbidity among children worldwide. The WHO (2024) reports approximately 443,832 child deaths annually due to diarrhea associated with the consumption of contaminated food and water (World Health Organization, 2024). Globally, 780 million people lack access to clean water, and 2.5 billion people worldwide a lack access to adequate sanitation, which contributes to the spread of diseases such as diarrhea. According to data from (SKI, 2023), the incidence of diarrhea among infants reached 7.4% of the total population of 86,364 infants. To prevent and manage diarrhea, relevant parties are working to improve environmental hygiene and sanitation, as well as using oral rehydration solution (ORS) and zinc to treat diarrhea (Ministry of Health, 2025). Based on data from the Palembang City Health Department, the total number of diarrhea cases in Palembang City in 2024 was recorded at 22,966 cases (Dinkes, 2024b). Meanwhile, in the service area of the Nagaswidak Community Health Center, 287 cases of diarrhea among toddlers were recorded, with 198 toddlers receiving treatment, oral rehydration solution, and zinc (Dinkes, 2024a). The city of Palembang is divided by the Musi River into two main areas, namely Seberang

Ulu and Seberang Ilir. Many residents have established settlements and carry out activities along the riverbanks, thereby increasing the risk of flooding due to river overflow (Toboroza and Febriyanti, 2025). BappedaLitbang has designated the service area of the Nagaswidak Community Health Center as a flood-prone zone. Given these characteristics, the service area of the Nagaswidak Community Health Center is one of the regions at risk of experiencing diarrhea due to poor water quality (BappedaLitbang, 2022). Flooding conditions, inadequate drainage systems, and community practices such as storing water without lids and failing to clean storage containers at least twice a week increase the risk of exposure to E. coli and diarrhea (Putri, 2023). Previous research has reported that flood-prone areas are associated with diarrhea, finding that households in tidal areas face limitations in access to clean water and adequate sanitation facilities (Satiti et al., 2019) . Based on these conditions, this study aims to analyze the relationship between water quality—as indicated by E. coli levels—in flood-prone areas and the incidence of diarrhea among infants in the service area of the Nagaswidak Community Health Center in Palembang City.

## 2. METHOD

This study employed a quantitative research design using a cross-sectional approach . This approach was used to analyze the relationship between toddler age, water quality based on E. coli content, clean water sources, water treatment, and water storage containers with the incidence of diarrhea among toddlers in the service area of the Nagaswidak Community Health Center, Palembang City, at a specific point in time. The population in this study consisted of all toddlers with their mothers as respondents residing within the service area of the Nagaswidak Community Health Center, Palembang City. In this study, the population comprised 2,481 households, with a total of 92 respondents. The sampling technique was determined using proportional random sampling, or random sampling according to the proportion of each group. This study used primary data obtained directly from respondents through interviews and observations using a questionnaire. The data in this study underwent univariate and bivariate analysis using the chi-square test.

## 3. RESULTS

Based on Table 1, of the total 92 toddlers who were research respondents, 69 toddlers (75%) experienced diarrhea, while 23 toddlers (25%) did not. This indicates that the incidence of diarrhea among toddlers in the Nagaswidak Community Health Center's service area is relatively high, as more than half of the respondents experienced diarrhea.

Based on Table 2, it is known that of the 92 toddlers in this study, The majority were aged $\leq$ 24 months. namely 54 toddlers (58.7%), while 38 toddlers (41.3%) were aged > 24 months. Regarding the water quality variable (based on E. coli content), it was found that the majority of water samples did not meet the standards, namely 71 respondents (77.2%), while 21 respondents (22.8%) had water samples that met the standards. Based on the source of clean water, more respondents used protected clean water sources, namely 80 respondents (87%), while 12 respondents (13%) used unprotected water sources. Regarding water treatment, 49 respondents (53.3%) performed water treatment that met the standards, while 43 respondents (46.7%) performed water treatment that did not meet the standards. Furthermore, regarding water storage containers, the majority of respondents used containers that did not meet standards—78 respondents (84.8%)—while only 14 respondents (15.2%) used containers that met standards.

Based on Table 2, it is known that of the 92 toddlers in this study, the majority were aged $\leq$ 24 months, namely 54 toddlers (58.7%), while 38 toddlers (41.3%) were aged > 24 months. Regarding the water quality variable (based on E. coli content), it was found that the majority of water samples did not meet the standards, namely 71 respondents (77.2%), while 21 respondents (22.8%) had water samples that met the standards. Based on the source of clean water, more respondents used protected clean water sources, namely 80 respondents (87%), while 12 respondents (13%) used unprotected water sources. Regarding water treatment, 49 respondents (53.3%) performed water treatment that met the standards, while 43 respondents (46.7%) performed water treatment that did not meet the standards. Furthermore, regarding water storage containers, the majority of respondents used containers that did not meet standards—78 respondents (84.8%)—while only 14 respondents (15.2%) used containers that met standards.

Based on Table 3, respondents aged $\leq$ 24 months had a higher incidence of diarrhea (92.6%) compared to those aged > 24 months (50%). The Chi-Square test yielded a p-value of 0.000 (< 0.05), indicating a statistically significant association between toddler age and the incidence of diarrhea (95% CI: 1.336–2.568), suggesting that toddlers aged $\leq$ 24 months have a 1.852-fold higher risk of experiencing diarrhea compared to those aged > 24 months.

Based on the results of the bivariate analysis in Table 4, it was found that the proportion of toddlers with diarrhea was higher in households with substandard water quality (based on E. coli content)—84.5%—compared to households with standard water quality (based on E. coli content)—42.9%. The results of the chi-square test indicate a statistically significant association between water quality based on E. coli levels and the incidence of diarrhea among infants (p-value = 0.000 < 0.05). The Prevalence Ratio (PR) obtained was 1.972 with a 95% Confidence Interval (CI): 1.191–3.263, indicating that infants in households with water quality (based on E. coli content) that does not meet standards have a 1.972 times higher risk of experiencing diarrhea compared to infants living in households with wa-

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**Table 1.** Results of Univariate Analysis: Frequency Distribution of the Dependent Variable (n=92)

| Incidence of Diarrhea in Toddlers | Frequency | Percentage (%) |
|---|---|---|
| **Diarrhea** | 69 | 75 |
| **No Diarrhea** | 23 | 25 |
| **Total** | 92 | 100 |

*Source : Primary Data 2026*

**Table 2.** Results of Univariate Analysis Frequency Distribution of Independent Variables (n=92)

| Variable | Frequency | Percentage (%) |
|---|---|---|
| **Toddler Age** | | |
| ≤24 months | 54 | 58.7 |
| > 24 months | 38 | 41.3 |
| **Water Quality Based on E. coli Content** | | |
| Does Not Meet Standards | 71 | 77.2 |
| Meets Standards | 21 | 22.8 |
| **Clean Water Sources** | | |
| Does Not Meet Standards | 12 | 13 |
| Meets Standards | 80 | 87 |
| **Drinking Water Treatment** | | |
| Does Not Meet Standards | 43 | 46.7 |
| Meets Standards | 49 | 53.3 |
| **Water Storage Container** | | |
| Does Not Meet Standards | 78 | 84.8 |
| Meets Standards | 14 | 15.2 |

*Source : Primary Data 2026*

ter quality (based on E. coli content) that meets standards. This association indicates that water quality that does not meet standards based on E. coli content is associated with an increased risk of diarrhea in infants. This finding is consistent with the role of E. coli as an indicator of fecal contamination in water, such that its presence reflects the potential presence of pathogenic microorganisms causing diarrhea.

Based on Table 5, the proportion of infants and toddlers with diarrhea in households using a qualified water source was 80%, while in households using an unqualified water source it was 41.7%. Based on the results of the Chi-Square test, a p-value of 0.009 and a PR value of 0.521 were obtained, with a 95% CI of 0.264–1.026. Since the CI crosses the value of 1, there is no statistically significant epidemiological association.

Based on the results of the bivariate analysis in Table 6, it is known that the proportion of toddlers with diarrhea is higher in households that use water treatment that does not meet standards (83.7%) compared to households that use water treatment that meets standards (67.3%). The chi-square test yielded a p-value of 0.117 ($p > 0.05$), indicating no statistically significant association between household water treatment and the incidence of infant diarrhea (95% CI: 0.982–1.573).

Based on Table 7, it was found that the proportion of toddlers with diarrhea was higher in households with substandard water storage containers (82.1%) compared to households with standard water storage containers (35.7%). The results of the Chi-Square statistical test yielded a p-value of 0.001 ($p < 0.05$), indicating a statistically significant association between the condition of household clean water storage containers and the incidence of diarrhea in infants. The Prevalence Ratio (PR) of 2.297 with a 95% Confidence Interval (CI) of 1.129–4.675, which indicates that infants living in households with substandard water storage containers have a 2.297 times higher risk of experiencing diarrhea compared to infants from households with standard water storage containers.

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**Table 3.** Relationship Between Toddler Age and the Incidence of Toddler Diarrhea

| Toddler Age | Incidents in Toddlers | | | | | | *p-value* | PR (95% CI) |
|---|---|---|---|---|---|---|---|---|
| | Diarrhea | | No Diarrhea | | Total | | | |
| | n | % | n | % | n | % | | |
| $\leq$ 24 months | 50 | 92.6 | 4 | 7.4 | 54 | 100 | 0.000 | 1.852 (1.336-2.568) |
| $>$ 24 months | 19 | 50 | 19 | 50 | 38 | 100 | | |

*Source : Primary Data 2026*

**Table 4.** Relationship Between Water Quality (E. coli Content) and the Log- t of Toddler Diarrhea Incidence

| Water Quality (E. coli Content) | Incidence in Infants | | | | | | *p-value* | PR (95% CI) |
|---|---|---|---|---|---|---|---|---|
| | Diarrhea | | No Diarrhea | | Total | | | |
| | n | % | n | % | n | % | | |
| Ineligible | 60 | 84.5 | 11 | 15.5 | 71 | 100 | 0.000 | 1.972 (1.191-3.263) |
| Eligible | 9 | 42.9 | 12 | 57.1 | 21 | 100 | | |

*Source : Primary Data 2026*

## 4. DISCUSSION

### 4.1 Relationship Between Toddler Age and of Toddler Diarrhea Incidence

The study results show a significant association between toddler age and the incidence of toddler diarrhea (p-value = 0.000). The highest proportion of diarrhea cases was found among toddlers aged $\leq$ 24 months at 92.6%, compared to those aged > 24 months, which was 50%. Conversely, the proportion of infants who did not experience diarrhea was higher in the age group > 24 months, at 50%, compared to the age group $\leq$ 24 months, at 7.4%. Theoretically, infants belong to an age group with a high level of vulnerability due to an immature immune system, so the body's ability to fight pathogenic infections remains limited. This condition makes infants more susceptible to infection by agents causing diarrhea, such as enteric bacteria, viruses, and parasites, including E. coli, which is commonly found in environments with poor sanitation (World Health Organization, 2024). Susceptibility to diarrhea increases further in infants aged 0–24 months, as during this phase, infants are in the transition period from exclusive breastfeeding to complementary feeding. This transition process increases the risk of exposure to pathogenic microorganisms from the use of unhygienic eating utensils, or from the infant's still-developing digestive system, as well as exploratory behaviors such as putting hands and objects into the mouth (Motuma et al., 2025).

These findings align with the study by (Dzulkifli et al., 2024) , which reported that toddler age significantly influences the occurrence of diarrhea, with children under 24 months having up to 2.5 times the likelihood of experiencing diarrhea compared to toddlers over 24 months (p = 0.001). This confirms that toddler age is a significant factor associated with cases of diarrhea, particularly among those aged 0–24 months who face a higher risk. However, cases of diarrhea are not solely influenced by age alone but result from a combination of biological factors, behavioral factors, the role of caregivers or mothers, and environmental conditions. Thus, the findings of this study confirm that toddler age is associated with the incidence of toddler diarrhea. Therefore, preventive efforts against diarrhea targeting the toddler age group are needed through improved practices of appropriate breastfeeding, hygienic handling and preparation of complementary foods, and the provision of clean water and safe sanitation, particularly in the service area of the Nagaswidak Community Health Center, which is located in a flood-prone area.

### 4.2 The Relationship Between Water Quality Based on E. coli Content and the Incidence of Diarrhea in Toddlers

This study shows a significant association between water quality based on E. coli levels and the incidence of diarrhea among toddlers (p-value = 0.000). Most of the infants with diarrhea came from households with substandard clean water quality (E. coli content), accounting for 84.5%, compared to households with water quality (based on E. coli content) that met standards, accounting for 42.9%. Conversely, infants without diarrhea were more commonly found in households with water quality (based on E. coli levels) that

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**Table 5.** Relationship Between Clean Water Sources and E. coli Levels and the Incidence of Diarrhea in Toddlers

| Clean Water Source | Incidence in Toddlers | | | | | | *p-value* | PR (95% CI) |
|---|---|---|---|---|---|---|---|---|
| | Diarrhea | | No Diarrhea | | Total | | | |
| | n | % | n | % | n | % | | |
| Ineligible | 5 | 41.7 | 7 | 58.3 | 12 | 100 | 0.009 | 0.521 (0.264-1.026) |
| Meet Requirements | 64 | 80 | 16 | 20 | 80 | 100 | | |

*Source : Primary Data 2026*

**Table 6.** Relationship Between Water Treatment and the Incidence of Diarrhea in Toddlers

| Water Treatment | Incidence in Toddlers | | | | | | *p-value* | PR (95% CI) |
|---|---|---|---|---|---|---|---|---|
| | Diarrhea | | No Diarrhea | | Total | | | |
| | n | % | n | % | n | % | | |
| Ineligible | 36 | 83.7 | 7 | 16.3 | 43 | 100 | 0.117 | 1.243 (0.982-1.573) |
| Meet Requirements | 33 | 67.3 | 16 | 32.7 | 47 | 100 | | |

*Source : Primary Data 2026*

met standards (57.1%) compared to households with water quality (based on E. coli levels) that did not meet standards (15.5%). These findings support the study's hypothesis that water quality based on E. coli levels is a risk factor for cases of infant diarrhea.

The detection of E. coli in water indicates fecal contamination, which generally originates from fecal waste entering or being carried into water sources or household water storage containers via flooding. Some E. coli strains are classified as pathogenic and can cause gastrointestinal infections. If water contaminated with these pathogens is consumed or used for daily needs without adequate treatment, the bacteria can infect the body through specific routes and trigger abnormalities in the gastrointestinal tract, characterized by symptoms of diarrhea (World Health Organization, 2022). The findings of this study align with a study by (Husein et al., 2023) in Ghana, which concluded that households with water contaminated with E. coli had a 2.3 times higher risk of infant diarrhea compared to households using water meeting microbiological standards (p = 0.001). These findings indicate that even though the initial water source is classified as safe, microbiological contamination can occur at the household level and impact children's health. This condition is likely due to other factors such as water treatment practices, water storage methods, and the hygiene behaviors of mothers and infants, which could not be fully controlled in this study (Merid et al., 2023) . Thus, the results of this study confirm that water quality based on E. coli content is associated with the incidence of diarrhea in infants. Therefore, preventive measures against diarrhea are needed in the service area of the Nagaswidak Community Health Center by focusing on microbiological water quality monitoring, particularly in flood-prone areas, as well as increasing public education regarding the importance of safe water treatment and storage to protect the health of infants.

### 4.3 The Relationship Between Clean Water Sources and the Incidence of Diarrhea in Toddlers

This study indicates that there is no significant association between clean water sources and the incidence of infant diarrhea (p-value = 0.009) with a PR of 0.521 and a 95% CI of 0.264–1.026, indicating that the Confidence Interval spans the value of 1; thus, from an epidemiological perspective, the relationship between clean water sources and the incidence of infant diarrhea cannot yet be deemed significant. In theory, water sources are the primary environmental determinants involved in the occurrence of diarrhea. Water that does not meet health standards—whether from unprotected sources or due to contamination during distribution and storage—has the potential to serve as a vehicle for the transmission of pathogenic microorganisms causing diarrhea via the fecal-oral route (World Health Organization, 2017) .

In contrast to the findings of this study, the research by Prüss-Ustün et al. (2019) concluded that the use of unsafe water sources is a major contributor to cases of diarrhea among infants, particularly in areas with poor environmental sanitation (Prüss-Ustün et al., 2019). The study by Merid et al. (2023) also suggests that children from households

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**Table 7.** Relationship Between Water Storage Containers and Incidence of Diarrhea in Toddlers

| Water Storage Container | Incidence in Toddlers | | | | | | *p-value* | PR (95% CI) |
|---|---|---|---|---|---|---|---|---|
| | Diarrhea | | No Diarrhea | | Total | | | |
| | n | % | n | % | n | % | | |
| Ineligible | 64 | 82.1 | 14 | 17.9 | 78 | 100 | 0.001 | 2.297(1.129-4.675) |
| Qualifies | 5 | 35.7 | 9 | 64.3 | 14 | 100 | | |

*Source : Primary Data 2026*

without access to safe water sources tend to have a higher risk of diarrhea compared to children using water sources that meet standards. Although municipal water (PDAM) is theoretically considered a safe water source, the quality of water received by the public is not always guaranteed to be safe, especially in flood-prone areas (Merid et al., 2023). Flood-submerged distribution networks, floodwater entering households, and the discharge of domestic wastewater into the surrounding environment can lead to water contamination, affecting both surface water sources, the clean water distribution system, and household storage containers (Wang et al., 2023). Thus, these findings conclude that the type of clean water source used does not directly determine the incidence of diarrhea in infants. It is suspected that other contributing factors exist, such as water storage practices, household hygiene, and environmental sanitation conditions in flood-prone areas, which may contribute to the occurrence of infant diarrhea. Therefore, strategies to prevent diarrhea in infants and toddlers need to focus not only on providing adequate clean water sources but also on improving education regarding sanitation hygiene practices, especially for communities living in flood-prone areas.

### 4.4 The Relationship Between Clean Water Treatment and the Incidence of Infant Diarrhea

TBivariate analysis results indicate that there is no significant association between water treatment and the incidence of infant diarrhea (p-value 0.117). Theoretically, household-level water treatment involves several methods, such as boiling, filtration, the use of disinfectants, and sedimentation. However, the effectiveness of these methods can decrease if the treatment process is not carried out correctly. For example, water that is boiled but does not reach the boiling point, or is boiled for an insufficient amount of time, may still contain pathogenic microorganisms. Water treatment is a preventive measure against diarrhea, but its effectiveness depends heavily on the treatment method used, the consistency of implementation, and post-treatment steps such as storage and water use (World Health Organization, 2017).

In line with the research findings, a study by Komarulzaman et al. (2017) reported that household-level water treatment was not associated with cases of diarrhea in infants ($p > 0.05$), after controlling for environmental and socioeconomic factors. This study confirms that water treatment alone is insufficient to reduce the risk of diarrhea if not accompanied by adequate hygiene and sanitation practices (Komarulzaman et al., 2017). The study by Merid et al. (2023) notes that while water treatment can reduce the risk of diarrhea, its protective effect is diminished if the treated water becomes recontaminated due to unhygienic storage containers or the use of open containers (Merid et al., 2023). Thus, the findings of this study indicate that household water treatment is not significantly associated with the incidence of diarrhea in infants. These findings demonstrate that the relationship between water treatment and the incidence of diarrhea is complex and likely influenced by hygiene behaviors, other sanitation practices, and varying demographic factors across different population contexts. Efforts to prevent diarrhea in infants and toddlers are needed that not only focus on water treatment but must be implemented comprehensively through improvements in environmental sanitation, safe water storage, and enhanced knowledge and hygiene practices among mothers and caregivers, particularly in flood-prone areas.

### 4.5 The Relationship Between Water Storage Containers and the Incidence of Diarrhea in Infants

This study indicates a significant association between water storage containers and the incidence of diarrhea among toddlers (p-value = 0.001). Toddlers with diarrhea were predominantly from households with substandard water storage containers—82.1%—compared to 35.7% in households with standard water storage containers. Conversely, infants with diarrhea were more frequently found in households with compliant water storage containers (64.3%) compared to those with non-compliant containers (17.9%). These findings indicate that the water storage stage at the household level is a critical point in the safe water chain. Theoretically, water quality can degrade during distribution and storage due to recontamination from the environment, equipment, or user behavior (World Health Organization, 2023).

In line with the research by Zora et al. (2022), which

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states that water storage containers are significantly correlated with access to safe water at the household level (p-value = 0.000) (Zora et al., 2022). According to the Ministry of Health's 2020, water storage containers that meet the requirements must be sealed, easy to clean, free from leaks or cracks, and use clean water-drawing tools (Ministry of Health, 2020). However, flooding conditions can potentially lead to contamination of water storage containers, as floods can carry mud and domestic waste, as well as human and animal feces that contaminate the home environment. Based on these findings, the results of this study confirm that water storage containers are significantly associated with the incidence of diarrhea in toddlers. Therefore, efforts are needed that go beyond merely providing clean water sources; these must be balanced with improvements in community knowledge and behavior, particularly regarding mothers' on safe and hygienic water storage practices, especially in areas with high environmental risks such as flood-prone regions.

## 5. CONCLUSION

Based on the results of the data analysis, the researchers concluded that 69 toddlers (75%) had diarrhea, while 23 toddlers (25%) did not. This indicates that the incidence of diarrhea among toddlers in the Nagaswidak Community Health Center's service area is relatively high, as more than half of the respondents had diarrhea. Based on the toddlers' ages, 58.7% were aged $\leq$ 24 months, and 41.3% were > 24 months. Based on water quality (E. coli content), 77.2% of water samples did not meet standards, while 22.8% met standards. Based on water sources, 13% of respondents used water sources that did not meet standards, and 87% used water sources that met standards. Based on water treatment, 46.7% of respondents performed water treatment that did not meet standards, while 53.3% of respondents performed water treatment that met standards. Based on water storage containers, 84.8% of respondents used water storage containers that did not meet standards, and 15.2% of respondents used water storage containers that met standards.

Of the 5 variables studied, only the variables of toddler age (p-value = 0.000), water quality based on E. coli content (p-value = 0.000), and water storage containers (p-value = 0.001) were found to be statistically associated with BABS practices. Meanwhile, the variables of clean water source (p-value = 0.009) and clean water treatment (p-value = 0.117) did not have a significant association with the incidence of infant diarrhea.

## FUNDING

The authors did not receive any financial support for this research.

## CONFLICT OF INTEREST

The authors declare that they have no conflicts of interestrest

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