



ANALYSIS OF RISK DETERMINANTS WITH DIARRHEA INCIDENCE IN TODDLERS

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ABSTRACT

According to the World Health Organization (WHO), diarrhea is a leading cause of morbidity and mortality among children worldwide, particularly in developing countries. Environmental factors, including access to clean water, adequate sanitation facilities, and community hygiene practices, play a significant role in the incidence of diarrhea. This study aims to analyze the risk determinants associated with diarrhea incidence in toddlers in the coastal area of Lake Limboto, Gorontalo Regency. This quantitative study employed an analytical design with a cross-sectional approach. A total of 84 respondents were selected using simple random sampling. Data were collected on variables including respondent knowledge, socio-cultural factors, environmental sanitation, handwashing practices, formula milk feeding, food preparation patterns, and complementary feeding. Statistical analyses were conducted using the chi-square test to determine the bivariate association between each independent variable and diarrhea incidence in toddlers, followed by multivariate analysis using logistic regression to identify the most significant risk determinants. The analysis revealed significant relationships between diarrhea incidence in toddlers and the following variables: respondent knowledge ($p = 0.01$), socio-cultural factors ($p = 0.01$), environmental sanitation ($p = 0.02$), handwashing with soap ($p = 0.00$), formula milk feeding ($p = 0.01$), food cooking patterns ($p = 0.01$), and provision of complementary foods ($p = 0.01$). All examined variables were significantly associated with the incidence of diarrhea in toddlers in the coastal area of Lake Limboto.

Keywords: coastal communities; diarrhea incidence; risk determinants; toddlers' health

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INTRODUCTION

In Indonesia, diarrhea remains one of the major public health concerns due to its relatively high prevalence. This disease is classified as endemic but can escalate into an outbreak (extraordinary event) and has the potential to cause mortality (Iryanto et al., 2021). Although diarrhea is not a new disease, it continues to persist, even in the digital era where access to health information is widely available and easily obtainable. According to data from the Ministry of Health of the Republic of Indonesia, the number of diarrhea cases among toddlers in 2018 was recorded at 37.88%, or approximately 1,516,438 cases. This number increased in the following year, reaching 40% or around 1,591,944 cases in the under-five age group (Setjen Kemenkes RI, 2020).

Recent data from the 2020 Indonesian Nutritional Status Survey (SSGI) indicated a diarrhea prevalence of 9.8% among toddlers. Additionally, diarrhea contributes significantly to under-five mortality. Among children aged 12 to 59 months, diarrhea was the leading cause of death, accounting for 10.3%, an increase from 4.55% in 2020. According to the 2022 SSGI, the prevalence of diarrhea among toddlers in Indonesia reached 10.2%, up from 9.8% the previous year. Although the 2023 Indonesian Health Survey (SKI) reported a decrease in prevalence to 7.4% among children aged 1–4 years, the figure still indicates a high disease burden.

In Gorontalo Province, diarrhea cases also show a concerning trend. Data from the Gorontalo Provincial Health Office recorded a significant increase in diarrhea cases, causing a surge in hospital admissions following the Lebaran holidays in 2025. Gorontalo City reported the highest

number of cases, with 17 hospitalized patients in week 13 and 38 cases in week 14. Based on the 2024 diarrhea case distribution among toddlers from the Gorontalo District Health Office, there were 1,138 cases spread across 23 districts, and in 2025, up to July, 680 cases were recorded.

The coastal areas of Lake Limboto in Gorontalo Regency are characterized by specific environmental conditions, such as inadequate sanitation, limited access to clean water, and relatively high population density. These factors potentially increase the risk of environmentally-transmitted diseases, including diarrhea among young children. Talaga Jaya, Tilango, and Talaga Biru districts are located along Lake Limboto, with diarrhea cases in 2024 totaling 46 cases in Talaga Jaya, 126 in Tilango, and 34 in Talaga Biru. In 2025, 28 cases were reported in Talaga Jaya, 62 in Tilango, and 59 in Talaga Biru. Considering the complex factors influencing diarrhea incidence, a comprehensive analysis is needed to identify the key determinants contributing to increased diarrhea risk among toddlers. This study aims to analyze various risk determinant factors associated with diarrhea in children in the coastal areas of Lake Limboto, with the expectation that the findings will provide a basis for developing more effective and context-specific prevention and intervention strategies at the local level

METHOD

This study employed a cross-sectional design to examine the relationships between various risk factors including maternal knowledge, socio-cultural factors, environmental sanitation, handwashing with soap, formula feeding practices, food preparation patterns, and complementary feeding (MP-ASI) and the incidence of diarrhea in toddlers at the time of the study. The research was conducted in the coastal areas of Lake Limboto, Gorontalo Regency, specifically in Buhu and Hutadaa villages (Talaga Jaya District), Dulomo and Ilotidea villages (Tilango District), and Lupoyo and Timuato villages (Talaga Biru District) in August 2025.

The study population consisted of parents of toddlers registered in the coastal areas of Lake Limboto, totaling 536 individuals. The sample size was determined using Slovin's formula and selected through stratified random sampling, considering the following inclusion criteria: 1) Mothers or guardians with toddlers aged 12–59 months who have resided in the study area for at least six months; 2) Willingness to participate, confirmed through the completion and signing of informed consent; 3) Ability to communicate verbally in either Indonesian or the local language understood by the researchers, enabling participation in interviews or questionnaire completion; 4) Direct experience with diarrhea episodes in their toddler within the past six months.

Data were collected using structured questionnaires and face-to-face interviews with respondents. Before the main data collection, the questionnaire was tested on 30 respondents to ensure its measurement quality. Construct validity was assessed using item–total correlation, where items with $r\text{-count} > r\text{-table}$ ($p < 0.05$) were considered valid. Reliability was tested using Cronbach's Alpha, and all variables demonstrated acceptable internal consistency, with Cronbach's Alpha values ≥ 0.70 . Bivariate analysis was performed using the chi-square test, while multivariate analysis was conducted using logistic regression.

RESULT

Table 1, the distribution of respondents by age among the 84 participants showed that the dominant age group was 26–35 years, comprising 49 respondents (58.3%), while the least represented group was 36–45 years, with only 7 respondents (8.3%). Regarding respondents' residence, the highest number came from Telaga Biru District with 30 respondents (35.7%), followed by Talaga Jaya District with 28 respondents (33.3%), and the fewest from Tilango District with 26 respondents (31%).

Table 1.
Respondent Characteristics

	Characteristics	f	%
Age	17-25	28	33.3
	26-35	49	58.3
	36-45	7	8.3
Address	Telaga Jaya	28	33.3
	Tilango	26	31
	Telaga Biru	30	35.7
Final Education	Elementary School	5	6
	Junior High School	14	16.7
	Senior High School	57	67.9
	Diploma 3/Bachelor's Degree	8	9.5
Mother's Knowledge	Good	39	46.4
	Enough	45	53.6
Socio-Cultural	Support	53	63.1
	Not Supported	31	36.9
Environmental Sanitation	Good	55	65.5
	Bad	29	34.5
Wash Your Hands With Soap	Routine	45	53.6
	Not Routine	39	46.4
Formula Milk Serving	Hygienic	54	64.3
	Unhygienic	30	35.7
Food Cooking Patterns	Hygienic	50	59.5
	Unhygienic	34	40.5
Giving MP-ASI	Compliant with Standards	54	64.3
	Not Up to Standard	30	35.7

The distribution by last education level showed that most respondents had completed high school (SMA), totaling 57 respondents (67.9%), followed by junior high school (SMP) with 14 respondents (16.7%), elementary school (SD) with 5 respondents (6%), and higher education (D3/S1) with 8 respondents (9.5%). Regarding maternal knowledge, 45 respondents (53.6%) were categorized as having sufficient knowledge, while 39 respondents (46.4%) were categorized as having good knowledge. For socio-cultural factors, 53 respondents (63.1%) were in the supportive category, whereas 31 respondents (36.9%) were in the non-supportive category. Environmental sanitation conditions showed that 55 respondents (65.5%) lived in households with good sanitation, while 29 respondents (34.5%) had poor sanitation. Regarding handwashing with soap, 45 respondents (53.6%) practiced it regularly, whereas 39 respondents (46.4%) did not. Concerning formula feeding practices, 54 respondents (64.3%) prepared formula hygienically, while 30 respondents (35.7%) did not. In terms of food preparation practices, 50 respondents (59.5%) followed hygienic cooking practices, whereas 34 respondents (40.5%) did not. Finally, regarding complementary feeding (MP-ASI), 54 respondents (64.3%) provided it according to the standard, while 30 respondents (35.7%) did not.

Table 2.
Analysis of the Relationship between Mother's Knowledge and the Incidence of Diarrhea

Knowledge	Incidence of Diarrhea				Total		P-Value
	Diarrhea		No Diarrhea		n	%	
	n	%	n	%			
Good	22	56.4	17	43.6	39	100	0.01
Enough	37	82.2	8	17.8	45	100	

Based on table 2. showed that of the 39 respondents with good knowledge, there were 22 people (56.4%) whose children had diarrhea and 17 people (43.6%) who did not have diarrhea. Meanwhile, of the 45 respondents with sufficient knowledge, as many as 37 people (82.2%) had diarrhea and only 8 people (17.8%) did not experience diarrhea. The results of the statistical test showed a p-

value of 0.01 (< 0.05), which means that there is a significant relationship between the level of maternal knowledge and the incidence of diarrhea in children in the coastal area of Lake Limboto, Gorontalo Regency. These findings indicate that the better the mother's knowledge about the prevention and treatment of diarrhea, the lower the likelihood of the child developing the disease.

Table 3.
Analysis of the Relationship between Socio-Cultural Factors and the Incidence of Diarrhea

Socio-Cultural Factors	Incidence of Diarrhea				Total		P-Value
	Diarrhea		No Diarrhea		f	%	
	f	%	f	%			
Support	42	79.2	11	20.8	53	100	0.01
Not Supported	17	54.8	14	45.2	31	100	

Based on table 3. It is known that of the 53 respondents with supporting socio-cultural factors, there were 42 people (79.2%) whose children had diarrhea and 11 people (20.8%) who did not have diarrhea. Meanwhile, of the 31 respondents with unsupportive socio-cultural factors, as many as 17 people (54.8%) experienced diarrhea and 14 people (45.2%) did not experience diarrhea. The results of the statistical test showed a p-value of 0.01 (< 0.05), which indicates a significant relationship between socio-cultural factors and the incidence of diarrhea in people in the coastal area of Lake Limboto, Gorontalo Regency. Social environments that support hygienic behaviors, such as handwashing habits, clean water use, and proper food processing, can affect the low incidence of diarrhea.

Table 4.
Analysis of the Relationship between Environmental Sanitation and Diarrhoea

Environmental Sanitation	Incidence of Malaria				Total		P-Value
	Diarrhea		No Diarrhea		f	%	
	f	%	f	%			
Good	43	78.2	12	21.8	55	100	0.02
Bad	16	55.2	13	44.8	29	100	

Based on table 4. It can be seen that of the 55 respondents with good environmental sanitation conditions, as many as 43 people (78.2%) had diarrhea and 12 people (21.8%) did not have diarrhea. Meanwhile, of the 29 respondents who had poor environmental sanitation, there were 16 people (55.2%) who had diarrhea and 13 people (44.8%) who did not have diarrhea. The results of the statistical test showed a p-value of 0.02 (< 0.05), which means that there is a significant relationship between environmental sanitation conditions and the incidence of diarrhea in the coastal area of Lake Limboto, Gorontalo Regency. These findings suggest that environmental sanitation is an important factor in the prevention of diarrheal diseases.

Table 5.
Analysis of the Relationship between Hand Washing with Soap and Diarrhoea

Wash Your Hands With Soap	Incidence of Malaria				Total		P-Value
	Diarrhea		No Diarrhea		f	%	
	f	%	f	%			
Routine	39	86.7	6	13.3	45	100	0.00
Not Routine	20	51.3	19	48.7	39	100	

Based on table 5. that of the 45 respondents who regularly washed their hands using soap, as many as 39 people (86.7%) experienced diarrhea, while 6 people (13.3%) did not experience diarrhea. Meanwhile, in the group of respondents who did not regularly wash their hands with soap, there were 20 people (51.3%) who had diarrhea and 19 people (48.7%) who did not have diarrhea. The results of the statistical test showed a p-value of 0.00 ($p < 0.05$), which means that there is a significant relationship between the habit of washing hands with soap and the incidence of diarrhea in the coastal area of Lake Limboto. These findings indicate that the behavior of washing hands with soap plays an important role in preventing the transmission of diarrhea. Lack of handwashing habits can increase the risk of exposure to pathogenic microorganisms through contaminated hands.

Table 6.
Analysis of the Relationship between Formula Milk Presentation and Diarrhoea Work

Penyajian Susu Formula	Incidence of Malaria				Total		P-Value
	Diarrhea		No Diarrhea		f	%	
	f	%	f	%			
Higienis	43	79.6	11	20.4	54	100	0.01
Tidak Higienis	16	53.3	14	46.7	30	100	

Based on table 6, it is known that of the 54 respondents who served formula milk hygienically, as many as 43 people (79.6%) experienced diarrhea and 11 people (20.4%) did not experience diarrhea. Meanwhile, in the group that served formula milk unhygienically, there were 16 people (53.3%) who had diarrhea and 14 people (46.7%) who did not have diarrhea. The results of the statistical test showed a p-value of 0.01 ($p < 0.05$), which indicates a significant relationship between the level of cleanliness in the presentation of formula milk and the incidence of diarrhea in the coastal area of Lake Limboto. These findings suggest that unhygienic formula serving practices can increase the risk of diarrhea in children. This can be caused by contamination of pathogenic bacteria during the preparation process, improper use of water, or unclean tableware.

Table 7.
Analysis of the Relationship between Food Cooking Patterns and Diarrhoea

Food Cooking Patterns	Incidence of Malaria				Total		P-Value
	Diarrhea		No Diarrhea		f	%	
	f	%	f	%			
Hygienic	40	80	10	20	50	100	0.01
Unhygienic	19	55.9	15	44.1	34	100	

Based on table 7, it is known that out of 50 respondents with hygienic food cooking patterns, as many as 40 people (80%) experienced diarrhea and 10 people (20%) did not experience diarrhea. Meanwhile, of the 34 respondents with unhygienic food cooking patterns, as many as 19 people (55.9%) had diarrhea and 15 people (44.1%) did not have diarrhea. The results of the analysis showed a p-value = 0.01 ($p < 0.05$), which means that there is a statistically significant relationship between food cooking patterns and the incidence of diarrhea in the coastal areas of Lake Limboto. These results indicate that food cooking patterns play an important role in determining the risk of diarrhea in the community.

Table 8.
Analysis of the Relationship between MP-ASI Administration and the incidence of malaria

Giving MP-ASI	Incidence of Malaria				Total		P-Value
	Diarrhea		No Diarrhea		f	%	
	f	%	f	%			
Compliant with Standards	43	79.6	11	20.4	54	100	0.01
Not Consistent with Standar	16	53.3	14	46.7	30	100	

Based on table 8. It is known that of the 54 respondents who gave MP-ASI according to the standard, there were 43 people (79.6%) who had diarrhea and 11 people (20.4%) who did not have diarrhea. Meanwhile, of the 30 respondents who gave MP-ASI that did not meet the standards, there were 16 people (53.3%) children who had diarrhea and 14 people (46.7%) who did not have diarrhea. The results of the statistical test showed a p-value = 0.01 ($p < 0.05$), which means that there is a significant relationship between MP-ASI administration and the incidence of diarrhea in the coastal area of Lake Limboto. These findings show that the pattern and method of MP-ASI administration have an influence on the risk of diarrhea in children.

Based on the results of the analysis in table 9, it is known that the variable of maternal knowledge shows a value of $p = 0.012$ with an odds ratio (OR) = 0.280 (95% CI: 0.104–0.755). An OR value of < 1 indicates that good maternal knowledge is protective against the incidence of diarrhea. Socio-cultural factors also had a significant effect ($p = 0.021$; OR = 3,144; CI 95%: 1,192–8,295).

Table 9.
Analysis of risk determinants with the incidence of diarrhea in toddlers

Research Variables	P-Value	Odds Ratio	95 C.I for EXP (B)	
			Lower	Upper
Maternal Knowledge	0.012	0.280	0.104	0.755
Sociocultural Factors	0.021	3.144	1.192	8.295
Environmental Sanitation	0.031	2.911	1.101	7.697
Handwashing with Soap	0.001	6.175	2.130	17.902
Preparing Formula Milk	0.014	3.420	1.289	9.079
Cooking Patterns	0.020	3.158	1.199	8.320
Providing Complementary Foods	0.014	3.420	1.289	9.079

These results show that toddlers who come from families with socio-cultural habits that do not support clean and healthy living behaviors are 3.1 times more likely to experience diarrhea. Environmental sanitation had a value of $p = 0.031$ and $OR = 2.911$ (95% CI: 1.101–7.697), suggesting that an environment with poor sanitation conditions increases the risk of diarrhea incidence by almost three times compared to a good environment. The variable of handwashing with soap had a value of $p = 0.001$ with $OR = 6.175$ (95% CI: 2.130–17.902), which means that the behavior of not washing hands with soap increased the risk of diarrhea more than sixfold. In the formula milk serving variable, $p = 0.014$ with $OR = 3.420$ (95% CI: 1.289–9.079) was obtained, indicating that the presentation of formula milk that did not meet hygiene standards increased the risk of diarrhea by about 3.4 times. Food cooking patterns also showed significant influence with $p = 0.020$ and $OR = 3.158$ (95% CI: 1.199–8.320). Unhygienic cooking patterns can lead to food contaminated with pathogenic microorganisms, thereby increasing the risk of diarrheal diseases in children. The variable of MP-ASI had $p = 0.014$ with $OR = 3.420$ (95% CI: 1.289–9.079), suggesting that non-standard MP-ASI administration increased the risk of diarrhea 3.4 times greater than prescribed administration.

DISCUSSION

Relationship Between Maternal Knowledge and Diarrhea Incidence

The study found that out of a total of 84 respondents, 59 toddlers (70.2%) experienced diarrhea, while 25 toddlers (29.8%) did not. When analyzed according to maternal knowledge, there was a noticeable difference in diarrhea incidence. Among mothers with good knowledge ($n = 39$), 22 toddlers (56.4%) experienced diarrhea, and 17 toddlers (43.6%) did not. In contrast, in the group of mothers with moderate knowledge ($n = 45$), the number of toddlers with diarrhea was significantly higher, at 37 toddlers (82.2%), while only 8 toddlers (17.8%) were unaffected. Mothers with good knowledge tended to have children who experienced diarrhea less frequently than those with moderate knowledge. Knowledge serves as a foundation for health behaviors because it influences decision-making regarding environmental hygiene, food management, and child care. In the context of diarrhea, maternal knowledge includes understanding the causes, symptoms, and appropriate preventive measures.

Good maternal knowledge directly impacts family health practices, such as handwashing before preparing food, boiling water, and maintaining the cleanliness of feeding utensils. This demonstrates that increasing awareness through health education can reduce the risk of environmentally-transmitted diseases like diarrhea. Conversely, mothers with lower knowledge often fail to recognize the importance of hygiene or how to prevent food contamination, making their children more susceptible to pathogens such as *E. coli* and *Salmonella*. However, even mothers with good knowledge do not always guarantee that their children will remain free from diarrhea. Factors explaining this phenomenon include the inconsistency of implementing knowledge in daily life and environmental conditions. For example, a mother may understand the importance of handwashing but may not do so at critical times, such as before preparing meals or after cleaning her child. Living environments, particularly coastal or densely populated areas, often have poor sanitation, low-quality water, and persistent sources of contamination, exposing children to pathogens despite good household practices. These findings are consistent with Rita et al. (2024) in

Samarinda City, who reported a negative correlation between maternal knowledge and diarrhea incidence in toddlers. Similarly, Suryani & Rini (2023) in Banyumas Regency found that mothers with high knowledge of clean water management and household sanitation had a 56% lower likelihood of having children with diarrhea compared to mothers with low knowledge. Good knowledge increases maternal vigilance toward environmental contamination and proactive preventive measures.

Relationship Between Socio-Cultural Factors and Diarrhea Incidence

The study indicated a relationship between socio-cultural factors and diarrhea incidence in toddlers in the coastal areas of Lake Limboto. Out of 84 respondents, 59 toddlers (70.2%) experienced diarrhea, and 25 toddlers (29.8%) did not. Among families with supportive socio-cultural practices ($n = 53$), 42 toddlers (79.2%) experienced diarrhea, while 11 toddlers (20.8%) did not. Conversely, in the group with non-supportive socio-cultural practices ($n = 31$), 17 toddlers (54.8%) experienced diarrhea, and 14 toddlers (45.2%) did not. Community habits, values, and norms can significantly influence daily health behaviors. In the Lake Limboto coastal area, some communities still use lake water for household needs without boiling it and dispose of domestic waste directly into open water, increasing environmental contamination and the spread of diarrhea-causing pathogens. Socio-cultural factors also encompass child-rearing patterns and traditional food preparation practices. Some communities believe that clear-looking lake water is safe to use without boiling, although it may contain pathogens such as *Vibrio cholerae* and *E. coli*. These beliefs often hinder the adoption of clean and healthy practices. Therefore, behavioral change requires not only knowledge but also culturally sensitive approaches. These findings align with Siregar & Lestari (2023) in Mandailing Natal, who found that socio-cultural factors are significant predictors of diarrhea incidence in rural children. Widyaningsih et al. (2022) also showed that culturally tailored health education reduced diarrhea incidence by 30% in coastal communities of Sulawesi.

Relationship Between Environmental Sanitation and Diarrhea Incidence

Analysis revealed a relationship between environmental sanitation and diarrhea incidence among toddlers in the Lake Limboto coastal area. Out of 84 respondents, 59 toddlers (70.2%) experienced diarrhea, while 25 toddlers (29.8%) did not. Among households with good sanitation ($n = 55$), 43 toddlers (78.2%) experienced diarrhea, and 12 (21.8%) did not. In contrast, in households with poor sanitation ($n = 29$), 16 toddlers (55.2%) experienced diarrhea, and 13 (44.8%) did not. Toddlers living in households with poor sanitation had a threefold higher risk of diarrhea compared to those in households with good sanitation. Environmental sanitation includes water cleanliness, waste disposal systems, availability of healthy latrines, and household waste management. Drinking water contaminated with fecal matter is a primary route for pathogens like *E. coli* and *Shigella sp.* In the coastal areas of Lake Limboto, many households lack permanent clean water access and rely on surface water at high risk of contamination. These results support findings by Rahman et al. (2023), who reported that 64% of diarrhea cases in South Sulawesi occurred in families with poor basic sanitation. Putri et al. (2024) also showed that improving drainage systems and domestic waste management reduced diarrhea incidence by up to 47% in coastal Lombok, highlighting sanitation as a key factor in reducing diarrhea risk.

Relationship Between Handwashing with Soap and Diarrhea Incidence

The study found that many children who regularly practiced handwashing with soap (HWWS) still experienced diarrhea. Among 45 respondents who practiced HWWS regularly, 39 children (86.7%) experienced diarrhea, and only 6 children (13.3%) did not. Conversely, in the group that did not practice HWWS regularly, 20 children (51.3%) experienced diarrhea, while 19 children (48.7%) did not. This difference was statistically significant ($p = 0.00$), indicating a strong relationship between HWWS habits and diarrhea incidence. Children from households without regular HWWS had six times higher risk of diarrhea compared to those with consistent HWWS practices. Hands serve as the primary medium for pathogen transmission from the environment to humans. Proper hand

hygiene, especially at critical times before preparing food, before eating, after defecation, and after cleaning a child effectively prevents gastrointestinal infections. Adib et al. (2022) reported that consistent HWWS practices reduced diarrhea risk by 45%, while Desty et al. (2022) found HWWS could lower gastrointestinal infections by 35% in young children. The Health Belief Model (HBM) explains that risk perception and perceived benefits motivate preventive behaviors. Individuals aware of contamination risks are more likely to wash hands regularly. Therefore, community awareness about HWWS benefits should be promoted through practical health education.

Relationship Between Formula Feeding Practices and Diarrhea Incidence

The study revealed a significant association between formula feeding practices and diarrhea incidence. Among 54 respondents who prepared formula hygienically, 43 children (79.6%) still experienced diarrhea, and 11 (20.4%) did not. In the group with unhygienic formula preparation (n = 30), 16 children (53.3%) experienced diarrhea, and 14 (46.7%) did not (p = 0.01). Toddlers receiving unhygienically prepared formula had three times higher risk of diarrhea compared to those receiving properly prepared formula. Errors included using unboiled water, non-sterile bottles, and storing formula at room temperature for more than two hours, enabling bacterial growth (*E. coli*, *Salmonella* sp., *Enterobacter sakazakii*). Safe formula preparation involves washing hands, sterilizing equipment, using water $\geq 70^{\circ}\text{C}$, and avoiding storage of leftover milk. Marianna & Utami (2021) reported that mothers unaware of proper formula preparation had children with 2.8 times higher diarrhea risk. Pratiwi et al. (2023) found 73% of diarrhea cases in children aged 6–24 months were linked to improper formula handling. Time-saving practices like preparing large quantities for repeated consumption increase contamination risk.

Relationship Between Food Preparation Practices and Diarrhea Incidence

The study indicated a difference in diarrhea incidence between households with hygienic versus unhygienic food preparation practices. In the hygienic cooking group (n = 50), 40 toddlers (80%) experienced diarrhea, while 10 (20%) did not. In the unhygienic group (n = 34), 19 toddlers (55.9%) experienced diarrhea, and 15 (44.1%) did not (p = 0.01). Toddlers from households with unhygienic cooking practices had three times higher risk of diarrhea. Contributing factors included using unclean water, low cooking temperatures, prolonged storage at room temperature, and using non-fresh ingredients, which promote pathogen growth. Proper food preparation should follow food safety standards, such as washing ingredients with clean water, cooking at $\geq 70^{\circ}\text{C}$, and serving immediately. In Lake Limboto coastal areas, limited clean water access and the use of lake water for washing ingredients increase microbiological contamination risk. These findings align with Hidayati & Fitria (2022), showing households cooking below 70°C had 2.3 times higher diarrhea risk. Sopian et al. (2023) also reported significant associations between household food handling practices and diarrhea incidence in coastal Banten, highlighting poor kitchen hygiene and food storage at room temperature.

Relationship Between Complementary Feeding (MP-ASI) and Diarrhea Incidence

The study showed a significant association between MP-ASI practices and diarrhea incidence (p = 0.01). Among toddlers receiving standard MP-ASI (n = 54), 43 (79.6%) experienced diarrhea, and 11 (20.4%) did not. In the non-standard MP-ASI group (n = 30), 16 (53.3%) experienced diarrhea, and 14 (46.7%) did not. Errors included introducing foods too early (<6 months), inappropriate texture, excessive portions, and unclean feeding utensils, which can cause digestive disturbances and facilitate pathogen transmission. Early complementary feeding (<6 months) disrupts immature digestive systems, lowers immunity, and increases contamination risk. Many mothers in coastal areas are unaware of hygiene standards for feeding utensils or safe food storage. Poor sanitation and humid environments accelerate pathogen growth, turning stored food into a medium for *E. coli* and *Campylobacter*. Lubis & Nasution (2023) reported infants receiving MP-ASI before six months had 2.5 times higher diarrhea risk. Ningsih & Putri (2022) emphasized hygiene and using boiled water

during MP-ASI preparation as critical factors in reducing diarrhea risk. Timely and hygienic feeding is thus essential for prevention.

Dominant Factors Associated with Diarrhea Incidence

Multivariate analysis indicated that all independent variables were significantly associated with diarrhea, with handwashing with soap (HWWS) being the most dominant (OR = 6.175; $p = 0.001$). Toddlers from households with poor HWWS practices had six times higher risk of diarrhea. This highlights hand hygiene as a key factor in breaking the transmission chain, especially for exploratory children. The dominance of HWWS in the multivariate model shows that individual hygiene behavior has a stronger impact than environmental factors alone. While maternal knowledge, socio-cultural factors, and environmental sanitation are important, their protective effects are weaker than direct hand hygiene. Adib et al. (2022) reported consistent HWWS reduces diarrhea risk by 45%, and Kusuma & Fitria (2023) showed that providing simple HWWS facilities at home increases compliance by 70%, significantly lowering diarrhea incidence. Other influential factors include formula preparation (OR = 3.420), food preparation practices (OR = 3.158), and MP-ASI (OR = 3.420). These findings underscore the importance of hygienic food handling in preventing diarrhea. Errors in formula or complementary feeding preparation can cause bacterial contamination due to unsafe water or storage conditions (Marianna & Utami, 2021; Lubis & Nasution, 2023). Maternal knowledge also appeared protective (OR = 0.280), indicating mothers with good knowledge had 72% lower likelihood of having children with diarrhea. While the effect is smaller than HWWS, knowledge forms the foundation for health behavior change. The Knowledge-Attitude-Practice (KAP) model asserts that good knowledge fosters positive attitudes and consistent hygiene behaviors. Rita et al. (2024) demonstrated that nutrition and sanitation education reduced diarrhea incidence by 38% within six months. Socio-cultural and environmental sanitation factors also contributed to diarrhea, but their effects were weaker after adjusting for individual behavior. This highlights that infrastructure improvement alone is insufficient; hygienic behavior remains the primary preventive measure. Nurfadilah et al. (2024) noted that clean water and sanitation facilities are effective only when accompanied by proper hygiene practices. In Lake Limboto's coastal areas, where clean water access is limited, hygienic behaviors like handwashing and thorough cooking serve as the main protection against pathogen exposure.

CONCLUSION

This study demonstrates that all variables examined are significantly associated with the incidence of diarrhea in toddlers in the coastal area of Lake Limboto, Gorontalo Regency. These factors include maternal knowledge, socio-cultural conditions, environmental sanitation, handwashing with soap, formula feeding practices, food preparation methods, and complementary feeding (MP-ASI), all of which statistically influence the risk of diarrhea. Multivariate analysis identified handwashing with soap as the most dominant factor, with toddlers from households with poor handwashing practices facing a sixfold higher risk of diarrhea. Other factors, such as formula feeding practices, food preparation methods, and complementary feeding, also contribute substantially, while maternal knowledge serves as a protective factor against diarrhea incidence.

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