

## Predictive Model for Recurrent Diarrhea in Children Aged 12-59 Months at Tanah Kali Kedinding Public Health Center, Surabaya

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### ABSTRACT

**Introduction:** Recurrent diarrhea occurs repeatedly within a short period, between one and three months or more than once per year. Diarrhea is a leading cause of toddler deaths globally, including in Indonesia with 100,000 deaths annually. Identifying factors predicting recurrent diarrhea significantly impacts prevention efforts.

**Objectives:** This research aims to create a prediction model for the incidence of recurrent diarrhea in toddlers at the Tanah Kali Kedinding Community Health Center, Surabaya.

**Methods:** This research method was a retrospective observational analytical study with a case-control design, involving 80 toddlers (40 case samples and 40 control samples) selected through purposive sampling. The sample homogeneity was tested with Levene's test. The independent variable was recurrent diarrhea in toddlers. The dependent variables were birth weight, nutritional status, measles immunization status, vitamin A supplementation, breastfeeding patterns, and mother's hand washing habits. The instrument used was a questionnaire. Data analysis used simple and multiple logistic regression.

**Results:** The research found that recurrent diarrhea was significantly associated with malnutrition status ( $p = 0.008$ ,  $OR = 20.184$ ), measles immunization status ( $p = 0.029$ ,  $OR = 9.599$ ), breastfeeding pattern ( $p = 0.002$ ,  $OR = 15.270$ ), and maternal hand washing habits ( $p = 0.001$ ,  $OR = 15.917$ ). Meanwhile, factors that were not significantly related included birth weight ( $p = 0.397$ ) and vitamin A supplementation ( $p = 0.456$ ).

**Conclusions:** Factors that influenced the formation of a prediction model for the incidence of recurrent diarrhea in toddlers were malnutrition status, measles immunization status, breastfeeding patterns, and mother's hand washing habits.

## Introduction

Diarrhea continues to be a major global health concern, including in Indonesia, where it ranks among the primary causes of illness and death in toddlers globally (WHO, 2020), with approximately 1.9 million children under five dying from diarrhea each year (WHO) and around 100,000 deaths annually in Indonesia (UNICEF). In Indonesia, diarrhea is a common endemic illness that carries the risk of triggering outbreaks (Lawrence & Lestari, 2023). The prevention of diarrhea is crucial in addressing this issue, as one of the steps in achieving the Millennium Development Goals (MDG) Goal 4 is the reduction of child mortality (Diouf, 2019). Furthermore, in achieving the Sustainable Development Goals (SDGs), particularly point 3.2, it is stated that the path toward healthy and prosperous living involves reducing child mortality (Kementerian Perencanaan Pembangunan Nasional/ Badan Perencanaan Pembangunan Nasional, 2017). To reduce child mortality and improve public health quality, a more targeted and evidence-based



approach is needed. This research aims to develop a predictive model for recurrent diarrhea in toddlers by analyzing dominant risk factors. This model will serve as an essential tool for identifying vulnerable groups of toddlers, enabling more effective and efficient preventive interventions. Developing this predictive model can serve as an initial step in creating strategies that directly impact the reduction of recurrent diarrhea cases in toddlers, thereby supporting better child health achievements in Indonesia.

Recurrent diarrhea is defined as diarrhea that occurs repeatedly within short intervals, typically between 1–3 months or more than once a year (Ummah, 2019). Acute diarrhea is defined as the passage of loose stools three or more times daily, lasting no longer than 14 days, while diarrhea lasting more than 14 days is categorized as chronic diarrhea (Ummah, 2019). The latest data from the results of the 2020 Indonesian Nutrition Status Survey, the prevalence of diarrhea in toddlers is at 9.8% (Imran, 2022). According to data (East Java Province Central Statistics Agency, 2022) East Java ranks as the province with the second-highest number of diarrhea cases, totaling 183,338 cases. Meanwhile, Surabaya alone handled 22,327 cases, accounting for nearly 50% of the total diarrhea cases in East Java particularly in the Kenjeran and Sawahan districts (Ernawati, 2015). Recurrent diarrhea significantly contributes to high morbidity and mortality rates due to complications such as severe dehydration, hypovolemic shock, electrolyte imbalance, organ failure, and growth and developmental disorders that can lead to stunting (Wibisono et al., 2020). The more frequently diarrhea occurs in toddlers, the greater their risk of experiencing various complications.

Various studies have shown that recurrent diarrhea in toddlers is influenced by interconnected factors, including Host, Agent, and Environment, as described in the epidemiological triangle. A systematic review conducted by (Khairunnisa et al., 2020) found that recurrent diarrhea is often influenced by factors related to infants and toddlers, their behavior, and environmental conditions. Factors including birth weight, nutritional status, measles immunization, zinc and vitamin A supplementation, breastfeeding patterns, maternal hygiene, and environmental sanitation also significantly affect the incidence of recurrent diarrhea (Proverawati, 2010). Additionally, sociodemographic factors such as parental education, family income, access to clean water, and healthcare services also play a crucial role (Permatasari et al., 2023). Although various studies have identified factors influencing recurrent diarrhea, comprehensive predictive models specifically addressing recurrent diarrhea in toddlers are still limited. Most research emphasizes individual factors without integrating multiple variables into a complete predictive framework.

This research seeks to create a mathematical model to predict the occurrence of recurrent diarrhea among toddlers aged 12–59 months in the service area of Tanah Kali Kedinding Public Health Center in Surabaya, considering risk factors such as birth weight, nutritional status, measles immunization, vitamin A supplementation, breastfeeding patterns, and maternal handwashing habits. Specifically, the research seeks to describe the characteristics of toddlers based on age, gender, vitamin A supplementation sources, and other child and maternal factors. It also aims to analyze the impact of various child-related factors, such as birth weight, nutritional status, measles immunization status, and vitamin A supplementation, as well as maternal factors, including breastfeeding patterns and handwashing habits, on the incidence of recurrent diarrhea. Through this mathematical predictive model, the dominant risk factors influencing recurrent diarrhea in toddlers can be identified, serving as a basis for more focused and effective intervention strategies. The most dominant risk factors contributing to recurrent diarrhea, which will serve as a foundation for targeted, evidence-based interventions to reduce the incidence and impact of recurrent diarrhea, ultimately improving child health outcomes. This research provides



significant benefits by offering a reliable predictive model for recurrent diarrhea incidence, enabling healthcare professionals to carry out more targeted interventions based on the model. The findings of this study can help reduce child mortality, increase knowledge, improve attitudes, and actions within the community in efforts to prevent recurrent diarrhea in toddlers, contribute to achieving global health targets, and enhance the quality of life for the affected population.

## Methods

This study used a retrospective and quantitative case control design. This research was carried out from July to October 2024 at Tanah Kali Kedinding Public Health Center in Kenjeran District, Surabaya, East Java using secondary medical record data and primary data obtained from questionnaires containing questions related to independent variables, as well as interviews conducted to clarify certain questionnaire data, guided by the questions included in the questionnaire. The independent variable in this study is recurrent diarrhea in toddlers, while the dependent variables are birth weight, nutritional status, measles immunization status, Vitamin A supplementation, breastfeeding patterns, and mothers' handwashing habits. The population in this study consisted of all children aged 12–59 months who visited the Public Health Center in Surabaya during July–December 2023, as recorded in the medical records of Tanah Kali Kedinding Public Health Center, Surabaya. The sample size calculation in this study was based on the Lameshow formula. With a case-to-control ratio set at 1:1, the total sample size was determined to be 72. However, to prevent disruptions to the research process due to potential sample withdrawals, the sample size was rounded up to 80, consisting of 40 case samples (children aged 12–59 months with recurrent diarrhea) and 40 control samples (children aged 12–59 months with no diarrhea or mild diarrhea at most once a year).

The samples were selected using purposive sampling from the medical records of Tanah Kali Kedinding Public Health Center in Surabaya during July–December 2023. The homogeneity test of the samples in this study was conducted using Levene's test. The exclusion criteria for both case and control samples were children aged 12–59 months with a history of serious comorbid diseases or severe congenital disorders, as these conditions could affect the study outcomes. The selection of case and control samples was carried out according to the established criteria. The control samples were selected by considering the same age and the occurrence of non-diarrheal illness during the same time period as the case samples, until the sample size was reached. Data were analyzed using univariate, bivariate, and multivariate analysis. Univariate analysis assessed the frequency distribution of each variable. Bivariate analysis, using simple logistic regression, examined the relationship between dependent and independent variables. Multivariate analysis, using multiple logistic regression, identified the most dominant variable and served as a foundation for developing a prediction model. Simple logistic regression explored the effect of one variable, while multiple logistic regression assessed the impact of multiple variables simultaneously.

## Results

### Univariate Analysis

Table 1 Distribution of Case Sample Characteristics of Toddlers

Toddler Characteristics	Frequency (n)	Percentage (%)
Age (months)		
12 - 24	36	90,0%
25 - 36	3	7,5%



37 - 48	1	2,5%
45 - 59	0	0,0%
<b>Gender</b>		
Male	21	52,5%
Female	19	47,5%
<b>Toddler Characteristics (Child Factors)</b>		
<b>Birth Weight</b>		
Normal	32	80,0%
Low Birth Weight	8	20,0%
Macrosomia	0	0,0%
<b>Nutritional Status</b>		
Good Nutrition	17	42,5%
Under Nutrition	12	30,0%
Malnutrition	4	10,0%
At Risk Of Overnutrition	5	12,5%
Overnutrition	2	5,0%
Obesity	0	0,0%
<b>Measles Immunization Status</b>		
Yes	25	62,5%
No	15	37,5%
<b>Vitamin A supplementation</b>		
Yes	31	77,5%
No	9	22,5%
<b>Vitamin A supplementation Location</b>		
Posyandu	25	62,5%
PAUD	3	7,5%
Public Health Center	1	2,5%
Pharmacy	2	5,0%
Did not receive vitamin A	9	22,5%
<b>Toddler Characteristics (Mother Factors)</b>		
<b>Breastfeeding Pattern</b>		
Exclusive Breastfeeding	8	20,0%



Non Exclusive Breastfeeding	32	80,0%
<b>Mother's Handwashing Habits</b>		
Always	9	22,5%
Sometimes	21	52,5%
Rarely	10	25,0%
Never	0	0,0%
<b>Total</b>	<b>40</b>	<b>100,0%</b>

Table 2 Distribution of Control Sample Characteristics of Toddlers

Toddler Characteristics	Frequency (n)	Percentage (%)
<b>Age (Months)</b>		
12 - 24	31	77,5%
25 - 36	6	15,0%
37 - 48	2	5,0%
45 - 59	1	2,5%
<b>Gender</b>		
Male	23	57,5%
Female	17	42,5%
Toddler Characteristics (Child Factors)		
<b>Birth Weight</b>		
Normal	37	92,5%
Low Birth Weight	3	7,5%
Macrosomia	0	0,0%
<b>Nutritional Status</b>		
Good Nutrition	28	70,0%
Under Nutrition	4	10,0%
Malnutrition	2	5,0%
At Risk Of Overnutrition	4	10,0%
Overnutrition	2	5,0%
Obesity	0	0,0%
<b>Measles Immunization Status</b>		
Yes	37	92,5%
No	3	7,5%



<b>Vitamin A supplementation</b>		
Yes	37	92,5%
No	3	7,5%
<b>Vitamin A supplementation Location</b>		
Posyandu	36	90,0%
PAUD	1	2,5%
Public Health Center	0	0,0%
Pharmacy	0	0,0%
Did not receive vitamin A	3	7,5%
Toddler Characteristics (Mother Factors)		
<b>Breastfeeding Pattern</b>		
Exclusive Breastfeeding	26	65,0%
Non Exclusive Breastfeeding	14	35,0%
<b>Mother's Handwashing Habits</b>		
Always	32	80,2%
Sometimes	8	20,0%
Rarely	0	0,0%
Never	0	0,0%
<b>Total</b>	<b>40</b>	<b>100,0%</b>

Table 3 Distribution of Total Toddler Characteristics

Toddler Characteristics	Frequency (n)	Percentage (%)
<b>Age (Months)</b>		
12 - 24	67	83,7%
25 - 36	9	11,2%
37 - 48	3	3,7%
45 - 59	1	1,2%
<b>Gender</b>		
Male	43	53,7%
Female	37	46,2%
Toddler Characteristics (Child Factors)		
<b>Birth Weight</b>		
Normal	69	86,2%
Low Birth Weight	11	13,7%
Macrosomia	0	0,0%
<b>Nutritional Status</b>		



Good Nutrition	45	56,2%
Under Nutrition	16	20,0%
Malnutrition	6	7,5%
At Risk Of Overnutrition	9	11,2%
Overnutrition	4	5,0%
Obesity	0	0,0%
<b>Measles Immunization Status</b>		
Yes	62	77,5%
No	18	22,5%
<b>Vitamin A supplementation</b>		
Yes	68	85,0%
No	12	15,0%
<b>Vitamin A supplementation Location</b>		
Posyandu	61	76,2%
PAUD	2	2,5%
Public Health Center	4	5,0%
Pharmacy	1	1,2%
Did not receive vitamin A	12	15,0%
Toddler Characteristics (Mother Factors)		
<b>Breastfeeding Pattern</b>		
Exclusive Breastfeeding	34	42,5%
Non Exclusive Breastfeeding	46	57,5%
<b>Mother's Handwashing Habits</b>		
Always	41	51,2%
Sometimes	29	36,2%
Rarely	10	12,5%
Never	0	0,0%
<b>Total</b>	<b>80</b>	<b>100,0%</b>

Table 1 displays the characteristics of toddlers in the case sample, showing that most were 12-24 months old, with a balanced gender ratio. Most had normal birth weight, but nutritional status varied, with many experiencing good or insufficient nutrition. Measles immunization and vitamin A coverage were generally high, though some were missed. Most toddlers did not receive exclusive breastfeeding, and mothers' handwashing habits needed improvement. Table 2 describes the control sample, with most toddlers aged 12-24 months and a higher proportion of males. Most had normal birth weight and good nutritional status. Immunization and vitamin A coverage were high, especially through Posyandu. Exclusive breastfeeding was common, and mothers generally had good handwashing habits. Table 3 summarizes the overall distribution, highlighting that toddlers aged 12-24 months were most common. Most had normal birth weight, good nutrition, and received measles immunization and

vitamin A. While most mothers practiced good handwashing, most toddlers did not receive exclusive breastfeeding.

Table 4 Distribution of Recurrent Diarrhea Incidence Based on Birth Weight at Tanah Kali Kedinding Public Health Center, Surabaya City

Birth Weight	Recurrent Diarrhea		Not Recurrent Diarrhea	
	N	%	N	%
Normal	32	80,0%	37	92,5%
Low Birth Weight	8	20,0%	3	7,5%
Macrosomia	0	0,0%	0	0,0%
<b>Total</b>	<b>40</b>	<b>100,0%</b>	<b>40</b>	<b>100,0%</b>

Table 4 is a cross-tabulation table displaying the frequency of recurrent diarrhea incidents based on birth weight. The study found that toddlers with normal birth weight had fewer recurrent diarrhea cases, while those with low birth weight (LBW) were at higher risk.

Table 5 Distribution of Recurrent Diarrhea Incidence Based on Nutritional Status at Tanah Kali Kedinding Public Health Center, Surabaya City

Nutritional Status	Recurrent Diarrhea		Not Recurrent Diarrhea	
	N	%	N	%
Good Nutrition	17	42,5%	28	70,0%
Under Nutrition	12	30,0%	4	10,0%
Malnutrition	4	10,0%	2	5,0%
At Risk Of Overnutrition	5	12,5%	4	10,0%
Overnutrition	2	5,0%	2	5,0%
Obesity	0	0,0%	0	0,0%
<b>Total</b>	<b>40</b>	<b>100,0%</b>	<b>40</b>	<b>100,0%</b>

Table 5 is a cross-tabulation table showing the frequency of recurrent diarrhea incidents based on nutritional status. The study found that toddlers with undernutrition and malnutrition were more prone to recurrent diarrhea than those with good nutritional status. Additionally, 70.0% of good Nutrition toddlers did not experience recurrent diarrhea, indicating that good nutrition may help reduce the risk of recurrent diarrhea.

Table 6 Distribution of Recurrent Diarrhea Incidence Based on Measles Immunization Status at Tanah Kali Kedinding Public Health Center, Surabaya City

Measles Immunization	Recurrent Diarrhea		Not Recurrent Diarrhea	
	N	%	N	%
Yes	25	62,5%	37	92,5%
No	15	37,5%	3	7,5%
<b>Total</b>	<b>40</b>	<b>100,0%</b>	<b>40</b>	<b>100,0%</b>





Table 6 is a cross-tabulation table that shows the frequency of recurrent diarrhea incidents based on measles immunization status. The study results indicate that the majority of toddlers who did not experience recurrent diarrhea had received measles immunization (92.5%). On the other hand, a higher proportion of toddlers who had not been immunized was found in the group experiencing recurrent diarrhea (37.5%). These findings suggest that measles immunization may contribute to reducing the incidence of recurrent diarrhea in toddlers.

Table 7 Distribution of Recurrent Diarrhea Incidence Based on Vitamin A supplementation Status at Tanah Kali Kedinding Public Health Center, Surabaya City

Vitamin A supplementation	Recurrent Diarrhea		Not Recurrent Diarrhea	
	N	%	N	%
Yes	31	77,5%	37	92,5%
No	9	22,5%	3	7,5%
<b>Total</b>	<b>40</b>	<b>100,0%</b>	<b>40</b>	<b>100,0%</b>

Table 7 is a cross-tabulation table that shows the frequency of recurrent diarrhea incidents based on Vitamin A supplementation status. The study found that most toddlers who did not experience recurrent diarrhea (92.5%) had received Vitamin A, while a higher proportion of toddlers who had not received Vitamin A was found in the group experiencing recurrent diarrhea (22.5%). This suggests that Vitamin A supplementation may help reduce the risk of recurrent diarrhea in toddlers, although a significant number of toddlers who received Vitamin A still experienced recurrent diarrhea.

Table 8 Distribution of Recurrent Diarrhea Incidence Based on Breastfeeding Pattern at Tanah Kali Kedinding Public Health Center, Surabaya City

Breastfeeding Pattern	Recurrent Diarrhea		Not Recurrent Diarrhea	
	N	%	N	%
Exclusive Breastfeeding	8	20,0%	26	65,0%
Non Exclusive Breastfeeding	32	80,0%	14	35,0%
<b>Total</b>	<b>40</b>	<b>100,0%</b>	<b>40</b>	<b>100,0%</b>

Table 8 is a cross-tabulation table that shows the frequency of recurrent diarrhea incidents based on breastfeeding patterns. The study found that toddlers who received exclusive breastfeeding tended to have a lower risk of recurrent diarrhea, with 65.0% of those receiving exclusive breastfeeding not experiencing recurrent diarrhea. In contrast, the majority of toddlers who experienced recurrent diarrhea (80.0%) were fed with non-exclusive breastfeeding.

Table 9 Distribution of Recurrent Diarrhea Incidence Based on Mother's Handwashing Habits at Tanah Kali Kedinding Public Health Center, Surabaya City

Mother's Handwashing Habits	Recurrent Diarrhea		Not Recurrent Diarrhea	
	N	%	N	%
Always	9	22,5%	32	80,0%
Sometimes	21	52,5%	8	20,0%
Rarely	10	25,0%	0	0,0%
Never	0	0,0%	0	0,0%



<b>Total</b>	40	100,0%	40	100,0%
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Table 9 is a cross-tabulation table that shows the frequency of recurrent diarrhea incidents based on mothers' handwashing habits. The study found that mothers who always washed their hands tended to have children who experienced recurrent diarrhea less frequently, with a rate of 22.5%. In contrast, children of mothers who washed their hands sometimes (52.5%) or rarely (25.0%) were more likely to experience recurrent diarrhea. These findings emphasize the importance of hand hygiene in preventing diarrhea in toddlers.

### Bivariate Analysis

To identify the dominant factors influencing recurrent diarrhea in toddlers, a multivariate analysis was conducted to explore the relationship between dependent and independent variables. The first step was selecting candidate variables with a p-value <0.25 from the bivariate analysis using simple logistic regression. Table 10 summarizes the results of the simple logistic regression, highlighting factors contributing to recurrent diarrhea in toddlers at Tanah Kali Kedinding Public Health Center, Surabaya.

Table 10 Recapitulation of Simple Logistic Regression Analysis Results on Recurrent Diarrhea Incidents in Toddlers at Tanah Kali Kedinding Public Health Center, Surabaya.

No	Research Variable	Analysis Result				
		B	P value	OR	95% CI for EXP (B)	
					Lower	Upper
1	Birth Weight	1,126	0,117	3,083	0,754	12,613
2	Nutritional Status	-	0,170	-	-	-
3	Measles Immunization	2,001	0,003	7,400	1,939	28,245
4	Vitamin A supplementation Status	1,276	0,072	3,581	0,891	14,391
5	Breastfeeding Pattern	1,856	0,0001	6,397	2,386	17,153
6	Mother's Handwashing Habits	-	0,0001	-	-	-

The findings from the simple logistic regression analysis are presented in Table 10 indicate that the variables meeting the criteria for inclusion in the multivariate modeling, with a p-value <0.25, are birth weight, nutritional status, measles immunization status, Vitamin A supplementation status, breastfeeding patterns, and mothers' handwashing habits. These variables will undergo multivariate analysis with multiple logistic regression.

### Multivariate Analysis

Table 11 contains several independent variables that are suspected to influence the dependent variable, after going through an elimination process with a p-value <0.05.

Table 11 Final Results of Multiple Logistic Regression Analysis on Recurrent Diarrhea Incidents in Toddlers at Tanah Kali Kedinding Public Health Center, Surabaya.

No	Research Variable	Analysis Result				
		B	P value	OR	95% CI for EXP (B)	
					Lower	Upper
1	Nutritional Status (Under Nutrition)	3,005	0,008	20,184	2,219	183,622



2	Measles Immunization	2,262	0,029	9,599	1,266	72,761
3	Breastfeeding Pattern	2,726	0,002	15,270	2,712	85,991
4	Mother's Handwashing Habits (sometimes)	2,767	0,001	15,917	3,172	79,871
<b>Constant</b>		-4,724	0,0001	0,009	-	-

The multivariate analysis is considered significant if ( $p < 0.05$ ). In the final model, four variables were identified as significantly associated to recurrent diarrhea in toddlers: nutritional status (underweight), measles immunization status, breastfeeding patterns, and mothers' handwashing habits (sometimes). The model is deemed valid as it shows significance in the omnibus test ( $p = 0.000$ ) and has a Nagelkerke R Square value of 0.702, indicating that the independent variables account for 70.2% of recurrent diarrhea occurrences. The dominant variable with the greatest influence on the risk of recurrent diarrhea is identified by the highest OR value among the significant variables. In the multivariate analysis results, the variable with the largest OR is nutritional status (underweight), meaning that poor nutritional status is the dominant factor with the greatest influence on the risk of recurrent diarrhea in toddlers.

#### Mathematical Prediction Model for Recurrent Diarrhea Incidents in Toddlers at Tanah Kali Kedinding Public Health Center, Surabaya

The mathematical prediction model for recurrent diarrhea in toddlers can be formulated based on the results of multivariate analysis in table 11 with the following formula:

$$\ln \frac{1}{1-p} = a + b_1x_1 + b_2x_2 + b_3x_3 + \dots$$

So, the prediction model for recurrent diarrhea in toddlers at the Tanah Kali Kedinding Health Center in Surabaya City is:

$$\ln \frac{1}{1-p} = -4,724 + 3,005*(\text{nutritional status}) + 2,262*(\text{Measles Immunization}) + 2,726*(\text{Breastfeeding Pattern}) + 2,767*(\text{Mother's Handwashing Habits})$$

#### Probability of Recurrent Diarrhea in Toddlers at Tanah Kali Kedinding Public Health Center, Surabaya

Probability of recurrent diarrhea in toddlers at Tanah Kali Kedinding Health Center, Surabaya, after the prediction model is structured under the following conditions: malnutrition status, no measles vaccination, non-exclusive breastfeeding pattern, and occasional hand-washing by the mother, is as follows:

$$\ln \frac{1}{1-p} = -4,724 + 3,005*(\text{Undernutrition status}) + 2,262*(\text{No measles immunization status.}) + 2,726*(\text{Non-exclusive breastfeeding pattern}) + 2,767*(\text{Mother's hand-washing habit is occasional})$$

$$P = \frac{1}{1 + e^{-(4,724+3,005(1)+2,262(1)+2,726(1)+2,767(1))}}$$

$$P = \frac{1}{1 + e^{(4,724 - 3,005 - 2,262 - 2,726 - 2,767)}}$$

$$P = \frac{1}{1 + e^{-6,036}}$$

$$P = \frac{1}{1,0023911042}$$

$$P = 0,9976$$



P = 99,76%

Thus, a toddler with malnutrition status, no measles immunization, a non-exclusive breastfeeding pattern, and a mother with an occasional hand-washing habit has a 99.76% probability of experiencing recurrent diarrhea.

Table 12 The results of estimating the probability of nutritional status, measles immunization status, breastfeeding pattern, and mother's hand-washing habit on recurrent diarrhea in toddlers.

No	Independent Variabel				Probability estimation
	Nutritional Status	Measles immunization status	breastfeeding pattern	mother's hand-washing habit	
1	Undernutrition	No	Non-exclusive breastfeeding	Sometimes	99,76%
2	Goodnutrition	No	Non-exclusive breastfeeding	Sometimes	95,39%
3	Undernutrition	Yes	Exclusive breastfeeding	Sometimes	74,03%
4	Undernutrition	Yes	Non-exclusive breastfeeding	Always	73,24%
5	Undernutrition	Yes	Exclusive breastfeeding	Always	15,20%
6	Goodnutrition	Yes	Exclusive breastfeeding	Sometimes	12,37%
7	Goodnutrition	Yes	Non-exclusive breastfeeding	Always	11,94%
8	Goodnutrition	No	exclusive breastfeeding	Always	7,85%
9	Goodnutrition	Yes	exclusive breastfeeding	Always	0,88%

## Discussion

### Characteristics of Toddlers Based on Age

This study found that most toddlers involved, especially those at the Tanah Kali Kedinding Community Health Center, were aged 12–24 months. At this stage, children's immune systems are weaker than those of older children, making them more prone to illnesses, particularly infections (Utami et al., 2023). The 12–24 month age range is a crucial period for monitoring toddler health, as children in this phase undergo rapid physical, cognitive, and socio-emotional development (Widyastuti, 2021). Consequently, they require more intensive health supervision, and parents must remain vigilant in observing their condition. Health interventions during this age are essential for preventing and managing health problems in toddlers.

The lower proportion of toddlers aged 25–36 months (11.2%), 37–48 months (3.7%), and 49–59 months (1.2%) visiting the community health center can be linked to parental attitudes. Parents often feel more reassured as their children grow older, especially after passing the early toddler phase (12–24 months). They might assume that older toddlers are healthier and do not need regular check-ups as frequently. This aligns with research indicating that visits to health facilities tend to decrease as children age (Ray KN, Shi Z, Ganguli I, Rao A, Orav EJ, 2020).



### **Characteristics of Toddlers Based on Gender**

This study revealed that the distribution of toddlers involved, particularly at the Tanah Kali Kedinding Community Health Center, was nearly balanced between boys (53.7%) and girls (46.2%). This finding reflects relatively equal access to primary healthcare services regardless of gender, which is essential to ensuring that every child receives the medical care needed to support their overall health and well-being. However, the slightly higher prevalence of illness among boys indicates a need for special attention to their health. Boys are more vulnerable to certain health conditions, which may explain their higher frequency of healthcare visits. Various factors contribute to this, including boys' increased susceptibility to infections and chronic conditions compared to girls. Biologically, boys tend to have slower immune system development and weaker immune responses than girls (Calabrò A, Accardi G, Aiello A, Caruso C, 2023; Warraich HJ, 2019). A gender-responsive healthcare approach is necessary to address these differences effectively. By understanding the biological, behavioral, and social factors influencing the health of each gender, targeted interventions can be designed to address specific challenges faced by boys and girls.

### **Influence of Birth Weight on the Occurrence of Recurrent Diarrhea in Toddlers**

The result of this study indicate that birth weight was excluded from the outcomes of the multiple logistic regression analysis, suggesting this variable does not significantly influence the occurrence of recurrent diarrhea in toddlers. This result is consistent with a study by (Kurniawati & Martini, 2016), which found no significant relationship between birth weight and the incidence of diarrhea in toddlers, with a p-value of 0.106. Similarly, research by (Nevinia, 2022) also reported no significant association between birth weight and diarrhea occurrence in toddlers. However, this study contrasts with findings by (Kapti et al., 2022) which indicated that birth weight is associated with diarrhea occurrence in toddlers. According to their research, toddlers with low birth weight have a higher risk of diarrhea compared to those with normal birth weight.

In this study, was found to have no considerable impact on recurrent diarrhea in toddlers. This suggests that other factors may play a more dominant role in affecting toddlers' susceptibility to recurrent diarrhea, considering the multifactorial nature of its occurrence. Additionally, the risks associated with low birth weight can be mitigated through age-appropriate feeding practices. Proper feeding can improve toddlers' nutritional status and immunological factors after the neonatal period, contributing significantly to preventing recurrent diarrhea. Birth weight primarily reflects the health condition only at birth and, as such, is not sufficient as a standalone risk indicator for recurrent diarrhea. The subsequent development of a child's health is influenced by more complex and multifaceted factors.

### **Influence of Nutritional Status on the Occurrence of Recurrent Diarrhea in Toddlers**

In this study, under nutritional status was found to significantly influence the incidence of recurrent diarrhea in toddlers. This finding is consistent with a study by (Linda & Daryanti, 2022) which found a significant relationship between nutritional status and the occurrence of diarrhea in toddlers. When a child's nutritional status is poor, they become more susceptible to recurrent illnesses. Similarly, research by (Velentina & Faizah, 2020) showed a significant connection between nutritional status and diarrhea occurrence in toddlers. Poor nutritional status can affect the frequency, duration, and occurrence of diarrhea.

Diarrhea is closely linked to an individual's nutritional status. When nutritional status is good, the body has sufficient capacity to defend against and protect itself from infections. However, when nutrition worsens, immune responses decline, meaning the body's ability to fight infections decreases. Therefore, even mild signs of nutritional deficiencies serve as early indicators of impaired immunity to infections (Velentina et al , 2020). Toddlers with nutritional



problems experience decreased antibody production and atrophy of the intestinal walls, which leads to reduced secretion of enzymes and weakened mucosal barrier protection. This increases their susceptibility to infections and makes it easier for pathogens, particularly those causing diarrhea, to enter the body (Muhammad et al., 2021).

Diarrhea can worsen an individual's nutritional status and conversely, under nutritional status can increase the likelihood of infections, including diarrhea. These two factors have a bidirectional relationship: nutritional status influences the body's response to infections, and infections can impact nutritional status (Brown KH., 2003). Each episode of diarrhea can result in nutrient deficiency due to anorexia and reduced absorption of food, and prolonged or recurrent diarrhea can have an adverse impact on a child's growth and health (Chintya N. Puhi et al., 2023). The duration of diarrhea is affected by several factors, including nutritional status. Diarrhea in toddlers with poor nutritional status may last longer because of slower healing of cells in the small intestine mucosa (Muhammad et al., 2021).

### **Influence of Measles immunization status on the Occurrence of Recurrent Diarrhea in Toddlers**

The results of this study indicate that measles vaccination status significantly influences the incidence of recurrent diarrhea in toddlers. The risk of recurrent diarrhea in toddlers who have not received the measles vaccine is 9.599 times higher compared to those who are vaccinated. This finding aligns with research by (Oktariana et al., 2023) which explains a notable connection between measles vaccination and diarrhea occurrence in toddlers. Similarly, research by (Anggraeni1 et al., 2023) reported that children who have been vaccinated against measles are 0.58 times less likely to develop diarrhea than those who have not been vaccinated. While in the uterus, infants receive maternal antibodies against measles, which protect them from the disease until the time for vaccination. As these maternal antibodies decrease and eventually disappear from the infant's body, measles vaccination becomes crucial and must be administered on time (Susilowati & Hutasoit, 2020).

Immunization is essentially a method to actively enhance a child's immune system against diseases. One of the essential vaccines that should be given to children is the measles vaccine. The measles vaccine provides indirect benefits by enhancing children's overall health and boosting their ability to combat other pathogens responsible for respiratory infections and diarrhea. Children who are vaccinated against measles have a lower risk of developing diarrhea compared to those who are not vaccinated (Anggraeni et al., 2023). Measles vaccination helps prevent toddlers from contracting measles, including secondary complications related to the disease (Oktariana M et al, 2023). The measles virus primarily targets epithelial cells and weakens the immune system, resulting in infections across different organs. In children infected with measles, the respiratory system and intestines are the most affected. When the measles virus attacks the intestinal epithelium, it can trigger enteropathy, causing diarrhea due to protein loss in the digestive tract (Bawankule et al., 2017).

Providing immunity against measles can help reduce the frequency of diarrhea that often accompanies the disease. Diarrhea can occur as a result of the measles virus invading the gastrointestinal mucosa, disrupting its normal function, or due to a decline in immunity in measles patients (Soegijanto, 2002). In toddlers, 1-7% of diarrhea cases are related to measles, and diarrhea associated with measles is typically more severe and longer-lasting (difficult to treat and tends to become chronic) due to damage to the intestinal epithelium (Ulfa & Sufriani, 2016). Therefore, administering the measles vaccine at the recommended age can prevent up to 25% of toddler deaths related to diarrhea (Depkes RI, 2009).



## **Influence of Vitamin A Supplementation on the Occurrence of Recurrent Diarrhea in Toddlers**

In this study, the supplementation of vitamin A was eliminated from the results of the multiple logistic regression analysis, indicating that this variable does not significantly affect the occurrence of recurrent diarrhea in toddlers. This finding is supported by another study conducted by (Susilowati & Hutasoit, 2020), which found no significant relationship between vitamin A supplementation and diarrhea incidence in children aged 12-59 months. However, there are other studies that contradict this result, such as research by (Restuti & Fitri, 2019) which reported a significant relationship between vitamin A intake levels and diarrhea occurrence in toddlers. Similarly, a study by (Mulatya DM, 2020) found a meaningful relationship between vitamin A supplementation and diarrhea incidence in toddlers, with an odds ratio of 0.91.

In this study, vitamin A did not influence the occurrence of recurrent diarrhea in toddlers. This could be because vitamin A is not specifically targeted at gastrointestinal infections. While vitamin A plays an essential role in enhancing immunity and eye health, diarrhea is caused by pathogenic infections such as bacteria, viruses, or parasites. If the source of diarrhea is not related to vitamin A deficiency or its associated immunity, then vitamin A supplementation will not impact the frequency of recurrent diarrhea. Another factor that could have affected the results of this study is that the sample size did not use total sampling, and the data on toddlers experiencing recurrent diarrhea was limited to a 6-month period. Additionally, the supplementation of vitamin A was not validated by the researcher through checking the vitamin A administration records in the maternal and child health book (Buku KIA) or by confirming with the village health cadre to strengthen the responses from the parents.

## **Influence of breastfeeding pattern on the Occurrence of Recurrent Diarrhea in Toddlers**

The results of this study show that the pattern of breastfeeding has a significant relationship with the occurrence of recurrent diarrhea in toddlers. This result is in line with a study by (Simatupang et al., 2022), which states that toddlers who do not receive exclusive breastfeeding are at a higher risk of developing diarrhea compared to those who are exclusively breastfed. Another study by (Bayu et al., 2020) also found a significant relationship between exclusive breastfeeding and the incidence of diarrhea in toddlers.

Breast milk is the best food for infants and toddlers. Overall, breast milk is known to prevent various diseases in children, reduce mortality rates, and lessen the severity of illnesses in infants. Diarrhea is a leading cause of death in infants that can be prevented, one of which is through breastfeeding (Irwan et al., 2023), as breast milk is an essential component of the gastrointestinal mucosal immune system. The nutritional content and energy provided to infants through breastfeeding are crucial for their growth, and the act of breastfeeding indirectly helps reduce the risks and effects of diarrhea in infants.

The colostrum in breast milk contains specific antibodies that boost the baby's immune system (Rafid et al., 2022). In the days following birth, babies cannot build their immune systems, so they rely entirely on the breast milk provided by their mothers. Breast milk also contains lactoferrin, which has the ability to fight viruses and bacteria, as well as high levels of mucosal secretions that provide strong protective functions (Simatupang et al., 2022). Breast milk is a vital component in the infant's immune system. Given these facts, it is highly recommended that breast milk be provided exclusively for the first six months of life, commonly referred to as exclusive breastfeeding. Breast milk serves as a preventive immunological measure due to the antibodies and other beneficial substances it contains. In toddlers, exclusive breastfeeding offers four times more protection against diarrhea than formula feeding (Proverawati, 2010). The normal gut



condition of a breastfed baby prevents the growth of bacteria from formula milk bottles, which can increase the risk of diarrhea.

Introducing non-breast milk supplements to infants under six months leads to digestive and growth disturbances. This shows that the baby's ability to digest and absorb foreign foods is not yet sufficient. Providing anything other than breast milk can directly impact the baby, such as causing digestive issues like diarrhea, constipation, vomiting, and food allergies (Proverawati, 2010). Malabsorption that occurs when infants are given food other than breast milk increases osmotic pressure in the intestinal cavity, causing a shift of water and electrolytes into the intestines, which leads to diarrhea. According to (Proverawati, 2010), the basic mechanism that causes diarrhea is an osmotic disturbance where undigested food or substances increase osmotic pressure in the intestinal cavity. The excess content in the intestines stimulates the intestines to expel the contents, leading to diarrhea.

### **Influence of mother's hand-washing habit on the Occurrence of Recurrent Diarrhea in Toddlers**

The findings from this study indicate that the habit of handwashing among mothers is significantly associated with recurrent diarrhea in toddlers. This result is supported by other research, such as the study by (Solomon et al., 2021), which found that handwashing significantly reduces diarrhea incidents by 41% in the intervention group. Similarly (Setyobudi, I et al, 2020) observed a relationship between maternal handwashing behavior and the occurrence of diarrhea in toddlers. Another study by (Adib et al., 2023) also highlighted that the practice of washing hands with soap is significantly linked to diarrhea incidents in toddlers.

Based on these findings, handwashing is an important behavior in preventing diarrhea, as hands are a common vector for disease transmission via the fecal-oral route (Kementrian Kesehatan RI, 2018). Mothers should make it a habit to clean their hands after using the restroom and after handling children's stool, before eating or feeding their children, and before preparing food. Handwashing with soap is especially important when hands appear dirty, before touching food (especially food intended for children), before eating, and after defecating or changing children's diapers (Adib et al., 2023). Maternal factors also play a role in diarrhea incidents in toddlers, as mothers are the primary caregivers. Thus, the actions a mother takes when a child has diarrhea will influence the progression of the illness (Anggraeni et al., 2021). Diarrhea can occur when hygiene is neglected, and people underestimate the importance of cleanliness. One of the main causes of diarrhea is dirty hands.

Making handwashing with soap a regular habit is the best way to prevent the spread of infectious diseases. Handwashing is a fundamental technique for preventing and controlling infections, including diarrhea. Handwashing with soap involves mechanically removing dirt and debris from the hands using regular soap and running water (Kementrian Kesehatan RI, 2018). Washing hands with just water is less effective in removing harmful germs compared to washing with soap, as water alone does not contain substances that can kill bacteria and germs like *E. coli* (Proverawati, 2010). Handwashing with soap effectively removes most microorganisms from the skin, making it a key practice in preventing diarrheal infections.

### **Dominant Factors Affecting the Occurrence of Recurrent Diarrhea in Toddlers**

The most influential factor in the risk of recurrent diarrhea in toddlers at the Kali Kedinding Health Center in Surabaya is nutritional status. This means that nutritional status is the dominant factor with the greatest impact on the risk of recurrent diarrhea in toddlers. The findings of this study are consistent with research by (Sugiarto et al, 2019), which explains that the dominant factor influencing diarrhea incidents in toddlers is nutritional status, with an odds ratio (OR) of 6.625, the highest among other variables. Similarly, a study by (Baidya et al., 2021)





highlighted that one of the strongest factors related to diarrhea in toddlers is poor nutritional status. Toddlers with suboptimal nutritional status tend to have weaker immune systems, increasing their vulnerability to infections like diarrhea. This indicates that better nutritional interventions and education on the importance of maintaining a clean and healthy lifestyle are essential to prevent recurrent diarrhea incidents.

### **Predictive Model for Recurrent Diarrhea in Toddlers**

The predictive model for recurrent diarrhea in toddlers in this study aims to identify the most influential risk factors, so that it can be used as a guide for effective preventive actions. Based on the analysis, it was found that poor nutritional status, measles immunization status, breastfeeding patterns, and mothers' handwashing habits are the key factors that significantly contribute to the development of this predictive model. The implementation of this model can be applied in healthcare facilities to assist medical staff in identifying high-risk toddlers and providing targeted education on child nutrition, the importance of breastfeeding, immunization, and hand hygiene, thereby significantly reducing the potential for recurrent diarrhea incidents. However, this model has limitations in covering other additional factors, which also play an important role in preventing recurrent diarrhea, and may be considered for inclusion in further model development.

### **Limitations of the Study**

This study utilized a case-control design with a retrospective approach, where data on risk factor exposure relied on the participants' memory, which could result in recall bias. The data collected for this study were based on records available at the health center, meaning the sample was hospital-based or health-center-based rather than population-based. Consequently, the generalizability of the study findings is limited to the broader population.

### **Conclusion**

This study concludes that most toddlers aged 12-24 months had normal birth weight, good nutritional status, measles immunization, and vitamin A supplementation, while maternal factors like non-exclusive breastfeeding and consistent handwashing were common. Nutritional status and measles immunization significantly influence recurrent diarrhea, as do breastfeeding patterns and maternal handwashing habits. Undernutritional status is identified as the most dominant risk factor, emphasizing the need for targeted interventions. The Mathematical Prediction Model developed for recurrent diarrhea in toddlers at the Tanah Kali Kedinding Health Center, Surabaya, is:

$$\ln \frac{1}{1-p} = -4,724 + 3,005*(\text{Nutritional Status}) + 2,262*(\text{measles immunization}) + 2,726*(\text{breastfeeding patterns}) + 2,767*(\text{maternal handwashing habits})$$

### **Ethics approval and consent to participate**

This study has obtained an ethical clearance certificate from the Health Research Ethics Committee of the Faculty of Medicine, Universitas Airlangga, with approval number 42/EC/KEPK/FKUA/2024, valid from July 3, 2024, to July 3, 2025. Additionally, research permits were granted by the Surabaya Investment and One-Stop Integrated Service Office and the Surabaya Health Office on May 27, 2024, under approval number 500.16.7.4/2194/S/RPM/436.7.15/2024.

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