

Investigating the Risk Factors of Diarrhea Among Children of Under Five (5) Years Using Ordinal Logistic Regression Analysis

Babayemi A. Wasiu¹, Gerald I. Onwuka² and Muhammad Bello Babangida³

^{1,2,3}Department of Mathematics, Statistics Unit, Kebbi State University of Science and Technology Aliero, Nigeria.

Corresponding Author's Email: mubarakhassan7@gmail.com

Received on: August, 2024

Revised and Accepted on: September, 2024

Published on: October, 2024

ABSTRACT

Diarrhea remains a significant global health challenge, particularly among children under the age of five, where it contributes substantially to morbidity and mortality rates. Despite being a preventable and treatable condition, it is a leading cause of malnutrition and death among young children, especially in developing nations like Nigeria. This study aims to investigate the association between specific risk factors and the occurrence of diarrhea among children under five years in Sokoto State, Nigeria. Data were collected from parents and guardians of children diagnosed with diarrhea at the Specialist Hospital Sokoto. Key risk factors analyzed included child preceding birth interval, breastfeeding duration, child feeding status, size at birth, and recent history of diarrhea episodes. Using ordinal logistic regression, the findings revealed significant associations between diarrhea and the identified risk factors. Children who were still breastfeeding, had lower feeding frequencies, or were smaller in size at birth were found to have a significantly higher likelihood of experiencing diarrhea. The study underscores the critical importance of targeted health interventions to mitigate these risk factors and reduce the burden of diarrhea in children. These findings provide essential evidence to guide policy formulation, community education programs, and healthcare strategies aimed at improving child health outcomes in Nigeria and other similar settings.

Keywords: Children, Diarrhea, Children under five, Risk factors, Ordinal logistic regression

1.0 BACKGROUND OF THE STUDY

Diarrhea is a major global health concern, particularly for children under the age of five, where it stands as one of the leading causes of illness and death. Annually, it is estimated that 800,000 children in this age group die from diarrhea, with the majority of these deaths occurring in developing nations (Bhutta, 2019). Diarrhea is characterized by the frequent passage of three or more watery or loose stools per day, which is a marked deviation from an individual's normal bowel movements. Unlike the loose stools commonly observed in breastfed babies, diarrhea is preventable and treatable. However, it continues to be a significant contributor to malnutrition and mortality in young children (WHO, 2019).

The burden of diarrheal disease is felt globally, but its impact is particularly severe in low- and middle-income countries. Acute diarrhea is one of the primary health issues affecting children under five, diminishing their overall well-being and increasing the demand for healthcare services. There is a strong correlation between diarrhea, poverty, and unhygienic living conditions, which further exacerbates the problem in developing countries (Andrés *et al.*, 2021).

According to WHO (2022), children under five in developing nations experience an average of three episodes of diarrhea annually. These episodes often lead

to malnutrition, with dehydration being the most critical threat. Severe dehydration can result in death if lost fluids and electrolytes are not promptly replenished. Importantly, a significant proportion of diarrheal cases can be prevented through the identification and mitigation of risk factors (WHO, 2022).

Risk factors for diarrhea among young children include inadequate sanitation, improper breastfeeding practices, child feeding status, short intervals between births, fever in the past two weeks, and the size of the child at birth. Poor sanitation and limited access to potable water also play a crucial role in increasing the disease burden. Despite ongoing efforts, there remains a need to better document the socio-demographic factors associated with diarrhea to inform targeted policies and intervention programs (Asare, *et al.*, 2022).

Although various studies have explored diarrhea and its associated factors across different countries, most have been small-scale, hospital-based, or community-based investigations. Additionally, the prevalence and correlates of diarrhea often vary based on season, geography, and country (Chao *et al.*, 2019).

In developing countries, poor access to safe drinking water, sanitation, and hygiene infrastructure heightens the risk of exposure to viral, bacterial, and parasitic

pathogens causing diarrhea. Furthermore, inappropriate child feeding practices present a significant public health challenge, with extensive social and economic consequences (Rohmawati, 2020).

In Nigeria, diarrhea affects 16% of children under five (non-bloody) and 3% (bloody), making it the second most common ailment after fever, which affects 21% of children. Approximately 15,000 Nigerian children under five suffer at least three episodes of diarrhea annually (Chilambwe *et al.*, 2014). Identifying the underlying causes of diarrhea is essential for implementing effective child health intervention programs, formulating policies, and assessing resource needs to prioritize interventions effectively.

This study seeks to identify the specific risk factors contributing to the occurrence of diarrhea among children aged 0–59 months in Nigeria. By utilizing data obtained from patients at the Specialist Hospital Sokoto, the research aims to provide insights into addressing this critical public health issue.

2.0 LITERATURE REVIEW

Diarrhea continues to be a major global health issue, particularly affecting children under the age of five. This condition poses a significant burden on developing nations, where the prevalence and impact are most pronounced. Research conducted on a global scale has identified several critical risk factors that contribute to the widespread occurrence of diarrhea. Among these are inadequate hygiene practices, suboptimal breastfeeding, malnutrition, and various socio-economic challenges. For example, a study conducted in Indonesia revealed that children who were never breastfed were at the greatest risk of developing diarrhea, highlighting the importance of breastfeeding as a protective measure (Augustina, 2023). Similarly, research findings from India and Brazil shed light on the influence of socio-economic and demographic variables, such as low household income, insufficient sanitation facilities, and the absence of community education programs, all of which exacerbate the prevalence of diarrhea (Gupta, 2024; Ferrer *et al.*, 2019).

In African nations, including Ethiopia, Malawi, and South Sudan, the situation is compounded by several additional factors. Poor sanitation, a lack of maternal education, and unsafe food handling practices have all been identified as major contributors to the high rates of diarrhea in these countries (IVAC, 2022; Chipeta, 2024; Siziya *et al.*, 2023). Moreover, studies conducted in Zambia and Egypt emphasize the detrimental effects of poor feeding practices, incomplete vaccination coverage,

and the pervasive challenges of low socio-economic status. These factors not only increase the risk of diarrhea but also hinder efforts to manage and prevent the condition effectively (Irena *et al.*, 2019; Sayed *et al.*, 2020).

In the Nigerian context, particularly in Sokoto State, diarrhea represents a serious public health concern that disproportionately affects young children under the age of five. The region grapples with a host of interrelated challenges, including insufficient access to clean and safe drinking water, inadequate sanitation infrastructure, and widespread malnutrition. These issues collectively contribute to the high incidence of diarrhea. The financial burden placed on families due to the costs of medical treatment, combined with the strain on already overburdened healthcare systems, further exacerbates the public health challenge posed by this disease (FMOH, 2021; Ameh, 2015).

In conclusion, existing literature consistently highlights the multifaceted nature of diarrhea and underscores the critical need to address its root causes. Socio-economic, environmental, and healthcare-related barriers all play a role in perpetuating the cycle of diarrhea, particularly in regions with a high disease burden, such as Sokoto State. Comprehensive and targeted interventions, alongside well-informed policies, are essential to reduce the impact of diarrhea, safeguard public health, and improve the quality of life for vulnerable populations, especially young children.

3.0 METHODOLOGY

3.1 Data Source

The data for this study were collected from primary sources. To identify various risk factors associated with diarrhea in children aged 0–59 months, a structured questionnaire was developed. The researcher personally visited the pediatric unit of Specialist Hospital, Sokoto, to distribute the questionnaires to parents and guardians of children under five years old, including infants and toddlers. The documented risk factors included the child's preceding birth interval, duration of breastfeeding, feeding practices, history of fever in the last two weeks, size at birth, and diarrhea status.

3.2 Variables Considered

3.2.1 Independent Variables

The independent variables in this study represent the potential risk factors for diarrhea among children under five years of age. These include: Child's preceding birth interval, Duration of breastfeeding, Feeding status of the child, Occurrence of fever in the past two weeks and Size of the child at birth.

3.2.2 Dependent Variable

The dependent variable is the diarrhea status of the child, which is categorized into three levels: **No diarrhea**: No symptoms of diarrhea, **Mild diarrhea**: Mild stomach upset lasting for a day or two, with slight diarrhea, and **Severe diarrhea**: Frequent bowel movements occurring every 1–2 hours or more often.

The classification of diarrhea severity is based on the guidelines provided by the World Health Organization (WHO, 2022).

3.2.3 Model

Given the nature of the problem and the data collected, the study employs the **Ordinal Logistic Regression** model as the primary analytical approach. This model is well-suited for examining the relationships between the categorical levels of diarrhea status and the identified risk factors. Additionally, relevant statistical tests are applied to validate the findings.

3.3 Ordinal Logistic Regression Model

Logistic regression models are classified as multinomial, ordinal, and binary. This study utilizes the Ordinal Logistic Regression model, suitable for analyzing ordered dependent variables and their relationships with explanatory variables, whether continuous or discrete.

Widely used in social sciences and demography, ordinal models analyze discrete, qualitative outcomes. The Proportional Odds Model is the most common, assuming consistent relationships between outcome categories, making it ideal for interpreting ordered data.

3.3.1 Proportional Odds (PO) Model

$$\text{logit} [pr(Y \leq i)] = \alpha_i + \sum_{j=1}^p \beta_j X_j$$

$$i = 1, \dots, c-1 \text{ and } j = 1, \dots, p$$

The model assumes a linear relationship for each logit and parallel regression lines. The above equation is called proportional odds model and it estimates simultaneously multiple equations of cumulative probability. An equation is solved for each category of the dependent variable except the last one.

3.3.2 Partial Proportional Odds Model (PPOM)

$$\lambda_i = \alpha_i + \left\{ \tau_i (\beta_1 + \gamma) X_1 + \dots + (\beta_q + \gamma_i) X_q + (\beta_{q+1} X_{q+1}) + \dots + (\beta_p \gamma) X_p \right\} + k \ln(n) - 2 \ln(L)$$

When the Proportional Odds Assumption is difficult to meet in practice, the Partial Proportional Odds Model (PPOM) can serve as an alternative. This model accommodates covariates that satisfy the proportional odds assumption while allowing flexibility for those that

do not. For such variables, an additional coefficient is included to represent their effect on each cumulative logit, adjusted for other covariates. While the general structure remains similar to the Proportional Odds model, the coefficients vary across the categories of the response variable.

3.4 Odds Ratio

The odds ratio quantifies the strength of the effect of each independent variable on the log odds of the dependent variable in a model. It represents the likelihood of an event occurring relative to its non-occurrence.

The odds of an event E are defined as the ratio of its occurrences to non-occurrences:

$$\text{odds}(E) = \frac{pr(E)}{pr(\text{not}E)} = \frac{pr(E)}{1 - pr(E)}$$

The odds of the response are multiplied by ℓ^β for every unit increment of x . That is, the odds at level $x + 1$ equal the odds at x multiplied by ℓ^β and odds less than one indicate the occurrence is less likely than non-occurrence.

3.5 Model Selection

Forward, backward, and stepwise selection methods are not recommended for logistic regression because they can exclude important variables and lead to inaccurate results. Instead, models should be compared using metrics like the Bayesian Information Criterion (BIC) or Akaike Information Criterion (AIC), which evaluate how well a model's predictions match the true values (Harrell, 2001). While simpler models may not fit as closely to the true model, they can still provide better estimates for certain outcomes, making them a preferable choice. The goal is to choose the model that most accurately reflects reality.

3.5.1 Akaike Information Criterion (AIC)

$$AIC = 2k - 2 \ln(L)$$

Where, k = number of estimated parameters in the model.

L = Maximized likelihood function for the estimated model

3.5.2 Bayesian Information Criterion (BIC)

$$BIC = k \ln(n) - 2 \ln(L)$$

Where, L = The maximized value of the likelihood function of the model, n = The number of observations, or equivalently, the sample size and k = The number of parameters estimated by the model.

3.5.3 Wald Test Statistic

To determine the significance of individual logistic regression coefficients, the Wald Statistic, which is similar to the t-test in linear regression, is utilized. It is the reciprocal of the square of the regression coefficient to the square of the coefficient standard error.

$$W_j = \frac{\hat{\beta}_j^2}{SE(\hat{\beta}_j)^2}$$

Where $\hat{\beta}_j$ represents the estimated coefficient of β and $SE(\hat{\beta}_j)$ is its standard error. Under the null hypothesis $H_0: \beta_j = 0$. The quantity follows a chi-square distribution with one degree of

4.0 RESULTS AND DISCUSSION

4.1 Preliminary Result

The study involves 84 children with no diarrhea, 58 with mild or moderate diarrhea, and 63 with acute or severe diarrhea. It also includes children with varying birth intervals: 66 with no preceding birth interval, 11 with 1-2 years, 88 with 3-4 years, and 40 with 5 or more years between births. The participants' breastfeeding history is diverse: 105 are currently breastfed, 88 were breastfed but are not anymore, and 12 were never breastfed. Feeding rates vary, with 8 children feeding 0-6 times a day, 129 feeding 7-9 times, and 68 feeding 10-12 times a day. In terms of birth size, 36 children were smaller than average, 104 had average size, and 65 were larger than average. Lastly, 170 children had no diarrhea in the past two weeks, while 35 experienced diarrheas during that time.

4.2 Multiple Ordinal Logistic Regression Analysis

The maximum likelihood method is used in estimating the coefficients, the table below shows the estimated results

Table 1: Model 1 - Analysis of Maximum Likelihood Estimates for all the predictor variables

Parameter	Estimate	Standard Error	Wald Test	Sig.
Threshold – 1	-0.270	0.481	15.612	0.000
Threshold – 2	-1.064	0.022	10.152	0.001
Duration of Breast Feeding (DBF)				
Still Breastfeeding				
Ever breastfed, but not currently	1.250	0.626	7.332	0.013
Never breastfed	-0.457	0.336	4.873	0.021
Size of child at Birth (SCB)				
Smaller than Average				
Average	0.510	0.751	3.741	0.004
Large	1.421	0.431	5.448	0.017
Child Feeding Status (CFS)				
Low (0 – 6 times)				
Medium (7 – 9 times)	-1.246	0.336	7.331	0.011
High (10 – 12 times)	-2.126	0.486	3.482	0.027
Child Preceding Birth Interval (CPBI)				
No preceding				
1 – 2 years	0.712	0.761	8.617	0.006
3 – 4 years	0.432	0.818	11.403	0.001
5 – above years	0.113	0.543	9.737	0.006
Had Diarrhea in the past 2 weeks (HP2W)				
Yes				
No	0.812	0.474	0.148	0.140

The maximum likelihood estimate output from table above shows the parameter estimates, their standard errors, the Wald statistic and the associated p-values. Considering the Wald and Significance column in the table, it was revealed that at 95% level of significance the predictors has significant effect on the diarrhea ($p < 0.05$), except for **Had Diarrhea in the past 2 weeks (HP2W)** which is the only non-significant predictor ($P > 0.05$).

Table 2: Model 2 - Analysis of Maximum Likelihood Estimates for only significant predictor variables

Parameter	Estimate	Standard Error	Wald Test	Sig.
Threshold – 1	-0.250	0.476	11.117	0.000
Threshold – 2	-1.184	0.321	9.015	0.001
Duration of Breast Feeding (DBF)				
Still Breastfeeding				
Ever breasted, but not currently	1.028	0.587	5.871	0.002
Never breasted	-0.551	0.439	4.554	0.011
Size of child at Birth (SCB)				
Smaller than Average				
Average	0.817	0.654	2.771	0.002
Large	1.337	0.372	4.769	0.013
Child Feeding Status (CFS)				
Low (0 – 6 times)				
Medium (7 – 9 times)	-1.217	0.217	6.320	0.001
High (10 – 12 times)	-1.961	0.731	4.842	0.006
Child Preceding Birth Interval (CPBI)				
No preceding				
1 – 2 years	0.520	0.643	5.811	0.002
3 – 4 years	0.665	0.319	9.114	0.001
5 – above years	0.281	0.942	5.855	0.003

Table above, shows the maximum likelihood estimates output of the model with only significant predictors.

The Fitted Ordinal Logistic Regression Model with only significant Parameters:

$$\log \left[\frac{\pi_o}{1 - \pi_o} \right] = -0.250 + 1.028DBF_2 - 0.551DBF_3 + 0.817SCB_2 + 1.337SCB_3 -$$

$$1.217CFS_2 - 1.961CFS_3 + 0.520CPBI_2 + 0.665CPBI_3 + 0.281CPBI_4$$

$$\log \left[\frac{(\pi_o + \pi_1)}{1 - (\pi_o + \pi_1)} \right] = -1.184 + 1.028DBF_2 - 0.551DBF_3 + 0.817SCB_2 + 1.337SCB_3 -$$

$$1.217CFS_2 - 1.961CFS_3 + 0.520CPBI_2 + 0.665CPBI_3 + 0.281CPBI_4$$

4.3 Odds Ratios

Table 3: Odds Ratios and Confidence Intervals for the coefficient estimates of the Significant Predictors

Parameter	$(\hat{\beta})$	S.E	95% C.I For OR	
Duration of Breast Feeding (DBF)				
Still Breastfeeding	1.636	0.367	0.917	2.356
Ever breasted, but not currently	1.358	0.370	0.635	2.084
Never breasted (ref)				
Size of child at Birth (SCB)				
Smaller than Average	1.748	0.270	1.277	2.219
Average	1.311	0.222	0.747	2.124
Large (ref)				
Child Feeding Status (CFS)				
Low (0 – 6 times)	2.152	0.441	3.017	4.287
Medium (7 – 9 times)	1.342	0.214	0.761	2.077

High (10 – 12 times) (ref)

Child Preceding Birth Interval (CPBI)

No preceding

1.337 0.276 0.878

1.503

1 – 2 years

1.128 0.426 1.923

1.553

3 – 4 years

1.367 0.265 0.886

2.153

5 – above years (ref)

The results in table above indicate that: children still breastfeeding were 1.636 times more likely to develop diarrhea when compared to children never breastfed. Children ever breastfed, but not currently were 1.385 times more likely to develop diarrhea when compared with children never breastfed.

Child's size at birth appears to be an important indicator of diarrhea risk. Children that are smaller than Average were 1.748 times more likely to develop diarrhea when compared to children of large in size. Again, children with average weight are 1.311 times more likely to develop diarrhea when compared to children of large in size.

Child feeding status also appears to be an important indicator of diarrhea risk. Children with low feeding status (0 – 6 times) appears to be 2.152 times more likely to develop diarrhea when compared to children with high feeding status (10–12 times).

Again children with medium feeding status (7–9 times) appears to be 1.342 times more likely to develop diarrhea when compared to children with high feeding status (10–12 times).

Finally, child preceding birth interval has significant impact on children of under age-5 diarrhea. The result of odds ratio shows that children with no preceding birth interval were 1.337 times more likely to develop diarrhea when compared to children with above 5 years preceding birth interval. Children with (1-2) years preceding birth interval were 1.128 times more likely to develop diarrhea when compared to children with above 5 years preceding birth interval. Again Children with (3–4) years preceding birth interval were 1.367 times more likely to develop diarrhea when compared to children with above 5 years preceding birth interval.

Table 4: Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC)

Model	Akaike Information Criterion (AIC)	Bayesian Information Criterion (BIC)
Model 1 – Model with All Predictors	331.201	279.551
Model 2 – Model with Significant Predictors Only	167.713	141.411

The table above shows the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) of the two models. In selecting the best model for diabetes disease, the calculated AIC and BIC of each model is to be considered. The smaller these values, the better the model fits the data. Hence, the second model which is the model with only significant predictors will be used for prediction.

5.0 CONCLUSION

In this study, some risk factors that influence the occurrence of diarrhea for under five years' children were studied using ordinal logistic regression analysis. The risk factors (independent or predictor variables) were Child receding birth interval, duration of breast feeding, child feeding status, had fever in the past 2 weeks and size of child at birth. The severity of diarrhea (ordinal variable) was considered as the dependent variable. The ordinal logistic regression was fitted after fulfilling its various assumptions. The model was then used to estimate the probability of occurrence of diabetes given the risk factors, respectively.

The significance testing for the ordinal logistic coefficients using Wald test showed that the factors (Child preceding birth interval, duration of breast feeding, child feeding status and size of child at birth) were significant predictors of diarrhea among children ages under-5 years.

In conclusion, the study demonstrated that ordinal logistic regression can be a prevailing statistical technique for exercise when the dependent variable is measured in ordinal scale. Thus, mathematically driven information on these factors is very crucial in order to facilitate change or to make necessary measures to control such factors that are making this problem so extreme.

6.0 RECOMMENDATION

Based on the findings from this study, the following recommendations are made to reduce the burden of diarrhea among children aged under 5.

- i. Policy makers should ensure that health promotion messages reach all masses especially those in the rural areas, by increasing frequency of health

- promotion messages through community health workers by doing house to house visits.
- ii. The long term solution for reducing the morbidity from diarrhea might involve the provision of better health care facilities and effective educational programs that emphasize hygiene strengthening.
 - iii. The government at all level should give more priority attention to seeking ways to bolster the level of awareness of individuals to understanding different risk factors associated with diarrhea disease especially among children aged under-5 and also to establish a working group to oversee this area and encourage appropriate adjunct studies.

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