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Application of Multilevel Binary Logistic Regressions Analysis in Determining Risk Factors of Diarrheal Morbidity among under Five Children in Ethiopia

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Abstract Diarrheal disease is the most common cause of illness and the second leading cause of child death in the world. The burden is greatest in the developing world including Ethiopia. The purpose of this study has been to identify socio-economic, demographic, environmental and nutrition proximate predictors that affecting diarrheal morbidity of under-five children in Ethiopia. In this research data from the Ethiopian Demographic and Health Survey conducted in 2011 was used. Multiple and multilevel binary logistic regressions were employed for data analysis. The prevalence of diarrhea, stunting, wasting, and underweight among under-five children were 15.6%, 37%, 10.2% and 35.3% respectively. Both in multiple binary logistic regression and multilevel logistic regression, it was found that age of child, maternal working status, duration of breast feeding, stunting, wasting, and underweight were significant determinants of childhood diarrhea. From multilevel logistic regression, it was found that the random intercept and fixed coefficients model provided the best fit for the data under consideration. The variance of the random component related to the intercept term was found to be statistically significant implying differences in prevalence of diarrhea among the regions. However, the significant predictors did not show underlying variation from region to region. Therefore, the concerned body should give implement on nutritional intervention activities at all level of the community and Efforts should be invested to educate parents about the importance of breastfeeding and initiate to adopt the culture of breastfeeding their children to reduce the exposure of children to diarrhea. Researchers should use multilevel models than traditional regression methods when their data structure is hierarchal as like in EDHS data.

Keywords Diarrhea, Under five children, Multilevel logistic regression

1. Introduction

Diarrhea remains one of the most common illnesses of children and one of the major causes of infant and childhood mortality in developing countries [1]. Diarrhea is caused by ingesting certain bacteria, viruses or parasites found in fecal matter which may be spread through water, food, hands, eating and drinking utensils, flies, and dirt under fingernails [2]. Diarrhea can last several days, and can leave the body without water and salts that are necessary for survival. Most people who die due to diarrhea actually die as a result of severe dehydration and fluid loss. Children who are malnourished or have impaired immunity are the most vulnerable for life threatening diarrhea [3].

Globally, diarrhea is the third largest cause of morbidity and the sixth largest cause of mortality among population of all ages [4]. Diarrhea disease accounts for approximately 1.34 million deaths among children aged 0-59 months and continued as the second leading cause of death [5].

It is widely recognized that exposure to diarrhea pathogens in developing countries is determined by age of the child, quality and quantity of water, availability of toilet facilities, housing conditions, level of education, household economic status, place of residence, feeding practices and the general sanitary conditions (personal or domestic hygiene) around the house [6]. Persons living in developing countries with poor access to safe water, sanitation, or hygiene infrastructure have increased risk of exposure to viral, bacterial, and parasitic pathogens that can cause diarrheal [7, 8].

In Africa, a child experiences five episodes of diarrhea per year, and 800,000 children die each year from diarrhea related dehydration [9].

In Ethiopia, morbidity reports and community-based studies indicate that diarrheal diseases are a major public health problem that causes excess morbidity and mortality among children [10]. The two-week period prevalence of

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diarrhea among under-five children in Ethiopia and Oromia region were 30.6% and 17.7%, respectively [11]. The 2000 Ethiopia DHS reported that 24 percent of under-five children have experienced diarrhea in the last two weeks prior to the survey [12]. Child diarrheal morbidity remains a major public health problem in Ethiopia. Diarrhea cannot be tackled without understanding its causes that is why the study was crucial to identify the major socio-economic, demographic, nutritional and environmental factors of childhood diarrhea and to estimate the within-regional and between-regional level of difference for the incidence of diarrhea among under five-children in Ethiopia.

2. Material and Methods

Data for this study were taken from the 2011 Ethiopian DHS which was conducted for the third time in Ethiopian the first one being in 2000. Information regarding fertility and family planning behavior, child mortality, nutritional status of children, utilization of maternal and child health services, and knowledge of HIV/AIDS and sexually transmitted diseases (STDs) is available from the data set. The 2011 Ethiopian Demographic and Health Survey (EDHS) is designed to provide estimates for the health and demographic variables of interest for the following domains: Ethiopia as a whole; urban and rural areas of Ethiopia (each as a separate domain); and 11 geographic areas (9 regions and 2 city administrations). In general, the DHS sample is stratified, clustered and selected in two stages. In the 2011 EDHS a representative sample of approximately 17817 households from 624 clusters was selected. In the first stage, 624 clusters (187 urban and 437 rural) were selected from the list of enumeration areas based on the 1994 Population and Housing Census sample frame. A total of children less than 59 months were identified in the households of selected clusters. From 11654 children aged less than 59 months only 9554 were measured for anthropometric measurements height and weight, and with complete information. Thus, the analysis presented in this study on nutritional status will be based on the 9554 children aged less than 59 months.

2.1. Variables Considered in the Study

The response variable of the study is the two weeks incidence of diarrhea prior to the survey and based on the available information, this study examined the influence of the following risk factors for causing diarrhea. Five categories of factors were assessed as independent variables;

i. *Socio-economic and demographic variables*; family size, income, place of residence, maternal education and working status, Marital status, and religion.
ii. *Child characteristics*; Age, Sex, birth order, preceding birth interval, size of child at birth, Having fever recently, and Experience of cough
iii. *Child caring practices*; feeding practice, maternal access to health facilities, and Vaccination status of a child.
iv. *Maternal Caring and characteristics*; number of children ever born, maternal health care, Breast feeding practice,
v. *Environmental Health condition*; Water supply, sanitation and housing conditions
vi. *Child anthropometry indicators:* stunting (chronic malnutrition), wasting (acute malnutrition) and underweight.

2.2. Statistical Methodology

In this study single and multilevel logistic regressions were employed to identify determinant factors of diarrheal morbidity among under-five children and to predict the two weeks probability of under-five children experiencing diarrhea. The response variable of the study is the two weeks incidence of diarrhea prior to the survey. Firstly, single level binary logistic regressions was analysed by assuming the occurrence of diarrhea was independent among under-five children. And finally we assessed the effect of determinant factors and regional difference on incidence of diarrhea using multilevel logistic regression model.

2.2.1. Binary Logistic Regression Model

Let $Y_{n\times 1}$ be a dichotomous outcome random variable with categories 1 (presence of diarrhea) and 0 (absence of diarrhea) in the two weeks prior to the survey. Let $X_{(n\times(k+1))}$ denote the collection of k-predicator variables of the response. Then, the conditional probability that the i^{th} child has diarrhea given the vector of predictor variables X_i is denoted by $\mathrm{P}_i = \mathrm{P}(y_i = 1|\mathrm{X}_i)$. The expression P_i in logistic regression model written in linear combinations of predictors can be expressed in the form of:

$$logit[\mathrm{P_i}] = log\left(\frac{\mathrm{P_i}}{1-\mathrm{P_i}}\right) = \sum_{j=0}^{k} \beta_j \mathrm{X}_{ij} \quad , i = 1,2,\dots n; j = 0,1,\dots,k$$

2.2.2. Multilevel Logistic Regression Model (Two-Level)

Multilevel models are statistical models which allow not only independent variable at any level of hierarchical structure but also at least one random effect above level one group [13].

The binary multilevel logistic regression model has a binary outcome (presence or absence of diarrhea). In this study the basic data structure of the two-level logistic regression is a collection of N groups (regions) and within-group $j\,(j = 1,2,\dots,N)$, a random sample $\mathrm{n_j}$ of level-one units (children). The response variables, i.e., we let $\mathrm{Y}_{ij} = 1$ if the $\mathrm{i^{th}}$ under five children in $\mathrm{j^{th}}$ region has diarrhea, and $\mathrm{Y}_{ij} = 0$ otherwise; with probabilities, $\mathrm{P}_{ij} = \mathrm{P}(y_{ij} = 1|\mathrm{X}_{ij}, u_j)$, is the probability of having diarrhea for children i in region j and u_j is a random cluster effect and often assumed to be $N(0,\sigma_u^2)$. The standard assumption is that Y_{ij} has a Bernoulli distribution. Let P_{ij} be modeled using a logit link function. The two-level model is given by:

$$\mathrm{logit}(p_{ij}) = \log\left(\frac{p_{ij}}{1-p_{ij}}\right) = \beta_{oj} + \sum_{l=1}^{k}\beta_{lj}x_{lij}\ ; \quad l = 1,2,\dots,k$$

Where $\beta_{0j} = \beta_0 + U_{0j}, \beta_{1j} = \beta_1 + U_{1j}, \dots, \beta_{kj} = \beta_k + U_{kj}$

Then level-two model can be rewritten as:,

$$\mathrm{logit}(p_{ij}) = \log\left(\frac{p_{ij}}{1-p_{ij}}\right) = \beta_o + \sum_{l=1}^{k}\beta_l x_{lij} + U_{oj} + \sum_{l=1}^{k}U_{lj}x_{lij}$$

Where $X_{ij} = (X_{1ij}, X_{2ij}, \dots, X_{kij})$ represent the first and the second level covariates, $\beta = (\beta_0, \beta_1, \dots, \beta_k)$ are regression coefficients, $U_{0j}, U_{1j}, \dots, U_{kj}$ are the random effect of model parameter at level two.

2.2.2.1. Empty Multilevel Logistic Regression Model

The empty two-level model for a dichotomous outcome variable refers to a population of groups (level-two units) and specifies the probability distribution for group-dependent probabilities p_j in $Y_{ij} = p_j + \varepsilon_{ij}$ without taking further explanatory variables into account. We focus on the model that specifies the transformed probabilities $f(p_j)$ to have a normal distribution. This is expressed, for a general link function f (p), by the formula

$$f(p_j) = \beta_o + U_{oj}$$

where β_o is the population average of the transformed probabilities and U_{oj} is the random deviation from this average for group j. If $f(p)$ is the logit function, then $f(p_j)$ is just the log-odds for group j. Thus, for the logitlink function, the log-odds have a normal distribution in the population of groups, which is expressed by:

$$logit(p_j) = \beta_o + U_{oj}$$

For the logit function, the so-called logistic transformation of β_0, is defined by

$$\pi_0 = logistic(\beta_0) = \frac{\exp(\beta_0)}{1+\exp(\beta_0)}$$

Note that due to the non-linear nature of the logit link function, there is no a simple relation between the variance of probabilities and the variance of the deviations U_{0j} [14]).

2.2.2.2. Random Intercept Model

In the random intercept model the intercept is the only random effect meaning that the groups differ with respect to the average value of the response variable, but the relation between explanatory and response variables cannot differ between groups. These variables are denoted by $X_h, (h = 1,2,\dots,k)$ with their values indicated by X_{hij}. since some or all of those variables could be level one variables, the success probability is not necessarily the same for all individual in a given group [14].

The random intercept model expresses the log-odds, i.e. the logit of P_{ij}, as a sum of a linear function of the explanatory variables. That is,

$$\mathrm{logit}(P_{ij}) = \log\left(\frac{p_{ij}}{1-p_{ij}}\right) = \beta_{oj} + \beta_1 x_{1ij} + \beta_2 x_{2ij} + \dots + \beta_k x_{kij} = \beta_{oj} + \sum_{h=1}^{k}\beta_h x_{hij}$$

where the intercept term β_{oj} is assumed to vary randomly and is given by the sum of an average intercept β_o and group-dependent deviations U_{oj}, that is

$\beta_{oj} = \beta_o + U_{oj}$

As a result we have: $\mathrm{logit}(P_{ij}) = \beta_o + \sum_{h=1}^{k}\beta_h x_{hij} + U_{oj}$

$$P_{ij} = \frac{e^{\beta_o + \sum_{h=1}^{k}\beta_h X_{hij} + U_{oj}}}{1 + e^{\beta_o + \sum_{h=1}^{k}\beta_h X_{hij} + U_{oj}}}$$

Thus, a unit difference between the X_h values of two individuals in the same group is associated with a difference of β_h in their log-odds, or equivalently, a ratio of $\exp(\beta_h)$ in their odds.

2.2.2.3. Random Coefficient Multilevel Logistic Regression Model

Suppose that there are klevel-one explanatory variables $X_1, X_2, \dots, X_k$, and consider the model where all predictor variables have varying slopes and random intercept. That is

$$\mathrm{logit}(P_{ij}) = \log\left(\frac{p_{ij}}{1-p_{ij}}\right) = \beta_{oj} + \beta_{1j}x_{1ij} + \beta_{2j}x_{2ij} + \dots + \beta_{kj}x_{kij}$$

Letting $\beta_{oj} = \beta_o + U_{oj}$ and $\beta_{hj} = \beta_h + U_{hj}$ where $h = 1, 2, \dots, k$, we have:

$$\mathrm{logit}(P_{ij}) = \log\left(\frac{p_{ij}}{1-p_{ij}}\right) = \beta_o + \sum_{h=1}^{k}\beta_h x_{ij} + U_{oj} + \sum_{h=1}^{k}U_{hj}x_{ij}$$

The first part $\beta_o + \sum_{h=1}^{k}\beta_h x_{ij}$ is called the fixed part of the model, and the second part, $U_{oj} + \sum_{h=1}^{k}U_{hj}x_{ij}$ is called the random part of the model. The random variables or effects $U_{0j}, U_{1j}, \dots, U_{kj}$ are assumed to be independent between groups but may be correlated within groups.

Data processing

First the data checked for completeness and consistency. Then it was coded and entered in the computer using EPI6 software. The software has a program (Epi – Nut) to convert nutritional data into Z – scores of the indices; H/A, W/H and W/A taking age and sex into consideration using NCHS reference population standard of WHO then, the data exported to SPSS and STATA program for analysis.

Table 1. Selected independent variables Analyzed with Incidence of Diarrhea among under-five children in Ethiopia (EDHS, 2011)

Variables	Levels	N	N%	Had diarrhea		DF	Chi-square	p-value
				No	Yes			
Sex of child	Female	4678	49.0%	85.1%	14.9%	1	3.898	0.048*
	Male	4876	51.0%	83.7%	16.3%			
Maternal work	No	6705	70.2%	85.1%	14.9%	1	8.304	0.004**
	Yes	2849	29.8%	82.7%	17.3%			
Maternal age	< 25	2266	23.7%	83.5%	16.5%	2	6.187	0.045*
	25-34	4993	52.3%	84.0%	16.0%			
	35+	2295	24.0%	86.0%	14.0%			
Maternal/caregiver educational level	No education	6657	69.7%	84.5%	15.5%	2	5.496	0.064
	Primary	2431	25.4%	83.5%	16.5%			
	secondary and higher	466	4.9%	87.8%	12.2%			
Place of residence	Rural	8024	84.0%	84.0%	16.0%	1	5.71	0.017*
	Urban	1530	6.0%	86.4%	13.6%			
No of under-five children	<=2	7692	80.5%	84.2%	15.8%	1	1.134	0.287
	>2	1862	19.5%	85.2%	14.8%			
Birth order	Firstborn	1809	18.9%	86.6%	13.4%	3	9.274	0.026*
	2-3	3054	32.0%	84.3%	15.7%			
	4-5	2222	23.3%	83.2%	16.8%			
	6+	2469	25.8%	83.9%	16.1%			
Religion	Christian	4998	52.3%	83.6%	16.4%	2	7.015	0.03*
	Muslim	4365	45.7%	85.4%	14.6%			
	Others	191	2.0%	81.7%	18.3%			
Region	Addis Ababa	321	3.4%	90.0%	10.0%	10	148.385	0.000**
	Tigray	1073	11.2%	86.1%	13.9%			
	Afar	889	9.3%	86.4%	13.6%			
	Amhara	1058	11.1%	85.5%	14.5%			
	Oromya	1504	15.7%	87.7%	12.3%			
	Somali	745	7.8%	79.1%	20.9%			
	Benishangul-Gumuz	828	8.7%	76.9%	23.1%			
	SNNP	1363	14.3%	83.1%	16.9%			
	Gambella	685	7.2%	75.9%	24.1%			
	Harari	508	5.3%	86.8%	13.2%			
	Dire Dawa	580	6.1%	92.6%	7.4%			
Duration of breastfeeding	Never breastfed	145	1.5%	77.9%	22.1%	2	178.563	.000**
	Ever breast fed, not currently breastfed	5098	53.3%	89.0%	11.0%			
	Still breastfeeding	4312	45.1%	79.1%	20.9%			
Source of water supply	Protected	3001	31.4%	84.2%	15.8%	1	0.093	0.76
	Unprotected	6553	68.6%	84.4%	15.6%			
Toilet facility	No	5315	55.6%	83.7%	16.3%	1	4.749	0.029*
	Yes	4239	44.4%	85.3%	14.7%			
Underweight	No	6180	64.7%	86.6%	13.4%	1	63.09	0.000**
	Yes	3374	35.3%	80.4%	19.6%			
Stunting	No	6021	63.0%	85.2%	14.8%	1	8.825	0.003**
	Yes	3533	37.0%	82.9%	17.1%			
Wasting	No	8583	89.8%	85.5%	14.5%	1	75.62	0.000**
	Yes	971	10.2%	74.8	25.2%			
	Yes	971	10.2%	74.8	25.2%			

*significant at 5%, **significant at 1%

3. Results and Discussions

3.1. Result

From sampled children, the two weeks prevalence of diarrhea among under-five children was about 15.6% in Ethiopia. Table 1 show that religion, place of residence, sex of child, birth order, geographical region, duration of breastfeeding, stunting, wasting, and underweight were significantly associated with incidence of diarrhea among under-five children (P<0.05).

The result of table 1also reveals that 49% and 51% were females and males, respectively. The prevalence of diarrhea among females and males were 14.9% and 16.3%, respectively. About 84.0% of under-five children were born to mothers who were resided in rural area and had higher prevalence of diarrhea (16.0%) as compared to under-five children who were born to mother who lived in urban area (13.6%).

Result displayed in Table 1 also showed that, among 9554 respondents, 29.8% of them had work and the prevalence of diarrhea in under-five children whose mothers had work were 17.3%. Majority of under-five children (52.3%) were born to mothers in the age range of 25-34 years, while 23.7% and 24.0% of under-five children were born to mothers aged below 25 and above 34 years, respectively. Two weeks incidence of diarrhea were 16.0% in under-five children from mothers in the age range of 25-34 years, while 16.5% and 14.0% in below 25 and above 34 years old, respectively.

Maternal educational level was categorized into three: 69.7% of under-five children were from uneducated mothers with 15.7% prevalence of diarrhea; 25.4% of under-five children were from mothers with primary education and had 16.5% diarrhea cases, and the remaining 4.9% were from mothers with secondary and higher education and had 12.2% diarrhea case. Gambella, Benshangul-Gumuz, and Somali had highest prevalence of diarrhea, which were 24.1%, 23.1%, and 20.9% respectively. Addis Ababa and Dire Dawa had lowest prevalence of diarrhea, which were 10%, and 7.4%, respectively.

The nutritional status of under-five children was determined by using anthropometric measurements such as wasting stunting and underweight. The result indicates that 10.2% of under-five children were wasted (acute malnutrition), 37% of under-five children were stunted, and 35.3% under-five children were underweight. The prevalence of diarrhea in under-five children with acute malnutrition (wasting), chronic malnutrition (stunting), and underweight (have low weight-for-age) were 25.2%, 17.1%, and 19.6% respectively.

Among 9554 respondents, 68.6% consumed water from unprotected source, and the remaining 31.4% used protected sources of water supply. Under-five children born to mothers who used unprotected source of water had the same prevalence of diarrhea (15.6%) with Under-five children born to mothers who used protected source of water (15.8%).

The coverage of toilet facilities among mothers having Under-five children during 2011 EDHS was 55.6%. The remaining 44.4% of mothers had no private or shared toilet facility, and had higher prevalence of diarrhea (16.3%) compared to mothers with toilet facility (14.7%).

Interpretation of Logistic Regression Coefficients

Results displayed in Table 2 revealed that region, maternal work, age of child in month, duration of breastfeeding, stunting, wasting, and underweight were found to be significant predictors of diarrhea morbidity among under-five children prior to the survey. The other variables such as maternal age, maternal educational level, birth order, the number of under-five children in a household, and sex of child were not significant predictors of childhood diarrhea when the other predictor variables were included in the model.

Under-five children diarrheal morbidity was significantly associated with geographical regions. The odds of having diarrhea in under-five children in Tigray, Afar, Amhara, Oromya, Harari, and Dire-Dawa were not significantly differing from that of under-five children in Addis Ababa. Under-five children in Somali were 2.338 times more likely to have diarrhea than in Addis Ababa city. Under-five children who live in Addis Ababa were less likely to experience diarrhea than children in SNNP, Gambella, and Benshagul-Gumuz.

Child age was significantly associated with incidence of diarrhea. For a month growth in age, the odds of having diarrhea were decreased by 2.6% (0.974-1). Under-five children who ever breastfeeding but not currently were 44.8% (0.552-1, OR: 0.552) less likely to have diarrhea than under-five children who never breastfeeding. Under-five children who were on still breastfeeding, were 36.4% (0.636-1, OR: 0.636) less likely to have diarrhea than under-five children who never breastfeeding. Under-five children whose mothers had work were 12.7% more likely to experience diarrhea than under-five children whose mothers had not work.

Nutritional status of child was significantly associated with diarrheal status of under-five children (P<0.05). Under-five children who were stunting (chronic malnutrition) were 22.6% (1.226-1) more likely to experience diarrhea than children who were not stunted. Under-five children who were wasting (acute malnutrition) were 49.2% (1.492-1) more likely to experience diarrhea than under-five children who were not wasted. Under-five children who were underweight (have low weight-for age) were 54.8% (1.548-1) more likely to experience diarrhea than children who were not underweighted.

Results of Multilevel Logistic Regression Analysis

In the multilevel analysis, a two-level structure is used with regions as the second-level units and under five children as the first level units. This is basically the analysis of region wise variation of incidence of diarrhea among under-five children. Children were nested in regions with a total of 9554 children included in this study.

Table 2. Logistic Regression Results of Incidence of Diarrhea among under-five children, Ethiopia (EDHS, 2011)

Variables	$\hat{\beta}$	$S.E.$	$Wald$	$d.f.$	P-value	$Exp(\hat{\beta})$	95% $CI\ for\ e^{\hat{\beta}}$	
							$Lower$	$Upper$
Age	-0.027	.003	97.287	1	0.000**	.974	.969	.979
Duration of breastfeeding (Never breasted=ref.cat)			9.116	2	0.010**			
Ever breasted, not currently	-0.593	.213	7.741	1	0.005**	.552	.364	.839
Still breast feeding	-0.452	.217	4.346	1	0.037*	.636	.416	.973
Maternal Current Working Status(no=ref.cat)								
Yes	0.245	.064	14.643	1	.000**	1.278	1.127	1.449
Stunting(Height-for-age (H/A): Z-score less than -2) (No=ref.cat)								
Yes	0.203	.078	6.809	1	0.009**	1.226	1.052	1.428
Underweight (Weight-for-age (W/A): Z-score less than -2) (No=ref.cat)								
Yes	0.437	0.080	29.643	1	.000**	1.548	1.322	1.811
Wasting(Weight for Height Z-score less than -2) (No=ref.cat)								
Yes	0.400	.091	19.239	1	0.000**	1.492	1.248	1.784
Region(Addis Ababa=Ref.Category)			134.94	10	0.000**			
Tigray	0.263	0.211	1.553	1	0.213	1.301	.860	1.966
Afar	0.201	0.216	0.867	1	0.352	1.223	.801	1.868
Amhara	0.312	0.211	2.192	1	0.139	1.366	.904	2.066
Oromiya	0.108	0.206	0.274	1	0.601	1.114	.744	1.666
Somali	0.787	0.212	13.810	1	0.000**	2.198	1.451	3.329
Benshangul-Gumuz	0.832	0.208	16.016	1	0.000**	2.298	1.529	3.454
SNNP	0.524	0.204	6.617	1	0.010**	1.688	1.133	2.515
Gambela	0.966	0.211	21.032	1	0.000**	2.627	1.739	3.970
Harari	0.252	0.231	1.187	1	0.276	1.287	.818	2.025
Dire Dawa	-0.434	0.249	3.056	1	0.080	0.648	.398	1.054
Constant	-1.24	0.287	18.802	1	0.000**	0.288		

*Significant at 5%, **significant at 1%, ref.cat-reference category.

Test of Heterogeneity

A chi-square test statistic was applied to assess heterogeneity in the proportion of under-five children who had diarrhea among regions. The test yield χ^2 = 148.385, d.f=10, P<0.000. Thus, there is an evidence of heterogeneity of incidence of diarrhea among regions.

Multilevel Logistic Regression Model Comparison

Table 3. Multilevel Logistic Regression Model for Incidence of Diarrhea and their Deviance Based Chi-square Test Statistics

	Empty model	Random intercept model	Random coefficient model
-2*log likelihood	8175.8534	7799.3388	7797.544
Deviance based chi-square test	106.1646	376.5146	3.5896
P-value	0.0000*	0.0000*	0.6099
Model Fit Diagnostics			
AIC	8179.853	7817.339	7825.544
BIC	8194.183	7881.821	7925.85

*significant at 5% level

The deviance-based chi-square value for the empty model shown in the above Table 3, the significance of this test implies that an empty model with random intercept is better than an empty model without random intercept. The significant deviance-based chi-square value and smallest AIC for random intercept model indicates that the random intercept and fixed slope model is a better fit as compared to the empty model. The deviance-based chi-square test of random effects for random coefficient model is not statistically significant and have larger AIC. This implies that as compared to the model with random intercept and fixed slope model, the random coefficients model found not be better fit. Thus, the deviance-based chi-square test and AIC in the above Table 3 shows that among multilevel logistic regression models, the random intercept and fixed slope model fits significantly better than the other multilevel logistic regression models.

Results of Empty Multilevel Logistic Regression Model

The variance of the random factor is significant which indicates that there is regional variation in experiencing diarrhea among under-five children (Table 4). The intercept β_O= -1.743597 interpreted as the odds of incidence of diarrhea in an average region. That is the intercept informs us that the average probability of incidence of diarrhea everywhere in Ethiopia is exp (-1.743597)/ [1+exp (-1.743597)] = 0.149. The intra-region correlation in intercept only model is 0.041 which is significant at 5% level of significance. This result implied that 4.1% of the variation in the incidence of diarrhea can be explained by grouping the under-five children in regions (higher level units). The remaining (100-4.1%=95.9% of the variation of incidence of diarrhea is explained within region-lower level units.

Table 4. Results for Multilevel Logistic Regression Model without Explanatory Variables

Fixed part	Coefficients	S.E.	Z-value	P-value
$\beta_{o-intercept}$	-1.743597	0.1178177	-14.8	0.000**
Random part	**Estimate**	**S.E.**	**Z-value**	**P-value**
Random intercept $\delta_0^2 = var(U_{oj})$	0.140688 ``	0.0665093	2.115	0.01722*
Rho (ρ)	0.0410165	0.0185969	2.20556	0.013707*
Deviance based chi-square 106.16			0.0000**	

**significant at 1% level, *significant at 5% level

Results of Random Intercept and Fixed Slope Logistic Regression Model

The random intercept and fixed slope logistic regression model is a multilevel model which have random intercept and fixed coefficient of predictors. As can be seen from Table 5, the analysis of multilevel logistic regression revealed that incidence of diarrhea in under-five children varied among regions. The result displayed that the region-wise difference in the incidence of childhood diarrhea was statistically significant. In addition, age of child, maternal working status, duration of breastfeeding, stunting, wasting, and underweight were also found to be significant determinants of variation in incidence of diarrhea among the regions.

The result presented in Table 4 showed that the intra-region correlation coefficient is statistically significant at the 5% level, and 3.92% of total variability of incidence of diarrhea was due variations between regions and the remaining 96.08% (1-0.0392) of total variability of incidence of diarrhea was due variations within regions or under-five children factor. This implies that incidence of diarrhea morbidity among under-five children within region is less homogenous than between regions in Ethiopia.

3.2. Discussions of Results

This study has been an attempt to identify socio-economic, demographic, environmental, and nutrition related determinants of childhood diarrheal morbidity based on Ethiopian Demographic and Health Survey conducted in 2011.

Table 5. Results of Random Intercept and Fixed Coefficient Logistic Regression Model

Fixed part				
Fixed effect	$\hat{\beta}$	**S.E.**	**Z-value**	**P-value**
Age	-.026414	.0026843	-9.84	.000*
Duration of breastfeeding(Never breasted=ref.cat)				
Ever breasted, not currently	-.6010689	.2131114	-2.82	0.005*
Still breast feeding	-.4555433	.2165306	-2.10	0.035*
Maternal Current Working Status(no=ref.cat)				
Yes	.2452757	.0639085	3.84	.000*
Stunting(Height-for-age (H/A): Z-score less than -2) (No=ref.cat)				
Yes	.2021277	.0778864	2.60	0.009*
Underweight (Weight-for-age (W/A): Z-score less than -2) (No=ref.cat)				
Yes	.4378549	.080129	5.46	.000*
Wasting(Weight for Height Z-score less than -2) (No=ref.cat)				
Yes	.400427	.0910844	4.40	.000*
Constant	-.8856897	.2500704	-3.54	.000*
Random part	**Estimate**	**S.E.**	**Z-value**	**P-value**
Random intercept $\delta_0^2 = var(U_{oj})$	0.13432	0.06651	2.02	0.0217*
Intra-region correlation (rho)	.0392259	.0178844	2.1933	0.0141*
Deviance based chi-square	376.5146		0.000*	

*significant at 5% level, (ref) = reference category, ICC: Intra-region correlation

This study revealed that the two weeks prevalence of diarrhea among under-five children were about 15.6% in Ethiopia which is consistent with various research [11, 15-17]. Although the significance disappeared in the multivariate analysis, maternal age; sex of child; place of residence; birth order; religion, and toilet facility were significantly associated with the occurrence of diarrhea in the bivariate analysis. This might be due to methodological differences, and time gap between the current and earlier surveys. But further studies are required to confirm these findings.

The prevalence of diarrhea in Tigray, Affar, Amhara, Oromya, and Harari were not significantly differing from that in Addis Ababa. Under-five children who live in, Somali, SNNPR, Gambella and Benishangul-Gumuz were more likely to experience diarrhea than children who live in Addis Ababa.

This study found that experiencing of diarrhea was significantly associated with age of children. For a unit change in age, the odds of having diarrhea in children were decreased by 2.6%. This finding is in agreement with a study done in Banten Province Indonesia where older children were less likely had chance of having diarrhea than younger children (p-value=0.001) [18]. Children are more vulnerable to diarrhea than adults, because their immune systems are less able to respond to these infections [19].

Under-five children whose mothers had work were 12.7% more likely to experience diarrhea than under-five children whose mothers had not work. These findings contradict those found in Egypt where diarrhea was significantly higher among children having mothers with lower education or not working. This might have mothers working status affect length of breastfeeding [20].

The study revealed that incidence of diarrhea was significantly associated with durations of breastfeeding. Under-five children who had ever been breast fed but not currently had 44.8% less likely to experience diarrhea as compared to under-five children who had never breasted. Under-five children who still breastfeeding were 36.4% less likely to experience diarrhea as compared to under-five children who never breast fed. This present findings is in agreement with a study done in Ghana, found that infants that were either fully breastfed or mixed-fed (fed both breast milk and other foods or liquids) had a lower incidence of diarrhea than non-breastfed infants [21]. This finding had also conformity with a study done in Bangladesh which showed than infants who were partially or not breastfed had a high risk of diarrhea death than exclusively breastfed infants [22]. Not breastfeeding resulted in high exposure of diarrhea morbidity in comparison to exclusive breastfeeding among infants 0-5 months of age (RR: 10.52) [23]. This might be breastfeeding provides vitamins and nutrients that help children develop important antibodies that reduce diarrheal disease.

This study found that incidence of diarrhea was significantly associated with nutritional status of under-five children. The prevalence of diarrhea was higher in stunting under-five children. The odds of having diarrhea in malnourished under-five children were 22.6% higher as compared to under-five children who had no chronic malnutrition. This finding is supported by a study done in Zimbabwe and Bangladesh that showed severely stunted children were more likely to had diarrhea than children of normal height and which had not severe malnutrition [24, 25].

Under-five children who were wasting (acute malnutrition) were 49.2% (1.492-1) more likely to experience diarrhea than under-five children who were not wasted. This present findings is in agreement with a study done in Uganda, which showed that Being wasted increases the probability of occurrence of diarrhea as compared to well-nourished counterparts [26]. The study revealed that incidence of diarrhea was significantly associated with underweight. Under-five children who were underweight (have low weight-for age) were 54.8% (1.548-1) more likely to experience diarrhea than children who were not underweighted

4. Conclusions and Recommendations

4.1. Conclusions

The purpose of this study has been to identify demographic, socio-economic, environmental and nutrition related determinants and to assess regional variation of incidence of childhood diarrhea in Ethiopia. The descriptive results showed that 15.6% of under-five children have experienced diarrhea in the two weeks prior to the time of survey (EDHS 2011).

In this study single level and multilevel logistic regression were used. In the single level logistic regression analysis, age of child, maternal working status, duration of breast feeding, stunting, wasting, and underweight were the most important determinant factors associated with incidence of diarrhea. The incidence of diarrhea was increased with the age of children i.e. the odds of having diarrhea decreased by 2.6% per unit month increment in age of child.

In multilevel logistic regression analysis, under-five children are considered as nested within the various regions in Ethiopia. As a first step in the multilevel approach, non-parametric statistical methods were applied to see if there were differences in the prevalence of diarrhea in under-five children among the regions. The non-parametric approach based on the chi-square test suggests that prevalence of diarrhea in under-five children varies among regions.

Among the three multilevel logistic regressions models, the random intercept and fixed coefficients model provided the best fit for the data under consideration. It found that the prevalence of childhood diarrhea was varying through regions. The significant determinants for the variations of prevalence of diarrhea among regions were age of child, maternal working status, duration of breast fed, stunting, wasting, and underweight.

4.2. Recommendations

Based on the findings of this study we forward the following recommendations:

- Efforts should be invested to educate parents about the importance of breastfeeding and initiate to adopt the culture of breastfeeding their children to reduce the exposure children to diarrhea.
- Efforts should be made to communicate through different programs, such as health and nutritional education, the importance of feeding breast milk and introducing other supplementary nutrient rich foods.
- It is useful to develop a policy for mothers to have sufficient time after giving birth and provide formal and qualified job.
- Further studies should be conducted to identify other correlates of diarrhea that are not analysed in this study such as hygiene practice and sanitation facilities.

REFERENCES

[1] Fagundes U, Andrade A. Acute Diarrhea and malnutrition: Lethality risk in hospitalized Infants. *Journal of the American College of Nutrition* 1999; 8(4): 303-8.

[2] UNICEF-Childinfo. Monitoring the situation of children and women. UNICEF; 2011.

[3] World Health Organization/ United Nation Children's Fund (2009). Diarrhoea: Why Children are Still Dying and What Can be Done? Geneva.

[4] Pond, K., Rueedi, J. and Pedley, S.M. (2004). Pathogens in Drinking Water Sources; Robens Centre for Public and Environmental Health, University of Surrey, UK.

[5] Black, R., Cousens, S., Johnson, H.L., Lawn, J.E., Rudan, I. and Bassani, D.G. (2010). Global, Regional, and National Causes of Child Mortality in 2008: A Systematic Analysis. The Lancet; 375: 1969-1987.

[6] Stephen, G. (2005). Childhood diarrhea in sub-Saharan Africa. http://www.jhpdc.unc.edu/ accessed on November 10, 2010.

[7] Arvelo.W.et.at (2010) Case-control study to determine risk factors for diarrhea among children during a large outbreak in a country with a high prevalence of HIV infection.

[8] Kermani, N.A, Jafari, F, .Mojarad, H. N., Hoseinkhan, N and Zali, M. R. (2010) prevalence and associated factor of persistent diarrhea in Iranian children to pediatric hospital. Eastern Mediterranean health journal vol.16 No.8.

[9] Woldemichael and Gebremariam (2001). Diarrheal Morbidity among Young Children in Eritrea: Environmental and Socio-economic Determinants. J Health Popul Nutr; 19(2): 83-90.

[10] Hamer, D.H., Simon, J., Thea, D., Keusch, G.T. (1998) Childhood diarrhoea in Sub - Saharan Africa. Child Health Research Project Special Report. World Health Organization Vol. 2(1).

[11] Central Statistical Agency (2005). Ethiopia Demographic and Health Survey. Addis Ababa, Ethiopia.

[12] Federal Ministry of Health of Ethiopia (FMOH) Health and Health Related Indicators. Addis Ababa, 2005.

[13] Guo, G. and Zheo, H. (2000). Multilevel Modeling for Binary Data. Annu. Rew Sociol; 26: 441-462.

[14] Snijders, T.A. and Bosker, R.J. (1999). An Introduction to Basic and Advanced Multilevel Modeling, 1st ed. Department of Statistics, University of Poone.

[15] Teklemariam, S., Getaneh, T. and Bekele, F. (2000). Environmental Determinants of Diarrhea Morbidity in Under-Five Children. Keffa-Sheka Zone, Southwest Ethiopia. Ethiop Med J; 38(1): 27-34.

[16] Mitike, G. (2001). Prevalence of Acute and Persistent Diarrhea in North Gondar Zone, Ethiopia. *East Afr Med J;* 78(8): 44-48.

[17] Muluken Dessalegn, Abera Kumie, Worku Tefera Predictors of under-five childhood diarrhea: Mecha District, West Gojam, EthiopiaEthiop. J. Health Dev 2011; 25(3).

[18] Mrs.Nida Rohmawati (2010) facror associated with diarrhea among under five years old children in Banten province Indonesia.

[19] Lochery, P. (2005). The Impact of Water and Sanitation on the Health of Children Under-Five: Global Health Council.

[20] El-Gilany, A. and Hammad, S. (2005). Epidemiology of Diarrhoeal Diseases among Children under Age Five Years in Dakahlia, Egypt. Volume 11, No 4.

[21] Ahiadeke, C. (2000). Breaste-feeding, diarrhoea and sanitation as components of infant and child health: A study of large scale survey data from Ghana and Nigeria [Electronic version]. *Joournal of Biosocial Science,* 32. 47-61.

[22] Arifeen, S., Black, R.E., Antelman, G., Baqui, A., Caulfield, L. and Becker, S. (2001). Exclusive Breastfeeding Reduces Acute Respiratory Infection and Diarrhea Deaths among Infants in Dhaka Slums. Pediatrics; 108:67.

[23] Lamberti, L., Walker, C.F., Noiman, A., Victora, C. and Black, R.E. (2011). Breastfeeding and the Risk for Diarrhea Morbidity and Mortality. BMC Public Health, 11(Suppl 3): 1471-2458.

[24] Root, G.P. (1997). Evidence of Malnutrition Having a Threshold Effect on the Risk of Childhood Diarrhea in Zimbabwe. Cent Afr J Med; 43(7): 185-188.

[25] Fauveau, V., Henry, F.J., Briend, A., Yunus, M., Chakra B.J. (1992). Persistent Diarrhea as a Cause of Childhood Mortality in Rural Bangladesh. Acta Paediatrica Supplement; 381: 12–14.

[26] Bbaale E. Determinants of diarrhoea and acute respiratory infection among under fives in Uganda. AMJ 2011, 4, 7, 400-409.