Determinants of Wasting Among Under-Five Children in Ethiopia: (A Multilevel Logistic Regression Model Approach)

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Abstract: Child malnutrition in Ethiopia is one of the most serious public health problems and the highest in the world. Wasting refers to low weight-for-height and measures the body's mass in relation to body length. The objective of this study was to identify determinants of wasting among under-five children in Ethiopia. The study used data collected in the Ethiopian Demographic and Health Survey in 2010/2011. A total of 9611 under-five age children were included in the present study. To analyze the data descriptive statistics and multilevel binary logistic regression techniques were employed. The descriptive statistics results indicate that about 11.7 % of under-five children in Ethiopia were wasted. The results of study indicated that the risk of wasting was highest among male children, small size at birth, children whose parents resided in rural areas, children's of illiterate mothers, children whose mother's body mass index was low, children from poor families and children who had diarrhea and fever two weeks before the date of the survey. The multilevel model also showed the existence of significant variations in the prevalence of wasting among the regions in Ethiopia.

Keywords: Children, Malnutrition, Wasting, Multilevel, Logistic.

INTRODUCTION

Malnutrition continues to be a major public health problem in developing countries like Ethiopia. It is an underlying cause of child morbidity and mortality and the most important risk factor for the burden of disease causing about 300, 000 deaths per year directly and indirectly responsible for more than half of all deaths in children [1,2]. Much of the burden of deaths resulting from malnutrition, estimated to be over half of childhood deaths in developing countries, can be attributed to just mild and moderate malnutrition, varying from 45% for deaths due to measles to 61% for deaths due to diarrhea [3]. It is estimated that 53 percent of deaths among pre-school children in the developing world are due to the underlying effects of malnutrition on diseases such as measles, pneumonia, and diarrhea.

Malnutrition in children is the consequence of a range of factors that are often related to poor food quality, insufficient food intake, and severe and repeated infection diseases, or frequently some combinations of the three. These conditions, in turn, are closely linked to the overall standard of living and whether a population can meet its basic needs, such as access to food, housing and health care. Growth assessment, thus, not only does it serve as a means for evaluating the health and nutritional status of children but also provides an indirect measurement of the quality of life of an entire population [4].

"The weight-for-height index measures body mass in relation to body length, which shows current nutritional status. Children whose weight-for-height is below minus two standard deviations (-2SD) from the median of the reference population are too thin for their height, or wasted, while those who measure below minus three standard deviations (-3SD) from the reference population median are severely wasted. Wasting represents the failure to receive adequate nutrition during the period immediately, before the survey and usually shows marked seasonal patterns associated with changes in food availability or disease prevalence. It might be the result of recent episodes of illness, particularly diarrhea; improper feeding practices; or acute food shortage" [5].

In Ethiopia, child malnutrition rate is one of the most serious public health problems and the highest in the world [6]. High malnutrition rates in the country pose a significant obstacle to achieving better child health outcomes. According to the 2011 Ethiopian Demographic and Health Survey report nutritional status of children for the period 2000, 2005 and 2011 showed the prevalence of wasting in Ethiopia has remained constant over the last 11 years [7]. So to reduce the current rate of acute malnutrition (wasting) one should understand its causes. It is, therefore, important to examine the risk factors for wasting of children. The objective of this study is to determine prevalence of under-five children wasting in Ethiopia, to

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identify demographic, socio-economic and health related factors of wasting among under-five children in Ethiopia and to examine the extent of the variation in wasting within and between regions of Ethiopia.

DATA AND METHODOLOGY

The Data

The data used in this study was secondary data collected by the 2011 Ethiopia Demographic and Health Survey data [7]. The analysis presented in this study on nutritional status of children in terms of weight for height is based on the 9611 children aged less than 59 months with complete anthropometric measurements.

Variables Included in the Study

Response Variable

The response variable of interest is child nutritional status wasting coded as Weight for Height Z-scores (standard deviation scores) $\geq$-2SD (Not wasted) and <-2SD (Wasted).

Independent Variables

The variables are factors affecting children malnutrition. Those variables are demographic, socioeconomic and health related variables: Gender of child, Child's age in months, birth order, size of children at birth, Number of household members, federal regional state, Place of residence, mother's educational level, wealth index of house hold, body mass index of mother, Had diarrhea in last two weeks before survey and Had fever in last two weeks before survey.

Methodology

Multilevel Logistic Regression Model

Multilevel analysis is a statistical approach that can be used for clustered sources of variability in multilevel data, which involves units at a higher level. It can take into account the variability associated with each level of the hierarchy [8]. In data with a hierarchical structure, individuals are not treated as independent, they are considered nested in a larger unit. Thus, multilevel analysis provides an approach to examining the effects of individual-level and group-level variables simultaneously. It can also estimate both between group and within group variations, and help to figure out how those levels interact with each other. Thus, multilevel models were used in order to draw insights regarding the causes of both the inter-individual and the inter-group variations [9].

Multilevel logistic statistical techniques can be used to predict a binary dependent variable from a set of independent variables. It can be employed in the simplest case without explanatory variables (usually called the empty model) and also with explanatory variables by allowing only the intercept term or both the intercept and slopes (regression coefficients) to vary randomly, and the coefficients are assumed to follow a multivariate normal. To keep the discussion on multilevel logistic regression models simple and taking into account the data to be analyzed in this study we concentrate on the case of two-levels. We note that extensions to the case of three or higher levels is straightforward.

The basic data structure of the two-level logistic regression is a collection of N groups (regions units at level two) and within-group j (j =1, 2,…, N) a random sample of n_j level-one units (Children). The outcome variable, Nutritional status of children, is dichotomous and is denoted by Y_{ij} for children i in region j (i=1, 2,…, n_j, j=1, 2, …, N) and Y_{ij} coded as 0(not wasted) and 1 (wasted). The total sample size is denoted by $M = \sum_{j=1}^{N} nj$. For the proper application of multilevel analysis, the first logical step is to test heterogeneity of proportions between the groups (regions). To test whether there are indeed systematic differences between the groups, the well-known chi-square test for contingency table can be used [10]. The test statistic is:

$$\chi^2 = \sum \frac{(O-E)^2}{E} \tag{1}$$

Where O is observed and E is the expected count in the cell of the contingency table. This can be written as:

$$\chi^2 = \sum_{j=1}^{N} \frac{n_j(\hat{p}_j - \hat{p}_.)^2}{\hat{p}_.} \tag{2}$$

Where: $\hat{p}_j = \frac{1}{n_j}\sum_{i=1}^{n_j} Y_{ij}$ is the proportion of children, who are low weight for height (wasted) in region j,

$$\hat{P} = \frac{1}{M} = \sum_{j=1}^{N}\sum_{i=1}^{nj} Y_{ij} \tag{3}$$

is the overall proportion of children who are wasted.

$M = \sum_{j=1}^{N} nj$, total number of under five children included in the study

This statistic (χ^2 chi-square statistic) follows approximately central chi-square distribution with N −1 degrees of freedom. Further note that $\hat{p}_j$ is an estimate for the group-dependant probability p_j.

The true variance between the group-dependent probabilities $\mathrm{var}(p_j)$ can be estimated by [10].

$$\mathrm{var}(\hat{p_j}) = \hat{\tau}_2 = S^2_{between} - \frac{S^2_{within}}{\tilde{n}} \quad (4)$$

Where $\tilde{n} = \frac{1}{N-1}\left\{ M - \frac{\sum_{j=1}^{N} n_j^2}{M} \right\}$

The between-groups variance is closely related to the chi-squared test statistic.

$$S^2_{between} = \frac{\hat{p}_{.}(1-\hat{p}.)}{\tilde{n}(N-1)}\chi^2$$

The with-in groups' variance is a function of the group averages.

$$S^2_{within} = \frac{1}{M-N}\sum_{j=1}^{N} n_j \hat{p}_j (1-\hat{P}_j) \text{ [10].}$$

The Empty Logistic Regression Model

Empty model is a model that contains no explanatory variables at all that serves as a point of reference with which other models are compared.

The empty two-level model for a dichotomous outcome variable refers to population of groups (level-two units, regions) and specifies the probability distribution for the group-dependent probabilities in equation $Y_{ij} = P_j + \varepsilon_{ij}$, without taking further explanatory variables in to account. The empty two-level logistic regression model is expressed by:

$$\log it(p_j)\beta_0 + U_{0j} \quad (5)$$

Where: Y_{ij} is the outcome for individual i in group j.

p_j is the probability (average proportion of successes) in group j.

ε_{ij} is individual-dependent residual.

β_0 the population average of the transformed probabilities and

U_{0j} the random deviation from this average for group j and distributed as

Normal with mean zero and variance $\sigma_u^2 \cdot (U_{0j} \sim N(0, \sigma_u^2))$

This model does not include a separate parameter for the level-one residual variance of the dichotomous outcome variable follows directly from the success probability Var(ε_{ij}) = $p_j(1-p_j)$. The residual ε_{ij}' s are assumed to have mean zero and variance σ_ε^2 [10].

The intra-class correlation coefficient (ICC) measures the proportion of variance in the outcome explained by the grouping structure. ICC can be calculated using an intercept-only model based on the following formula:

$$ICC = \frac{\sigma_0^2}{\sigma_0^2 + \sigma_e^2} \quad (6)$$

Where: σ_0^2 is between group variance.

σ_e^2 is variance of individual (lower) level units.

Since the logistic distribution for the level one residual variance implies a variance of $\pi^2/3 \approx 3.29$ [10] and this formula can be reformulated as:

$$ICC = \frac{\sigma_0^2}{\sigma_0^2 + 3.29} \quad (7)$$

The Random Intercept Logistic Regression Model

The logistic 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 and random group-dependent deviation U_{0j}.

Consider K explanatory variables $X_1, X_2, \ldots, X_k$. The values of $X_h (h = 1,2,\ldots,k)$ are indicated in the usual way by $x_{hij} (h = 1,2,\ldots,k; i = 1,2,\ldots,n; j = 1,2,\ldots,N)$ Since some or all of these variables could be level-one variables, the success probability is not necessarily the same for all individuals in a given groups. Therefore, the success probability depends on the individual as well as on the group, and is denoted by p_{ij}. The outcome variable is expressed as the sum of success probability (expected value of the outcome variable) and a residual term ε_{ij}.

$$\log it(p_{ij}) = \left(\frac{p_{ij}}{1-p_{ij}}\right) = \beta_{0j} + \beta_1 x_{1ij} + \beta_2 x_{2ij} + \ldots + \beta_k x_{kij} \quad (8)$$

By letting $\beta_{0j} + \beta_0 + U_{0j}$ then

$$\log it(p_{ij}) = \beta_0 + \sum_{h=1}^{k} \beta_h x_{hij} + U_{0j}$$

The p_{ij} 's can be written as

$$p_{ij} = \frac{e^{\beta_0 + \sum_{h=1}^{k} \beta_k x_{hij} + U_{0j}}}{1+e^{\beta_0 + \sum_{h=1}^{k} \beta_k x_{hij} + U_{0j}}} \quad (9)$$

Note, that in the above equation $\beta_0 + \sum_{h=1}^{k} \beta_h x_{hij}$ is the fixed part of the model, the remaining U_{0j} is called the random part of the model. 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 (β_h) in their odds. The deviations U_{0j} mutually independent with zero mean (given the values of all explanatory variables) and a variance σ_0^2. For equation (5) does not include a level-one residual because it is an equation for the probability p_{ij} rather than for the outcome Y_{ij} [10].

The Random Coefficient Logistic Regression Model

In logistic regression analysis, linear models are constructed for the log-odds. The multilevel analogue, random coefficient logistic regression, is based on linear models for the log-odds that include random effects for the groups or other higher-level units. Consider explanatory variables, which are potential explanations for the observed outcomes. Denote these variables by $X_1, X_2, \ldots, X_k$. The values of $X_h (h = 1,2,\ldots,k)$ are indicated in the usual way by x_{hij}. Since some or all of these variables could be level-one variables, the success probability is not necessarily the same for all individuals in a given group. Therefore, the success probability depends on the individual as well as the group, and is denoted by p_{ij}. Now consider a model with group-specific regressions of log it of the success probability, $\log it(p_{ij})$ on a single level-one explanatory variable X.

$$\log it(p_{ij}) = \left(\frac{p_{ij}}{1-p_{ij}}\right) = \beta_{0j} + \beta_{1j} x_{1ij} \quad (10)$$

The intercepts β_{0j} as well as the regression coefficients, or slopes, β_{1j} are group-dependent. These group-dependent coefficients can be split into an average coefficient and the group dependent deviation:

$$\beta_{oj} = \beta_0 + U_{0j}$$

$$\beta_{1j} = \beta_1 + U_{1j} \quad (11)$$

Substitution into equation (11) leads to the model

$$\log it(p_{ij}) = \log\left(\frac{p_{ij}}{1-p_{ij}}\right) = (\beta_0 + U_{0j}) + (\beta_1 + U_{1j}) x_{1ij} \quad (12)$$

There are two random group effects, the random intercept U_{0j} and the random slope U_{1j}. It is assumed that the level-two residuals U_{0j} and U_{1j} have means zero given the value of the explanatory variable X. Thus, β_1 is the average regression coefficient and β_0 is the average regression intercept.

The term $\beta_{1j} x_{1j}$ can be regarded as a random interaction between group and X. This model implies that two random effects characterize the groups: their intercept and their slope. These two group effects U_{0j} and U_{1j} will not be independent, but correlated. Further, it is assumed that, for different groups, the pairs of random effects (U_{0j}, U_{1j}) are independent and identically distributed. Thus, the variances and covariance of the level-two random effects (U_{0j}, U_{1j}) are denoted as follows:

$$\mathrm{var}(U_{0j}) = \sigma_{00} = \sigma_0^2$$

$$\mathrm{var}(U_{1j}) = \sigma_{11} = \sigma_1^2$$

$$\mathrm{var}(U_{0j}, U_{1j}) = \sigma_{01}$$

The model for a single explanatory variable discussed above can be extended by including more variables that have random effects. Suppose that there are *k* level one explanatory variables $X_1, X_2, \ldots, X_k$, the model where all X-variables have varying slopes and random intercept.

That is

$$\log it(p_{ij}) = \log\left(\frac{p_{ij}}{1-p_{ij}}\right) = \beta_{0j} + \beta_{1j} x_{1ij} + \beta_{2j} x_{2ij} + \ldots + \beta_{kj} x_{kij} \quad (13)$$

Letting $\beta_{0j} = \beta_0 + U_{0j}$ and $\beta_{hj} = \beta_h + U_{hj}$ h=1,2,…,k. We get

$$\log it(p_{ij}) = \log\left(\frac{p_{ij}}{1-p_{ij}}\right) = \beta_0 + \sum_{h=1}^{k} \beta_h x_{hij} + U_{0j} + \sum_{h=1}^{k} U_{hj} x_{hij} \quad (14)$$

The first part of this model, $\beta_0 + \sum_{h=1}^{k} \beta_h x_{hij}$, is the fixed part and the second part,

$U_{0j} + \sum_{h=1}^{k} U_{hj} x_{hij}$, is the random part of the model [10].

ESTIMATION METHOD

The most frequently used methods are based on a first-or second order Taylor expansion of the link function. When the approximation is around the estimated fixed part this called marginal quasi-likelihood (MQL), when it is around an estimate for the fixed plus random part it is called Penalized or predictive quasi-likelihood (PQL) [11, 12]. For fixed coefficients of multilevel logistic regression tests about parameters are done using the Wald test. Random effects tests examine hypotheses about whether the variance of intercept or slopes is significantly different from zero. The tests of variances and covariances are made using a Wald z-test and chi-square test [10]. Based on the model selection criterion the model with smallest AIC and BIC value is considered as better fit model. In this study, the data has been analyzed by using STATA 11 and SAS 9.2 software packages.

RESULTS

A total of 9,611 under-five age children in Ethiopia were included in the study. Out of this sample, 11.7 percent of children were wasted. The chi-square test results presented in Table **1** revealed that except number of household members, all other predictor variables showed a significant association with wasting independently. We were included in multiple logistic regression model the variables significant in univariate at 25% level of significance [13]. All variables are significant at 25% and considered in multiple logistic regression model.

The data have a two-level hierarchical structure with 9,611 under-five age children at level 1, nested within 11 regions at level 2. This is based on the idea that there might be differences in under-five children wasting between regions that are not captured by the explanatory variables and hence might be regarded as unexplained variability within the set of all regions.

Before starting to multilevel analysis, one has to test for the heterogeneity of under-five children wasting among regions of Ethiopia. A chi-square test statistic was applied to assess heterogeneity in the proportion of wasted children among the regions in Ethiopia. The test yields a Pearson chi-square χ^2 =163.736 which is

Table 1: Results of Chi-Square Test for Weight-for-Height Z-Score (WHZ) and Independent Variables

Variables	Sex of child	Age of child in month	Birth Order	Size of child at birth	Region	Place of Residence
χ^2	21.465	151.6	19.371	94.311	163.4	19.615
P-value	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

Variables	Number of household member	Mothers level of Education	Body Mass Index of Mother	Sex of household head	Husband Educational level
χ^2	5.1117	42.571	141.6	7.504	46.299
P-value	0.077	<0.0001	<0.0001	0.004	<0.0001

Variables	Household Wealth Index	Had diarrhea	Had fever
χ^2	70.891	78.588	62.112
P-value	<0.0001	<0.0001	<0.0001

greater than χ^2_{tab} (10) = 18.30704, and P =0.0001is less than 0.05 level of significance. Thus, there is evidence for heterogeneity among the regions with respect to wasting in under-five children in Ethiopia.

The empty binary logistic regression model presented in Table **2** contained only region random effect. The deviance based Chi-square=114.148 was the difference in -2*log likelihood between an empty model without random effect (-2LL= 6951.5) and an empty model with random effect (-2LL =6837.352) was greater than χ^2_{tab} (1)=3.8414 with a corresponding p-value<0.0001 at 5% level of significance. This implies that an empty logistic regression model with random intercept was much better than an empty model without random intercept.

From the model estimated without considering explanatory variable, the estimated average log-odds of wasted children in an 'average' region (one with u_{0j} = 0) is estimated as $\hat{\beta}_0$ = -2.080627. The intercept for region j was -2.080625 + u_{0j} and the between region variance of under-five children wasting was estimated as $\hat{\sigma}^2_{u0}$ =0.4231626 which was significant at 5% level of significance, indicating the variations of under-five children wasting among regions of Ethiopia was non-zero. This indicates that there were regional differences in under-five children wasting across regions in Ethiopia.

The intracorrelation coefficient (ICC) from the empty model was estimated at 0.05162 which was found to be significant at 5% level of significance, suggesting that about 5.162% of the variance in under-five children wasting in Ethiopia could be attributed to differences across regions.

Two-Level Random Intercept and Fixed Slope Binary Logistic Regression Model

The random intercept binary logistic regression model for under-five children wasting is significant based on deviance based Chi-square, the difference between log-likelihood of two-level empty binary logistic and two-level random intercept binary logistic regression model. The deviance based chi-square= 458.99 was greater than tabulated chi-square (17) =27.587 with corresponding P-value=0.0000 at 5% level of significance. This suggests that, after controlling all indicators of under-five children wasting, the intercept varied across regions (i.e., the variations of under-five children wasting among regions of Ethiopia was non-zero).

The overall average log-odds of wasted children estimated at -4.3526, which was lower by about 2.27 as compared to empty model thus, indicating that inclusion of explanatory variables decreased overall mean of under-five child wasting. The variance component for the constant term was found significant at 5% significant level, indicating strong evidence of the variations across regions for under-five children wasting was non-zero (Table **3**).

The intracorrelation coefficient was found to be 0.0211 implying that the percentage of the variance of under-five child wasting could be attributed to the differences between regions. The between-region (level two) variance of constant term for under-five child wasting was estimated at 0.2663 which is decreased by about 0.157 as compared to empty model indicating that, there was a contribution of those significant factors on under-five children variations across regions.

The two-level random intercept and fixed slope binary logistic regression has less AIC and BIC compared to random empty logistic regression model (Table **3**). This indicates the random intercept and fixed slope model was a better fit compared to the empty model for predicting variation of under-five children wasting among regions in Ethiopia.

The results revealed that child age, sex of child, size of child at birth, type of place of residence,

Table 2: Result of Random Empty Two-Level Binary Logistic Regression Model

Fixed Part	Coefficient	S.E	Z-value	P-value	[95% CI]
β_0 =Intercept	-2.080627	.1332478	-15.61	0.000*	-2.341788 -1.819466
Random Part					
$\hat{\sigma}^2_{u0}$	.4231626	.1038034	4.08	0.002*	.2616401 .6844003
ICC(ρ_u)	.05162	.0240179	2.15	0.032*	.0203838 .1246328
AIC BIC	6841.351 6855.693				

(*significant at 5% level of significance).

Table 3: Result of Random Intercept and Fixed Slope Logistic Regression Analysis for Wasting

Fixed Part		Coeff.	Std.Er.	Z	P>|Z|	OR	[95% Conf. Interval]
Sex of child	Female	-.3415	.0666	-5.12	0.000*	.7107	.6237 .8099
	Male(Ref)						
Child age at birth	<6months	.6348	.1218	5.21	0.000*	1.887	1.486 2.396
	6-11months	.7876	.1205	6.54	0.000*	2.198	1.736 2.784
	12-23months	.5671	.1075	5.28	0.000*	1.763	1.428 2.177
	24-37months	-.0196	.1159	-0.17	0.866	.9806	.7813 1.23
	38-47months	-.1656	.1177	-1.41	0.160	.8474	.6728 1.067
	48-59(Ref)						
Size of child at birth	Small	.5359	.0876	6.12	0.000*	1.709	1.439 2.029
	Average	.1414	.0888	1.59	0.111	1.152	.9679 1.371
	Large(Ref)						
Place of residence	Rural	.3049	.1359	2.24	0.025*	1.356	1.039 1.771
	Urban (Ref)						
Mother Educational level	No education	.8377	.2677	3.13	0.002*	2.311	1.367 3.906
	Primary	.5842	.2696	2.17	0.030*	1.793	1.057 3.042
	Sec (Ref)						
Body Mass Index of Mother	Thin	.9714	.2115	4.59	0.000*	2.642	1.745 3.999
	Normal	.4172	.2080	2.01	0.045*	1.518	1.009 2.282
	Over(Ref)						
Household wealth Index	Poor	.3719	.0941	3.95	0.000*	1.451	1.206 1.744
	Medium	.2349	.1147	2.05	0.041*	1.265	1.010 1.584
	Rich(Ref)						
Had diarrhea	Yes	.3681	.0869	4.23	0.000*	1.445	1.218 1.713
	No(Ref)						
Had Fever	Yes	.3110	.0809	3.84	0.000*	1.365	1.165 1.599
	No(Ref)						
Constant	Constant	-4.352	.3337		0.000*		

Random Part					
	Coeff.	S.E	Z-value	P-value	[95% Conf. Interval]
$\hat{\sigma}_0^2$	.2663	.0667	3.99	0.002*	.1630 .4351
ICC (ρ_u)	.0211	.0103	2.04	0.041*	.0080 .0544
AIC	6416.359				
BIC	6552.602				

(Ref =reference category), (*= significant at 5% level of significance).

mothers educational level, body mass index of mothers, diarrhea and fever were found to be statistically significant (at 5% level of significance) indicating strong effects on under-five children wasting and also contributing to under-five children wasting variations among regions in Ethiopia (Table **3**).

The results of below are based on Table **3** for the random intercept and fixed slope logistic regression. Results of fixed part of coefficients can be interpreted similarly as binary logistic regression. The odds of under-five children wasting for female child was reduced by a factor of 0.711 (OR: 0.711; CI (0.624, 0.810)) compared to male child, controlling other variables in the model. Children in age groups: 0-5months, 6-11months, 12-23months, 24-37 were 1.889(OR: 1.889; CI (1.486, 2.396), 2.198(OR: 2.198; CI (1.736, 2.784) and 1.763(OR: 1.763; CI (1.428, 2.177) times more likely to be wasted compared to children aged 48-59months respectively, controlling the other variables in the model. The probability of wasting among children age groups 24-37 and 38-47months were not significantly different from children in age group 48-59 at 5% level of significance. Small size children are 70.9% more likely to be wasted (OR: 1.709; CI (1.439, 2.029)) than large size child at birth. While the probability of wasting for average size child at birth was not statistically different from large size children at birth.

Children whose parents resided in rural area were 1.356 times more likely to be wasted than children whose parents reside in urban area (OR: 1.356; CI: 1.039, 1.771). Children from poor households were about 45% more likely to be wasted than those children who live in rich households controlling for other variables in the model (OR: 1.450; 95%CI: 1.206, 1.744). Children from medium economic households were 1.265 times more likely to be wasted than children whose parents reside in urban area (OR: 1.265; CI: 1.010, 1.584). The odds of wasting for children born to mothers body mass index was thin (BMI< 18.5) was higher by a factor of 2.64 compared to children whose mothers body mass index of overweight (BMI>=25) controlling for other variables in the model. On the other hand, children of normal body mass index mothers were about 51.8% more likely to be wasted than children of overweighed body mass index mothers controlling for other variables in the model.

Children whose mother had no education were 2.311 times more likely to be wasted (OR=2.311; 95% CI 1.367, 3.906) compared to children whose mothers had secondary or higher education controlling for other variables in the model, while children whose mothers had primary education were 79.3% more likely to be wasted compared to children whose mother had secondary or higher education controlling for other variables in the model. Children who had diarrhea and fever in the preceding two weeks of the survey had 44.5% (OR: 1.445, CI: 1.218, 1.714) and 36.5% (OR: 1.365; CI: 1.165, 1.599) higher risk of being wasted than those children who did not have these illnesses, respectively.

Two-Level Random Coefficient Binary Logistic Regression Model

Random coefficient logistic regression model allows the effect that the coefficient of the covariates to vary from region to region. First we run this model for each covariate separately to check the significance effect of those variables. We used a deviance-based chi-square test to test whether the effect of sex of child, age of child, size of child at birth, place of residence, mother level of education, body mass index of mothers, household wealth index, illness (diarrhea and fever) varies across regions. The null hypothesis is that the random factors have no effect.

The calculated deviance-based chi-square test for each variable was as follows: sex of child (χ^2 = 0.17, d.f = 2, p-value = 0.9200), age of child (χ^2 = 8.31, d.f=2, p-value = 0.157), size of child (χ^2 = 0.12, d.f=2, p-value= 0.9428), place of residence (χ^2 = 3.03, d.f=2, p-value= 0.2202), mothers level of education (χ^2 = 0.52, d.f=2, p-value= 0.7700), body mass index of mothers (χ^2 = 0.20, d.f =2, p-value = 0.9027), household wealth index (χ^2 = 2.11, d.f=2, p-value= 0.3482), illness diarrhea (χ^2 = 0.06, d.f=2, p-value= 0.9680) and fever (χ^2 =1.90, d.f=2, p-value = 0.3873). The results showed that the random factor parts of all variables were not significantly different from zero at 5% level of significance. We concluded that the coefficients of all variables do not indeed vary across regions. Therefore, considering multiple logistic regression models for those variables having random slope coefficients has no significant importance. The AIC, BIC result for random intercept and fixed intercept model was less than for random coefficient logistic regression model result. This indicated that the random intercept and fixed slope binary logistic regression model was more appropriate model for variation of under-five children wasting in Ethiopia compared to other two-level binary logistic regression model.

DISCUSSION

This study had the objective to identify the determinants of wasting among under-five children wasting based on 2011 EDHS data.

The findings of this study revealed that female children were less likely to be wasted than males. A study in Botswana showed that male children were at high risk of wasting than female [14]. Another study in Sub-Sahara Africa (SSA) showed that male children in Niger and Central Africa Republic had significantly higher probability of wasting whereas the study in Swaziland showed that female children were more likely wasted than male children [15].

The study showed that the risk of wasting was highest for children in the age group 6-11 months and children less than 6 months. Also the study in Sub-Saharan Africa showed that, as the children grow older it was observed that wasting significantly reduced in Niger and Comoros [15]. Wise (2004) had a similar finding and explained that due to high vulnerability of children to illness at the early stage of growth [16]. This result is not consistent with the study conducted in Kwara state, Nigeria that examined the prevalence and determinants of malnutrition among under-five children of farming households in Kwara State, Nigeria [17]. The study revealed that older children were more likely wasted.

Children who are small in size at birth were more likely wasted than large size children at birth. A study in Bangladesh indicated that size of children at birth was an important factor of wasting and the risk of being wasted is higher in children small size at birth than large size at birth [18]. A study in Nepal revealed that the likelihood of wasting was higher among children with smaller than average size at birth as compared to average or bigger size at birth [19].

Children whose parents resided in rural area were more likely wasted than children whose parents resided in urban area. Also, according to the findings of the 2000 Ethiopia DHS wasting was higher among children in rural areas than children in urban areas [20]. Food Consumption and Nutrition Division International Food Policy Research Institute reported weight-for-height z-score (WHZ) wasting was generally higher in urban areas [21]. This common pattern has been previously documented [22]. The urban areas offer more favorable living conditions and opportunities and that this is reflected in better health and nutrition outcomes for children.

Children who lived in poor households were more likely to be wasted than that of children who live in rich households. The result was similar with studies [6]. Increase in household income at community level leads to improved access to high quality health care, improved water and sanitation systems and greater access to information which affect the nutritional status of children.

The present study showed that the hazard of wasting for children whose mothers body mass index +(BMI< 18.5) was higher by a factor of 2.66 compared to children whose mothers body mass index were overweight (BMI>=25). A similar study in Nigeriarevealed that children born to mothers with high body mass index were less likely to be wasted [17].

Children whose mother had no education were more likely to be wasted compared to children whose mothers' had secondary and higher education. A study by Oyekale (2012) showed that attainment of mother's secondary education reduces the probability of wasting [15]. Also a study in Gondar university hospital, Ethiopia showed that the risk of children wasting were higher for those children born to illiterate mothers [23].

Babatunde *et al*. (2011) showed that better education by mothers significantly reduced the risk of wasting among under-five children [17]. Education was expected to broaden the knowledge of the mothers on the best way to take care of children. In enhancing the quality of care and nutritional status of children, the role of mothers' education is widely recognized. Also Smith and Hadad (2000) showed that more educated mothers are committed to child care and interact very well with their children [24].

The findings of this study also revealed that prevalence of wasting was higher among children who had diarrhea and fever two weeks before the date of the survey than those who had not diarrhea and fever. This result is consistent with other studies [15, 25]. Diarrhea affects dietary intake and utilization, which may have a negative effect on improved child nutritional status and associated with body dehydration.

This study revealed that about 11.7% of under-five children in Ethiopia were wasted (low weight for height z-score). The results from Multilevel binary logistic regression analysis should that the factors sex of child, age of child, size of child at birth, place of residence, region, mother's body mass index, mothers level of education, household wealth index, illness (diarrhea and fever two weeks before survey) had significant effects on wasting of under-five children at 5% significance level. Birth order, sex of household head, number of household members and parent's level of educations had no significant effect on under-five children wasting. The results of random intercept binary logistic regression model revealed that the overall mean of under-five children wasting varied across the regions in Ethiopia. Based on log likelihood deviance based Chi-square, AIC and BIC the two-level random intercept binary logistic regression fitted the data set well.

The study recommended the need for programs related to income generating activities for poor households, improve mother education, caring child in appropriate age. Also, efforts should be made to improve environmental sanitation and personal hygiene to prevent exposures to diarrhea and fever.

Limitation of the study: The data, we used in this study was the 2011 Ethiopian Health and Demographic survey. Since the data is secondary this study is undertaken to explore a few of the demographic, socio-economic and health related characteristics. Also the study not concerned with the determinants of severe wasting and moderate wasting individually.

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