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DETERMINANTS OF MALNUTRITION AMONG UNDER FIVE AGE CHILDREN IN ETHIOPIA

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Abstract

Purpose: Childhood stunting is one of the most significant impediments to human development. Stunting is a major health problem in children under-five years in many low and middle income countries around the world. Wasting is sometimes referred to as acute malnutrition because it is believed that episodes of wasting have a short duration, in contrast to stunting, which is regarded as chronic malnutrition.

Methodology: The data for the study were taken from the Ethiopian Demographic Health Survey of year 2011. Three models, random intercept only model, random intercept and fixed slope model and random coefficient model compared based on the AIC value for stunting and wasting. Random coefficient model has a significant deviance chi-square and the value of AIC are less than from the random intercept with fixed slope model and random intercept only model so, the random coefficient model is a good fit.

Results: Age of children, region, place of residence, wealth index, mothers BMI, the incidence of diarrhea in the last two weeks before the survey and mother and husband/partner educational level were found to be significant predictors for stunting. For wasting age of child, region, wealth index, mothers BMI, sex, incidence of diarrhea and fever and husband/partner education are significant predictor.

Contributions to Theory, Policy and Practice: The study shows that age of children, region, place of residence, wealth index, mothers BMI, the incidence of diarrhea in the last two weeks before the survey and mother and husband/partner educational level were found to be significant predictors for stunting. For wasting age of child, region, wealth index, mothers BMI, sex, incidence of diarrhea and fever and husband/partner education are significant predictor. The study also shows that there is heterogeneity or cross-regional variation in stunting and wasting. Further, this study shows that there exist considerable differences in stunting and wasting among regions and random coefficient model is more appropriate to explain the regional variation than a model with fixed coefficients or empty model with random effects. Since there are variations in stunting and wasting across regions the concerned body should give special attention to regions like Affar and Ben-gumuz.

Key words: *Malnutrition, Stunting, Wasting, Akaike Information Criteria, Multilevel Logistic Regression Model.*

Introduction

Malnutrition is a major public health problem faced by children under-five years as it inhibits their cognitive and physical development as well as contributes to child morbidity and mortality (WHO, 2013). These malnutrition indicators are caused by an extremely low energy and protein intake, nutrient losses due to infection or a combination of both low energy/ protein intake and high nutrient loss by the mother during pregnancy or by the child after birth (WHO, 2000).

Worldwide, over 10 million children under the age of 5 years die every year from preventable and treatable illnesses despite effective health interventions (Mussie A. et al., 2014). In developing countries, malnutrition is a major health problem (Caulfield et al., 2004). Childhood stunting is one of the most significant impediments to human development, globally affecting approximately 162 million children under the age of five years. Stunting, or being too short for one's age, is defined as a height that is more than two standard deviations below the WHO child growth standards median (WHO, 2006). Stunting is a major health problem in children under five years in many low and middle income countries around the world (UNICEF, 2015). It is defined as a deficit in height relative to a child's age (De Onis M. WHO, 2006).

Stunting has long term effects on individuals and societies, including diminished cognitive and physical development reduced productive capacity, poor health and an increased risk of degenerative diseases such as diabetes (The state of the world's children, 2013). If current trends continue, projections indicate that 127 million children under five years will be stunted in 2025

(Walker et al., 2007). An estimated 80% of world's stunted children lived in just fourteen countries (India, Nigeria, China, Pakistan, Indonesia, Bangladesh, Ethiopia, Democratic Republic of Congo, Philippines, United Republic of Tanzania, Egypt, Kenya, Uganda and Sudan). SubSaharan Africa and South Asia were the home to three fourths of the world's stunted children, 40% and 39%, respectively (Desalegne et al., 2016).

Wasting is caused by the same factors that contribute to stunting. Actions focused on prevention, such as ensuring that pregnant and lactating mothers are adequately nourished that children receive exclusive breastfeeding during the first six months of life and provision of adequate complementary feeding in addition to breastfeeding for children aged six to 23 months can help address both stunting and wasting (Bloem M., 2014).

Globally, 52 million children below five years of age were moderately or severely wasted, a 11% decrease from 58 million in 1990. More than 29 million children below five years of age an estimated 5% suffered from severe wasting (M. De Onis et al., 2012). Wasting was decreased by 36% from 1990 which was 159 million, while 51 million children below five years of age were wasted and 17 million were severely wasted in 2013.

The prevalence in 2013 was 8% and closely a third of that was for severe wasting totaling 3% and approximately two thirds of all wasted children who lived in Asia and one-third in Africa. The prevalence of wasting was the highest in South Asia, which was approximately 16%. This moderate or severe wasting was the highest in India which had more than 25 million wasted children (UNICEF, 2013).

In Africa, high prevalence levels of stunting among children under-five years of age (36% or 56 million in 2011). These children have elevated risk of mortality, cognitive deficits and increased risk of adult obesity and non-communicable diseases (De Onis M., 2006). Africa shows rising numbers of stunted children due to population increase and an almost stagnant prevalence of stunting over the past two decades of the 34 countries that account for 90% of the global burden of malnutrition, 22 are in Africa. Some African countries (e.g. Ethiopia, Ghana and Mauritania) have had substantial reductions in stunting but overall in this region little improvement is anticipated in the coming years if recent trends continue (De Onis M., 2006).

In Africa, an estimated 13.4 million children under-five years of age or 8.5% were wasted (W/H <–2SD) in 2011. These children are at substantial increased risk of death. Increasing trends in child overweight in most world regions not just the developed world. In Africa, the estimated prevalence under-five overweight increased from 4% in 1990 to 7% in 2011.

According to CSA report in 2011 EDHS nationally 44 percent of children under age five are stunted and 21 percent of children are severely stunted. Male children are slightly more likely to be stunted than female children (46 percent and 43 percent respectively).

Overall, 10 percent of Ethiopian children are wasted and 3 percent are severely wasted. Wasting or acute malnutrition is highest in children age 9-11 months (19 percent) and lowest in children age 36-47 months (6 percent). Male children are slightly more likely to be wasted (11 percent) than female children (8 percent). Ten percent of children in rural areas are wasted compared with 6 percent in urban areas (EDHS, 2011).

Statement of the problem

Under-nutrition can best be described in Ethiopia as a long term year round phenomenon due to chronic inadequacies of food combined with levels of illness in under five children. Worldwide, ten and a half million children of age under-five die every year, with 98% of these deaths reported to occur in developing countries (UNICEF, 2007). The nutritional and health status of children in Ethiopia is among the worst in the world. For example, almost one in every 17 babies born in Ethiopia (59 per 1000) does not survive to celebrate its first birthday and one in every eleven children (88/1000) dies before its fifth birthday. As a result, it will be challenging to reach the child survival Millennium Development Goals (reducing child mortality by 3/4) with the current pace of mortality reduction (WB, 2011).

The annual costs associated with child under nutrition are estimated at Ethiopian birr (ETB) 55.5 billion, which is equivalent to 16.5% of GDP (UNICEF, 2015). So, a research on child stunting and wasting is important. Most of the studies from DHS data in Ethiopia does not include some important variables associated with stunting and wasting. Therefore, this study attempts to investigate this gap by addressing the following research questions:

1. Which covariates are the most determinant factors for stunting and wasting of under-five age children in Ethiopia?
2. Which factors explain the variation in stunting and wasting among regions of Ethiopia?
3. Which model is appropriate to stunting and wasting of under-five age children in Ethiopia?

Objective of the study

The objective of this study is to identify determinants of stunting and wasting among under five age children in Ethiopia.

METHODOLOGY

The source of data for this study is the 2011 Ethiopia Demographic and Health Survey (EDHS) which is obtained from the Central Statistical Agency (CSA). The study populations are all the under five children residents of Ethiopia using the 2011 EDHS data set. In the 2011 EDHS from 11,654 under-five children, total number of children covered in the current study on the stunting and wasting status of children is based on 9370 under-five children with complete anthropometric measurements and the study considered height-for-age and weight-for-height anthropometric index as indicator of a children's stunting and wasting status respectively.

Variables in the Study Dependent variable

The outcome variable of interest is stunting and wasting of children less than five years. There are anthropometric indicators of nutritional status, such as height-for-age, weight-for-age and weightfor-height. These indices were based on the growth standards published by WHO in 2006. The three indices were expressed as standard deviation units from the median for the reference group.

Children whose height-for-age Z-score below minus two standard deviations (−2 SD) and (-3 SD) from the median of the WHO reference population are considered short for their age (stunted) and severely stunted or chronically malnourished respectively. Stunting reflects failure to receive adequate nutrition over a long period of time and is affected by recurrent and chronic illness. Height-for-age, therefore, represents the long-term effects of malnutrition in a population and is not sensitive to recent, short-term changes in dietary intake. (De Onis M. WHO., 2006). Weightfor-height index describes current nutritional status.

Binary and multicategory outcomes are very common in biomedical studies, for instance, in the evaluation of nutritional status among children of under-five. Based on these classifications, it is possible to employ plausible statistical tools for estimating the magnitude of the association between the response variable of interest as a function of the predictor variables.

$$Stunted = \begin{cases} 1, & if\ stunted\ (z - score < -2) \\ 0, & if\ not\ stunted\ (z - score \geq -2) \end{cases}$$

$$Wasted = \begin{cases} 1, & if\ wasted\ (z - score < -2) \\ 0, & if\ not\ wasted\ (z - score \geq -2) \end{cases}$$

Independent variables

The explanatory variables included in this study are mother's education, employment status of the mother, education of husband/partner, household income, household size, place of residence and geographical region, age of the child, sex of the child, birth interval, birth order of the children, diarrhea and fever in the last two weeks before survey, water supplies and toilet facilities, Incidence of acute respiratory infection in the last two weeks, Mother's nutritional status or Mother's BMI are important factors are included in this study.

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Logistic regression

Regression methods have become an integral component of any data analysis concerned with describing the relationship between a response variable and one or more explanatory variables. Over the last decade the logistic regression model has become in many fields, the standard method of analysis in this situation (Hosmer and lemeshow, 2000).

Logistic regression is the most important model for categorical response data. It is used increasingly in a wide variety of applications. Early uses were in biomedical studies, but the past 20 years have also seen much use in social science research and marketing (Agresti A., 2002).

Regression analysis is model building for the relationship between a dependent and one and/or more independent variables. In the regression if the response variable is continuous we can use the usual linear regression model, whereas when the response variable is discrete, taking on two or more possible values the appropriate regression model is logistic regression which was proposed as an alternative method in the late 1960s and early 1970s (Cabrera, 1994). Such a technique was developed by McCullough and Nelder (1989) and is called generalized linear model (GLM), one of its applications is logistic regression (Fox, 1984).

Logistic regression models are classified according to the type of categories of response variable as follows: -binary logistic regression model, multinomial logistic regression model and ordinal logistic regression models (Hosmer and Lemeshow, 2000). The binary logistic regression model is used to model the binary response variable, whereas the multinomial logistic regression is a simple extension of the binary logistic regression model where the response variable has more than two unordered categories.

Multilevel Logistic Regression Model Two-Level Model

A multilevel logistic regression model as a hierarchical model, can account for the lack of independence across levels of nested data (i.e., individuals nested within groups). Let y_{ij} be the binary outcome variable, coded '0' or '1', associated with level-one unit *i* nested within level two unit *j*. Also, let p_{ij} be the probability that the response variable equals 1, and $p_{ij} = \Pr(y_{ij} = 1)$. Here, y_{ij} follows a Bernoulli distribution. Like the logistic regression the p_{ij} is modeled using the link function, logit. The two-level logistic regression model can be written as:

$$\log\left(\frac{p_{ij}}{1-p_{ij}}\right) = \beta_0 + \beta_1 x_{ij} + u_{oj} \quad (1)$$

Where u_j is the random effect at level two. Without u_j, this equation (1) can be considered as a standard logistic regression model.

Therefore, conditional on u_j, the y_{ij}'s can be assumed to be independently distributed. Here, u_j is a random quantity and follows N(0, σ_u^2).

Equivalently, we can split model (1) into two models: one for level 1 and the other for level 2.

p_{ij}

$$log\left[\frac{p_{ij}}{1-p_{ij}}\right] = \beta_{0j} + \beta_1 x_{ij} \quad model: level\ 1 \quad \text{and} \quad \beta_{0j} = \beta_0 + u_{oj} \quad model: level\ 2 \qquad (2)$$

Testing Heterogeneity of Proportions

For the proper application of multilevel analysis in general and multilevel logistic regression analysis in particular, the first logical step is to test for heterogeneity of proportions between groups (in our case between Regions). To test whether there are indeed systematic differences between groups, the well-known chi-square test for contingency table can be used. In this case the chi-square test statistic is:

$$x^2 = \sum_{j=1}^{N} \frac{n_j(\square p_j - p_{\square .})^2}{p_{.}(1-p_{.})} \qquad (3)$$

The Empty Logistic Regression Model

The empty two-level model for a dichotomous outcome variable refers to a population of groups (level-two units (regions)) and specifies the probability distribution for group-dependent probabilities$\square_{ij}$ in $y_{ij} = p_{ij} + \square_{ij}$ in without taking further explanatory variables into account. For the logit link function, the log-odds have a normal distribution in the population of groups, which is expressed by:

$logit(p_j) = \square_0 + U_{0j}$ and the probability corresponding to the average value $\square_0$, denoted by $\square_0$

$$\square_0 = \frac{\exp(\square_0)}{1+\exp(\square_0)} \qquad (4)$$

The Random Intercept Logistic Regression Model

In the random intercept logistic regression 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 variables and the response can differ between groups in more

The random intercept model expresses the logit of p_{ij} as a sum of a linear function of the explanatory variables. That is,

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

$\beta_{0j} = \beta_0 + u_{oj}$ As a result

$$\text{logit}(p_{ij}) = \log\left(\frac{p_{ij}}{1-p_{ij}}\right) = \beta_0 + \beta_1 x_{1ij} + \beta_2 x_{2ij} + \ldots + \beta_k x_{kij} + U_{0j} \quad (5)$$

Where the intercept term β_{0j} is assumed to vary randomly and is given by the sum of an average intercept β_0 and group-dependent deviations U_{0j}.

The first part incorporating the regression coefficients is the fixed part of the model, because the coefficients are fixed. The remaining part U_{0j} is called the random part of the model. It is assumed that the residual, U_{0j} are mutually independent and normally distributed with mean zero and variance σ_u^2.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 Random Coefficient Logistic Regression Model

In above, we have allowed the probability of stunting and wasting to vary across regions, but we have assumed that the effects of the explanatory variables are the same for each region. Now modify this assumption by allowing the difference between explanatory variables within a region to vary across regions. To allow for this effect, we will need to introduce a random coefficient for those explanatory variables. So, a random coefficient model represents the heterogeneity in relationship between the response and explanatory variables. Suppose that there are k level-one explanatory variables X_1, X_2... X_k and consider the model where all predictor variables have varying slopes and random intercept. That is

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

Letting $\beta_{0j} = \beta_0 + U_{oj}$ and $\beta_{hj} = \beta_h + U_{hj}$ where h=1, 2,….k, we have:

$$\frac{p_{ij}}{1-p_{ij}} \quad k \quad U_{hj} X_{ij} \quad (6)$$

$(p_{ij}) = log\left(\frac{ij}{}\right) = \beta_o + \sum^k \; log_{h=1}\beta_h X_{ij} + U_{oj} + \sum_{h=1}$

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

Model Selection Criteria

In regression analysis fitting a model is the main issue and should give more care for selecting model that will fit the data. In this study, to select the best model AIC (Akaki information criterion) was used. The model with small value of AIC is the optimal model, that means a model that close to actual one (Agresti, 2002) and the model which have few parameters to be estimated. AIC and BIC are defined as:

$$AIC = -2 * \ln(likelihood) + 2k$$

$$BIC = -2 * \ln(likelihood) + \ln(N) * k$$

Where k is the model degrees of freedom calculated as the rank of a variance–covariance matrix of the parameters and N is the number of observations used in the estimation or, more precisely, the number of independent terms in the likelihood.

Test of overall model fit

For the selected model before proceeding to examine the individual coefficients, we should look at an overall test of the null hypothesis that the location coefficients for all of the variables in the model are 0. It can base this on the change in -2 log-likelihood when the variables are added to a model that contains only the intercept. The change in likelihood function has a chi-square distribution even when there are cells with small observed and predicted counts. This value provides a measure of how well the model fits the data.

The log likelihood statistic is analogous to the error sum of squares in multiple linear regressions. As such, it is an indicator of how much unexplained information remains after fitting the model. The larger the value of the log likelihood the more unexplained observations there is and a poorly fitting model. Therefore, a good model means a small value for −2LL. If a model fits perfectly, the likelihood is 1 and −2 × log 1=0 (Agresti, 2002).

The likelihood-ratio test statistic is given by (Hosmer and Lemeshow, 2000)

$$G^2 = -2\, ln \left(\frac{likelihood\ without\ the\ variable}{likelihood\ with\ the\ variable}\right) \quad (7)$$

Goodness-of-Fit Measures

As in linear regression, goodness of fit in logistic regression attempts to get at how well a model fits the data. It is usually applied after a "final model" has been selected. Much of the goodness of fit literature is based on the following hypothesis:

H_0. The model fit the data well Vs H_A: The model does not fit the data well

The measure of goodness of a fit is done by testing whether a model fits is to compare observed and expected values. From the observed and expected frequencies, we can compute the usual Pearson and Deviance goodness-of-fit measures. For a sample of n independent observations, the deviance and Pearson chi-square for a model with p degrees of freedom, both X^2 and D has Chi square distribution with (n-p) degrees of freedom.

$$Pearson\ goodness\ of\ fit\ statistic\ is\ X^2 = \frac{\sum\sum(o_{ij}-e_{ij})^2}{e_{ij}\ O^{ij}}\ and\ deviance\ measure\ is\ D = 2\sum\sum O_{ij}\ ln\ (\_\_E_{ij}) \quad (8)$$

Where Oij is the observed frequency and eij is the expected frequency.

The observed frequency is obtained from the data on the response, but the frequency is obtained from the estimated probabilities of the response. Both goodness-of-fit statistics should be used only for models that have reasonably large expected values in each cell. If we have a continuous independent variable or many categorical predictors or some predictors with many values, we may have many cells with small expected values. If our model fits well, the observed and expected cell counts will be similar, the value of each statistic will be small, and the observed significance level will be large. We shall reject the null hypothesis that the model fits the data well if the observed significance level for the goodness of- fit statistics is small. Good models have large observed p-values.

RESULTS AND DISCUSSIONS

The analysis was done using SPSS version 20 and STATA version 12.

Descriptive statistics

The analysis presented in the study is based on 9370 under-five children with complete height-forage and weight-for-height anthropometric index as indicator of children's stunting and wasting status respectively. Table 1 shows that the relative frequency distributions of the stunting and wasting status of the child. 37.1% are stunted and 62.9% are not stunted. Table 1 also shows that 10.4% of children are wasted and 89.6% are not wasted.

Result of Multilevel Logistic Regression Analysis

Multiple logistic regression was used to select the important determinants of stunting and wasting in SPSS software using enter method variable selection procedure. The statistical significance of the individual regression coefficients is tested using the Wald chi-square statistic. Accordingly age of children, region, place of residence, wealth index, mothers BMI, the incidence of diarrhea in the last two weeks before the survey and mother and husband/partner educational level were found to be significant predictors for stunting. For wasting age of child, region, wealth index, mothers BMI, sex, incidence of diarrhea and fever and husband/partner education are significant predictor.

The first step in performing a multilevel analysis is testing the heterogeneity of proportions between groups (regions). For stunting chi-square test statistic was applied to assess heterogeneity in the proportion of individuals among regions. The test yield χ^2 (10) = 280.4339 with $P = 0.000 < 0.05$, where 10 is the degrees of freedom. Thus, there is an evidence of heterogeneity of individuals among regions. For wasting χ^2 (10) = 141.8441 P = 0.000 which is less than 0.05 indicating that there is heterogeneity among regions.

Random Intercept Only Model for stunting

This is the type of model that incorporates only the grand mean and random intercept (regional effect) without covariate. Table 2 shows the output of the estimates of fixed effects and random effects. From the table, we can see that the estimate of the fixed part of the model is -0.669 with a z-value of -4.71 and p-value of 0.000 which implies that the average log odd of stunting is significantly different from zero. The intercept informs us β_o = -0.669 that the average probability of stunting is $\frac{\exp(-0.669)}{1+\exp(-0.669)}$ = 0.339 which means the chance of stunting is 33.9% on average.

The table also contains the variance estimate of random effects at regional level, with a confidence interval of (0.0887, 0.5215) which implies that the between region variance of stunting is 0.2150 and reveals that there is a significant difference in stunting among children across regions. This implies that multilevel model is more appropriate relative to single level. At the bottom of the table there is the result of the hypothesis H_0: $\sigma^2{}_u = 0$ is provided showing that there is no crossregional variation in stunting. For this hypothesis, we see that the value of the test statistic is 240.42 with p = 0.0000 Therefore, the null hypothesis is rejected and there is evidence of heterogeneity or cross-regional variation in stunting.

Random Intercept and fixed coefficient logistic regression analysis for stunting

In a random intercept and fixed coefficient multilevel logistic regression model, we allowed the probability of stunting to vary across regions, but we assumed that the effects of the explanatory variables are the same for each region. That is, the random intercept varies across regions, but children level explanatory variables are fixed across regions.

The Wald test of overall goodness of fit gives Wald chi2 (12) = 609.44 with p = 0.0000 where 12 is the degrees of freedom. This indicates that all explanatory variables jointly are significant. From the table 3 we see that the inclusion of level one covariates decreased regional variations from 0.2150 (level-two variance without covariates) to 0.0968, it indicates that there is a significant variation between regions in stunting. Moreover, the values of chi2 (1) =113.62 and p = 0.0000 (see Table 3) lead to the rejection of the null hypothesis that the random effect is zero as in the assumption of ordinary logistic regression. From this we can conclude that the random effect at regional level is significantly different from zero. From Table 3 mothers and husband/partner education (secondary and above) significant factors for stunting as compared to their reference categories and age of child in a month, place of residence, wealth index, mothers BMI and incidence of diarrhea have a significant effect.

The Random Coefficient Model for stunting

Multilevel logistic regression can allow the coefficient of level-one covariates to vary across regions instead of keeping them fixed across regions. Now we are going to see the effect of children level covariates by allowing them to vary randomly across regions. This model contains fixed effects and random effects. The fixed effects are analogous to standard logistic regression coefficients and are estimated directly. The random effects are not directly estimated but are summarized in terms of their estimated variances and covariance.

The random effects can take random intercepts (regional effects) and random coefficients (levelone covariates effect). In this section we investigate whether level-one covariates have random effects across regions or they have the same effects across regions. Estimates of this model show that the random slope variances of all included variables except for age children and husband/partner education were approximately zero. This indicates that the effects of age of children and husband/partner education varied across regions, whereas the effect of other covariates remained fixed across regions. The results of the random coefficient estimates are given in Table 4.

In Table 4 the value of Var(ageofc~o) and Var(eduahu~t) are the estimated variance of age of child in a month and husband/partner education respectively. These estimated variances indicated that there is a significant variation in the effect age of child in month and husband/partner education across regions in Ethiopia.

For wasting response see the result of multilevel logistic regression in Table 6, Table 7 and Table 8 for random intercept only model, random intercept and fixed coefficient logistic regression model and the random coefficient model respectively.

Multilevel logistic regression Model comparison for stunting and wasting

Before interpreting multilevel models, we compare the three multilevel logistic regression models (nested models) considered. To do so, deviance, AIC and BIC were used. The AIC value of the empty model with random intercept (AIC = 12125.23) is larger than that for the random intercept and fixed coefficient model (AIC =11371.14), which implies that random intercept and fixed slope model is better than the empty model with random intercept in predicting stunting across regions. The significant deviance-based chi-square value for random intercept model indicates that the random intercept and fixed slope model are better than single level multiple logistic regression in stunting across regions as well (see Table 3 and Table 4).

The AIC value of the random coefficient model (AIC = 11354.56) is smaller than the random intercept and fixed coefficient model (AIC = 11371.14) implying that random coefficient model is better compared to the random intercept and fixed slope model in describing stunting status (see Table 5) indicating that the random coefficient model is preferred model. Furthermore, the significant deviance-based chi-square value for random coefficient model indicates that the random coefficient model is better than the multiple logistic regression model in explaining stunting (see Table 4).

Therefore, from the random coefficient model children age group 12-23 and 24+ had (OR=exp(1.517867)) 4.562 and (OR=exp(1.745911)) 5.731 times more likely to be stunted respectively as compared to age group 0-11 in months controlling for other variables in the model and random effect at level two. Children who reside in rural areas had (OR=exp(0.4230424))

1.527 times more likely to be stunted as compared to children who reside in urban area controlling for other variables in the model. Children from medium and rich household are (OR=exp(0.1442489)) 0.866 and (OR=exp(-0.2214671)) 0.801 times less likely to be stunted respectively as compared to children from poor household controlling for other variables in the model.

Compared to children with thinness level (BMI<18.5) mothers, children belonging to normal level (BMI 18.5-24.9) and overweight level/obese (BMI $\geq$ 25) mothers were (OR=exp(-0.1763178)) 0.838 and (OR=exp(-0.5220219)) 0.593 times less likely stunted respectively controlling for other variables in the model. Children who had an incidence of diarrhea in the last two weeks are (OR=exp(0.3190488)) 1.376 times more likely stunted as compared to children who had no diarrhea controlling for other variables in the model. Specifically, children from mothers who had secondary and above educational level are (OR=exp(-0.3770605)) 0.686 times less likely stunted as compared to children from no education mothers and also children from husband/partner who had secondary and above educational level are (OR=exp(-0.4902556)) 0.612 times less likely stunted as compared to children from no education husband/partner controlling for other variables in the model.

An overall evaluation of the multilevel logistic model was assessed using the deviance that is good model is the model that have small value of deviance and also test is done by comparing the deviance of two models by subtracting the smaller deviance from the larger deviance. The difference is a chi-square with the number of degrees of freedom equal to the number of different parameters in the two models. The significance of this chi square indicates that the model is a good fit. Similarly, it was also assessed by using AIC.

Similarly, based on Table 9 for wasting random coefficient model have a significant deviance chisquare and the value of AIC are less than from the random intercept with fixed slope model and Random intercept only model. So, we conclude that the random coefficient model is a good fit. In Table 8 the value of Var(ageofc~o) and Var(haddia~a) are the estimated variance of age of child in the month and incidence of diarrhea in the last two weeks before survey respectively. These estimated variances indicated that there is a significant variation in the effect age of child in month and incidence of diarrhea in the last two weeks before the survey across regions in Ethiopia.

Discussion

The results of the study indicate that age of child is one of determinant associated with stunting and wasting status of children in Ethiopia. The stunting and wasting was higher in children aged greater than 12 months than the age 0-11 groups. This finding is consistent with the studies conducted by Kabubo-Mariara et al. (2006); Shrimpton et al. (2001); Nguyen and Kam., 2008; Alemu Adeba, Sileshi (2014); which revealed a rapid fall in children's height from birth to 59 months; although stunting continues after 24 months and children in the youngest age 0-11 months had significantly lower risk of being stunted, underweight and wasted than children in the older age groups. This could be as a result of weaning and lower breast milk intakes, which make them prone to childhood stunting.

The Mother's highest educational level was identified to be the most significant factor to reduce the occurrence of child stunting. The findings of this study showed that there is a significant difference in the status of stunting in children by mothers' educational level. The risk of worse level stunting is significantly higher for children whose mothers have no education and primary education level than children whose mothers have secondary and higher level of education. This finding is consistent with other studies (Nure, Nuruzzaman and Goni, 2011, Semali, I.A.; TengiaKessy, 2015; Blessing

Jaka Akombi, 2017). They indicated that education improves the ability of mothers to implement simple health knowledge and facilitates their capacity to manipulate their environment, including health care facilities, interact more effectively with health professionals, comply with treatment recommendations, and keep their environment clean.

Furthermore, educated women have greater control over health choices for their children. This finding also suggests that stunting and wasting status was found highest for the children having father's/partner with no education when compared with higher level educated fathers' children (Nguyes and Kam, 2008; Blessing Jaka Akombi, 2017). Place of residence was found to be significant determinants of stunting status in under five children. The analysis also showed that children whose parents reside in rural areas more likely to be stunted when compared to those children whose parents reside in urban areas. This study is similar to the study conducted by Shen et al. (1996), Fotso JC, Kuate-Defo (2005).

The study revealed that under-five children from poor households are at a higher risk of stunting and wasting than children from rich households. This finding is similar with studies Woldemariam and Timotewos, (2002); Smith et al., (2005); Alemu Adeba, Sileshi (2014); Loida, Gloria (2017).

Mother's nutritional status significantly influences the stunting and wasting status of children. Children from thinness level (BMI<18.5) mothers higher status of stunting and wasting as compared to normal levels (BMI 18.5-24.9) and overweight (BMI≥25) mothers. This finding is consistent with study conducted by Pendael Zephania Machafuko (2013);Semali, I.A.; TengiaKessy (2015) which reveals that mother's nutritional status had a positive effect indicating that children belong to thinness level (BMI<18.5) mothers are associated with high probability of stunting and wasting.

Male children have a greater risk of the status of stunting and wasting than female children (Salah E.O. Mahgoubet al., 2006, Mandefroet.al., 2015). The result of this finding is consistent with these studies, but the covariate genders of a child are an insignificant factor for stunting status. This finding also similar to the studies conducted by Salah and Nnyepi (2006). The result of this study indicates that children who had an incidence of diarrhea in the last two weeks are significant factors for stunting and wasting as compared to children who had no diarrhea. This study is consistent with the study Alemu Adeba, Sileshi (2014); Blessing Jaka Akombi, (2017). The result of this study suggests that children who had incidence of fever in the last two weeks are significant factor for wasting status. This study is consistent with the studies conducted by Blessing Jaka Akombi, (2017).

CONCLUSION

The study shows that there is heterogeneity or cross-regional variation in stunting and wasting. Further, this study shows that there exist considerable differences in stunting and wasting among regions and random coefficient model is more appropriate to explain the regional variation than a model with fixed coefficients or empty model with random effects. Age of children, region, place of residence, wealth index, mothers BMI, the incidence of diarrhea in the last two weeks before the survey and mother and husband/partner educational level were found to be significant predictors for stunting. For wasting age of child, region, wealth index, mothers BMI, sex, incidence of diarrhea and fever and husband/partner education are significant predictor.

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Table 1: stunting and wasting status of children

Stunting status	Frequency	Percent
Not stunted	5891	62.9
stunted	3479	37.1
Total	9370	100
Wasting status		
Not wasted	8398	89.6
Wasted	972	10.4
Total	9370	100

Table 2: Result of Parameter Estimate of Random Intercept-Only Model for stunting

	Coef.	Std. Err.	Z	P>|z|	95% Conf. Interval	
cons	-.6691916	.1422053	-4.71	0.000	-.9479089	-.3904742

Random-effects Parameters estimate Std. Err. 95% Conf. Interval region:

Identity var(cons) .2150448 .0972008 .0886715 .5215238

LR test vs. logistic regression: chibar2(01) = 240.42 Prob>=chibar2 = 0.0000

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Table 3: Result of Parameter Estimate of Random Intercept and Fixed Slope Model for stunting

		Coef.	Std. Err.	Z	P>|z|	95% Conf. Interval	
Age of child in month	12-23	1.461058	.0905591	16.13	0.000	1.283565	1.638551
	24+	1.675453	.081562	20.54	0.000	1.515595	1.835312
	0-11 (ref)						
Place of residence	Rural	.4181639	.090562	4.62	0.000	.2406656	.5956622
	Urban (ref)						
Wealth index	Medium	-.1512343	.0641515	-2.36	0.018	-.276969	-.0254996
	Rich	-.2354387	.0619936	-3.80	0.000	-.3569439	-.1139336
	Poor (ref)						
MothersBMI	Normal	-.1708086	.0523391	-3.26	0.001	-.2733914	-.0682258
	Overweight	-.5162158	.1243348	-4.15	0.000	-.7599074	-.2725241
	Thinness (ref)						
Incidence of Diarrhea	yes	.327131	.0634424	5.16	0.000	.2027861	.4514759
	no (ref)						
Mothers education	primary	-.0508885	.0586562	-0.87	0.386	-.1658525	.0640756
	secondary&above	-.3712433	.1584496	-2.34	0.019	-.6817987	-.0606878
	No education (ref)						
Husband/partner education	Primary	-.0399978	.0522726	-0.77	0.444	-.1424502	.0624546
	secondary&above	-.4804148	.1050213	-4.57	0.000	-.6862528	-.2745769

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	No education (ref)						
Cons		-2.10177	.1578546	-13.31	0.000	-2.41116	-1.792381

Random-effects Parameters estimate Std. Err. 95% Conf. Interval
region: Identity var(cons) .0968598 .0450367
.038937 .2409487 LR test vs. logistic regression: chibar2(01) = 113.62 Prob>=chibar2 = 0.0000

Wald chi2(12) = 609.44 Prob > chi2 = 0.0000

Table 4: Result of Parameter Estimate of Random Coefficient Model for stunting

		Coef.	Std. Err.	Z	P>|z|	95% Conf. Interval	
Age of child in month	12-23	1.517867	.1117068	13.59	0.000	1.298926	1.736808
	24+	1.745911	.148287	11.77	0.000	1.455273	2.036548
	0-11 (ref)						
Place of residence	rural	.4230424	.0901214	4.69	0.000	.2464076	.5996772
	Urban (ref)						
Wealth index	medium	-.1442489	.064319	-2.24	0.025	-.2703119	-.0181859
	Rich	-.2214671	.0621326	-3.56	0.000	-.3432448	-.0996894
	Poor (ref)						
Mothers BMI	normal	-.1763178	.0524258	-3.36	0.001	-.2790704	-.0735652
	Overweight	-.5220219	.1245861	-4.19	0.000	-.7662061	-.2778376
	Thinness (ref)						
Incidence of Diarrhea	yes	.3190488	.0637295	5.01	0.000	.1941413	.4439563
	No (ref)						
Mothers education	primary	-.0557345	.0586566	-0.95	0.342	-.1706993	.0592303

	Secondary&above	-.3770605	.1582007	-2.38	0.017	-.6871283	-.0669928
	No education (ref)						
Husband/partner education	Primary	-.0104356	.0641735	-0.16	0.871	-.1362134	.1153421
	Secondary&above	-.4902556	.127003	-3.86	0.000	-.7391768	-.2413344
No education (ref)							
Cons		-2.194183	.2086728	-10.51	0.000	-2.603174	-1.785192

Random-effects Parameters	estimate	Std. Err.	95% Conf. Interval	
region: Unstructured				
var(ageofc~o)	.0365292	.0139326	.0172975	.0771433
var(eduahu~t)	.0135708	.0069997	.0049382	.0372946
var(_cons)	.2883819	.1156404	.131413	.6328456
cov(ageofc~o,eduahu~t)	-.0077422	.0083851	-.0241767	.0086923
cov(ageofc~o,_cons)	-.0749362	.0333591	-.1403188	-.0095535
cov(eduahu~t,_cons)	-.0241982	.0212709	-.0658884	.0174919

LR test vs. logistic regression: chi2(6) = 140.20 Prob > chi2 = 0.0000

Wald chi2(12) = 359.68 Prob > chi2 = 0.0000

Table 5: Summary of multilevel logistic regression model selection criteria for stunting

Model	Log-likelyhood(LL)	-2LL=deviance	AIC
Random intercept only Model	-6060.6129	12121.226	12125.23
Random intercept and fixed slope model	-5671.5683	11343.137	11371.14
Random coefficient model	-5658.28	11316.56	11354.56

Assumption: m2 nested in m1 Prob > chi2 = 0.0000

Table 6: result of parameter estimate of random intercept only model for wasting

	Coef.	Std. Err.	Z	P>|z|	95% Conf. Interval	
Cons	-2.222524	.13498	-16.47	0.000	-2.48708	-1.957969

Random-effects Parameters estimate Std. Err. 95% Conf. Interval region: Identity

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var(cons)	.1814286	.0913269	.0676443	.4866094

LR test vs. logistic regression: chibar2(01) = 94.58 Prob>=chibar2 = 0.0000

Table 7: Result of Parameter Estimate of Random Intercept and Fixed Slope Model for wasting

		Coef.	Std. Err.	Z	P>|z|	95% Conf. Interval	
Age of child in month	12-23	.6751245	.107392	6.29	0.000	.4646401	.8856088
	24+	-.1230919	.1004861	-1.22	0.221	-.320041	.0738572
	0-11	(ref)					
Wealth index	medium	.0288523	.0979952	0.29	0.768	-.1632147	.2209194
	Normal	-.3216217	.0920871	-3.49	0.000	-.5021092	-.1411342
	Poor (ref)						
MothersBMI	normal	-.5595643	.0741688	-7.54	0.000	-.7049325	-.4141961
	Overweight/obese	-1.195579	.2285288	-5.23	0.000	-1.643487	-.747671
Thinness (ref)							
Sex of children	Male	.1744573	.0699426	2.49	0.013	.0373724	.3115422
	Female (ref)						
Incidence of Diarrhea	yes	.3831462	.0915262	4.19	0.000	.2037581	.5625343
	no (ref)						
Incidence of Fever	yes	.3474534	.0855397	4.06	0.000	.1797987	.5151081
	no (ref)						
Husband/partner education	primary	-.1760605	.0809111	-2.18	0.030	-.3346433	-.0174778
	secondary&above	-.3091459	.1416438	-2.18	0.029	-.5867626	-.0315293
	No education (ref)						
Cons		-1.946263	.1534409	-12.68	0.000	-2.247001	-1.645524

Random-effects Parameters	estimate	Std. Err.	95% Conf. Interval region:	
Identity				
var(_cons)	.0988483	.0506142	.0362344	.2696606

LR test vs. logistic regression: chibar2(01) = 52.47 Prob>=chibar2 = 0.0000

Wald chi2(11) = 296.00 Prob > chi2 = 0.0000

Table 8: Result of Parameter Estimate of Random coefficient Model for wasting

		Coef.	Std. Err.	Z	P>|z|	95% Conf. Interval	
Age of children in month	12-23	.6629794	.1245806	5.32	0.000	.418806	.9071529
	24+	-.170923	.1633887	-1.05	0.296	-.4911589	.1493129
	0-11 (ref)						
Wealth index	medium	.0298823	.0981326	0.30	0.761	-.1624541	.2222188
	Rich	-.3096961	.0921895	-3.36	0.001	-.4903843	-.129008
	Poor (ref)						
MothersBMI	normal	-.5610981	.0744001	-7.54	0.000	-.7069195	-.4152766
	Overweight	-1.193012	.2289022	-5.21	0.000	-1.641653	-.7443723
	Thinness (ref)						
Sex of child	Male	.1735333	.070071	2.48	0.013	.0361966	.3108699
	Female (ref)						
Incidence of diarrhea	yes	.3475652	.1224956	2.84	0.005	.1074783	.5876521
	No (ref)						
Incidence of fever	yes	.338674	.0858553	3.94	0.000	.1704006	.5069473
	No (ref)						
Husband/Partner education	primary	-.1818422	.0811049	-2.24	0.025	-.3408048	-.0228795
	Secondary&above	-.3017075	.1417613	-2.13	0.033	-.5795545	-.0238604
	no education (ref)						
Cons		-1.931374	.1499025	-12.88	0.000	-2.225177	-1.63757

Random-effects Parameters		estimate	Std. Err.	95% Conf. Interval	
region: Unstructured	var(ageofc~o)	.0403366	.032035	.0085051	.191301
	var(haddia~a)	.0598774	.0630429	.0076044	.4714808
	var(_cons)	.0837385	.0654003	.0181189	.3870072
	cov(ageofc~o,haddia~a)	.0464048	.0365101	-.0251536	.1179633
	cov(ageofc~o,_cons)	-.0232879	.0375235	-.0968326	.0502568
	cov(haddia~a,_cons)	-.0481526	.051377	-.1488497	.0525445

LR test vs. logistic regression: chi2(6) = 62.86 Prob > chi2 = 0.0000

Wald chi2(11) = 281.62 Prob > chi2 = 0.0000

Table 9: Summary of multilevel logistic regression model selection criteria for wasting

Model	Log-likelyhood (LL)	-2LL=deviance	AIC
Random intercept only Model	-3074.923	6149.846	6153.847
Random intercept and fixed slope model	-2924.578	5849.156	5875.156
Random coefficient model	-2919.381	5838.762	5874.762
Assumption: m2 nested in m1	Prob > chi2 = 0.0000		