Multilevel Analysis of Factors Associated with Stunting Among Under Five Children in Ethiopia

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Introduction: Stunting is a major health problem in children under-five years in many low and middle income countries around the world. This study was aimed to identify factors associated with stunting among under five age children in Ethiopia.

Methods: Cross-sectional data from Ethiopian Demographic and Health Survey was used for the analysis. The statistical models that suit the hierarchical data such as variance components model, random intercept model, and random coefficients model were used to analyze the data.

Results: This study revealed that among the under-five children considered in the study around 37.1% children was stunted. Age of children, region, place of residence, wealth index, mothers BMI, incidence of diarrhea in the last two weeks before survey and mother and husband/partner educational level were found to be significant predictors for stunting.

Conclusions: Multilevel logistic regression shows that there is heterogeneity or cross-regional variation in stunting. Further this model implies that there exist considerable differences in stunting among regions and a model with a random coefficient is more appropriate to explain the regional variation than a model with fixed coefficients or empty model with random effects.

Keywords: Multilevel model, under five children; Stunting

Introduction

Malnutrition indicators are caused by an extremely low energy and protein intake, nutrients losses due to infection or 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). Sub-Saharan Africa and South Asia were the home to three fourths of the world's stunted children 40% and 39%, respectively (Desalegne et al., 2016).

In Africa, high prevalence levels of stunting among children under-five years of age (36% or 56 million in 2011). 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).

Objectives of the study
The main concerns of authors were to identify the major factors associated with stunting among under five age children in Ethiopia., that is,
 (i) to analyze the within- and between-regions variation of stunting among under five age children in Ethiopia.
(ii) to make model comparison and suggest an appropriate model for analyzing stunting among under five age children in Ethiopia.
(iii) to identify the most important socio-economic, demographic and environmental factors associated with stunting level among under-five children in Ethiopia.

Data and Methodology
The source of data for this study was the 2011 Ethiopia Demographic and Health Survey (EDHS) which is obtained from 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 status of children is based on 9370 under-five children with complete anthropometric measurements and the study considered height-for-age anthropometric index as indicator of a children's stunting status respectively.

Variables in the Study
Dependent variable
Binary and multi category 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 predictor variables.

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

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 child's, diarrhea and fever in the last two weeks before survey, water supplies and toilet facilities, Incidence of acute respiratory infection (such as cough) in the last two weeks, Mother's nutritional status or Mother's BMI are important factors are included in this study.

Multilevel Logistic Regression Model
Multilevel logistic regression model as a hierarchical model, can account for 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,

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

Where u_j is the random effect at level two. Without u_j, this equation (3.11) 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, δ_u^2).

Equivalently, we can split model (3.11) into two models: one for level 1 and the other for level 2.

$$log\left[\frac{p_{ij}}{1-p_{ij}}\right] = \beta_{0j} + \beta_1 x_{ij} \qquad model: level\ 1$$

$And\ \beta_{0j} = \beta_0 + u_{oj} \qquad model: level\ 2 \qquad (2)$

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:

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

$$(3)$$

Variance Components 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 π_{ij} in $y_{ij} = p_{ij} + \varepsilon_{ij}$ in without taking further explanatory variables into account. For the log*it* link function, the log-odds have a normal distribution in the population of groups, which is expressed by

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

And the probability corresponding to the average value β_0, denoted by π_0

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

$$(4)$$

The 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 variables and the response can differ between groups in more ways.

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

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

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

$$\log it(p_{ij}) = \log\left(\frac{p_{ij}}{1 - p_{ij}}\right) = \beta_0 + \beta_1 x_{1ij} + \beta_2 x_{2ij} + ... + \beta_k x_{kij} + U_{0j}$$

$$(5)$$

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 δ_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 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 heterogeneity in relationship between the response and explanatory variables. Suppose that there is 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

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

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

$$log(p_{ij}) = log\left(\frac{p_{ij}}{1-p_{ij}}\right) = \beta_o + \sum_{h=1}^{k} \beta_h X_{ij} + U_{oj} + \sum_{h=1}^{k} U_{hj}X_{ij} \qquad (6)$$

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 $U_{oj}, U_{1j}, \dots, U_{kj}$ are assumed to be independent between groups but may be correlated within groups.

Model Selection Criteria

To achieve this task selection criterion's such as R-square, adjusted R-square, Pseudo R^2, BIC, AIC, etc should be considered. In the case of logistic regression, the model selection criteria will be taken as AIC. The AIC computation is based on the likelihood of the fit and the number of parameters in the model is considered.

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 are 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 $−2 \times log\ 1=0$ (Agresti, 2002).

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

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

Results

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

Descriptive statistics

Table 1 shows that the relative frequency distributions of the stunting status of child. 37.1% are stunted and 62.9% are not stunted.

Result of Multilevel Logistic Regression Analysis

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 region.

Variance components model

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 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 $\hat{\beta}_o$ = -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 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 cross-regional 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

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 we see that the inclusion of level one covariates decreased regional variations from 0.2150 (level-two variance without covariates) to .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 month, place of residence, wealth index, mothers BMI and incidence of diarrhea have significant effect.

The Random Coefficient Model
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 (level-one 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 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.

Multilevel logistic regression Model comparison
Before interpreting multilevel models, we compare the three multilevel logistic regression models (nested models) considered. To do so, deviance, AIC and BIC were used. 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 is 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 regressions 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 area 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 ≥ 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 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. Based on Table 5 for stunting random coefficient model have 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, we conclude that the random coefficient model is a good fit.

Discussion

The results of the study indicate that age of child is one of determinant associated with stunting status of children in Ethiopia. The stunting 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.

Mother's highest educational level was identified to be the most significant factor to reduce the occurrence of children 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.; Tengia-Kessy, 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 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 were 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 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 status of children. Children from thinness level (BMI<18.5) mother's higher status of stunting as compared to normal level (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.; Tengia-Kessy (2015) which reveals that mother's nutritional status had positive effect indicating that children belong to thinness level (BMI<18.5) mothers are associated with high probability of stunting

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

Conclusion

Multilevel logistic regression shows that there is heterogeneity or cross-regional variation in stunting. Further this model implies that there exist considerable differences in stunting among regions and a model with a random coefficient 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, incidence of diarrhea in the last two weeks before survey and mother and husband/partner educational level were found to be significant predictors for stunting. The concerned bodies (government and other stakeholders) have to give different priorities to different children age group, family background in terms of their mothers fathers education level, mother's nutritional status, incidence of diarrhea and fever, household wealth status to control children stunting. Since we have shown that children in rural areas are more likely to be stunted than children in urban areas, special attention should be given for the residence difference. Since there are variations in stunting across

regions the concerned body should give special attention to regional variation.

Declarations

Authors, declare that this article is our original work and has not been published on any journal.

Ethics approval and consent to participate

Not Applicable

Consent for publication

Not Applicable

Availability of data and material

The analysis in this study is based on data available from the Ethiopian Demographic and Health Survey.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

Hulle Hassen and Kemal Nure generated the idea and designed the study and also doing statistical analysis, editing, reviewing and write up the manuscript. All authors read and approved the final manuscript.

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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

Table 2: Result of Variance component model

	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

Table 3: Result of Random Intercept and Fixed Slope Model

		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
	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 Random Coefficient Model

		Coef.	Std. Err.	Z	P>|z|	[95% Conf. Interval]	
Age of child in	12-23	1.517867	.1117068	13.59	0.000	1.298926	1.736808
month	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	yes	.3190488	.0637295	5.01	0.000	.1941413	.4439563
Diarrhea	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	Primary	-.0104356	.0641735	-0.16	0.871	-.1362134	.1153421
education	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 Model comparison

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		