STATISTICAL Analysis of the Nutritional Status OF Women in Ethiopia: Evidence From the 2016 ETHIOPIA Demographic and Health Survey

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Abstract *Poor nutritional status of women has been a serious problem in Ethiopia for many years. This study aims at identifying and investigating determinants of women nutritional status in Ethiopia. The analysis is based on Body Mass Index (BMI) of 11,955 women aged between 15 and 49 years that are obtained from the 2016 Ethiopian Demographic and Health Survey. A multilevel logistic regression analysis is employed to estimate the parameters and captures the hierarchical nature of the dataset. The result indicates that women's nutritional status differs across regions, and that nutritional status of women varies from 20 percent to 45 percent. Demographic, socio-economic and infrastructure variables significantly determine nutritional status of women. Strengthening primary health care, educating women and creating employment opportunities are found to be crucial way forwards.*

Key Words: **Nutritional Status, Women and Multilevel Analysis**

I. Introduction

Nutritional status is the result of complex interactions between food consumption and the overall status of health and health care practices. Numerous socioeconomic and cultural factors influence patterns of feeding children and the nutritional status of women and children. The period from birth to age two is especially important for optimal growth, health, and development. Unfortunately, this period is often marked by micronutrient deficiencies that interfere with optimal growth. Additionally, childhood illnesses such as diarrhea and acute respiratory infections (ARI) are common. For women, improving overall nutritional status throughout the life cycle is crucial to maternal health. Women who become malnourished during pregnancy and children who fail to grow and develop normally due to malnutrition at any time during their life, including during fetal development, are at increased risk of prenatal problems, increased susceptibility to infections, slowed recovery from illness, and possibly death. Improving maternal nutrition is crucial for improving children's health (CSA and ICF 2012).

Chronic energy deficiency is caused by eating too little or having an unbalanced diet that lacks adequate nutrients. Women of reproductive age are especially vulnerable to chronic energy deficiency and malnutrition due to low dietary intake, inequitable distribution of food within the household, improper food storage and preparation, dietary taboos, infectious diseases, and inadequate care practices. It is well known that chronic energy deficiency leads to low productivity among adults and is related to heightened morbidity and mortality. In addition, chronic under-nutrition among women is a major risk factor for adverse birth outcomes (CSA and ICF, 2016)

Women in developing country are most vulnerable to malnutrition, due to low dietary intakes, inequitable distribution of food at household level, improper food storage and preparation and infectious diseases (CSA and ORC Macro, 2006). Poor nutritional status of women has been a serious problem in Ethiopia for many years. For example, more than one out of every four (27 per cent) women in Ethiopia who are in the reproductive age is undernourished (CSA and ICFI, 2012).

Under-nutrition among women age 15-49, as measured by BMI less than 18.5, has declined over the last 16 years. The percentage of thin women dropped from 30% in 2000 to 22% in 2016. In contrast, the proportion of women who are overweight or obese, which is indicative of over nutrition, has increased during the same period. The proportion of women who are overweight or obese has increased from 3% in 2000 to 8% in 2016 (CSA and ICF, 2016).

A number of research works were conducted on the levels and determinants of maternal nutritional status using Ethiopian Demographic and Health Surveys (EDHS). However, those studies have not looked into sources of women nutritional status disparity among regions. In Ethiopia context, however, there is a significant variation among regions in terms of resource allocation, level of poverty, social services, environmental challenges and level of infrastructure development that may directly or indirectly affect nutritional status of women. Thus, this it is worth capturing region as one important source of variation for women nutritional status.

This study, thus, takes into account important sources of regional variation to investigate determinants of women's nutritional status using a multilevel model. This study centers on estimating the level, identifying determinants and examining determinants of women nutritional status at intra-regional and inter-regional levels. The remainder is organized in four sections. Section 2 presents the methodology of the study in some detail. In section 3 the findings of the study are presented. Section 4 highlights conclusions and recommendations of the study.

II. Methodology

Study area and data

Ethiopia is the second most populous nation in Africa with a total population of 86.6 of which half of them are females (CSA, 2016). The latest country's census depicted those women in the reproductive age group (15-49) make up about a quarter (24 per cent) of the total population (CSA, 2007).

The country is administratively divided into nine regional states-Tigray, Affar, Amhara, Oromiya, Somali, Benishangul-Gumuz, Southern Nations Nationalities and Peoples (SNNP), Gambela, and Harari-and two city administrations-Addis Ababa and Dire Dawa.

The analysis of this study is based on the fourth comprehensive EDHS 2016 dataset.
In the interviewed households, 16,583 eligible women were identified for individual interviews. Interviews were completed with 15,683 women, yielding a response rate of 95%. A total of 14,795 eligible men were identified in the sampled households and 12,688 were successfully interviewed, yielding a response rate of 86%. Although overall there was little variation in response rates according to residence, response rates among men were higher in rural than in urban areas (CSA and ICF, 2016).

The 2016 EDHS collected anthropometric data on height and weight for women age 15-49. These data were used to calculate several measures of nutritional status such as maternal height and body mass index (BMI). BMI is calculated by dividing weight in kilograms by height in meters squared Kg/m^2 . For this study, ***11,955*** women's BMI data were taken for which information on height and weight were available. Women age 15-49 who are not pregnant and who have not had a birth in the 2 months before were included.

Variables

Outcome variable The response variable is the nutritional status of women measured in BMI. Most frequently this indicator is used as a standard indicator to assess the progressive loss of body energy. The International Dietary Energy Consultative Group (IDECG) suggests the cut-off point for adults Chronic Energy Deficiency (CED) to be BMI < 18.5 (James et.al., 1988). For this study the same threshold is used, as well. The response variable dichotomized as malnourished if BMI<18.5, and otherwise (if BMI>=18.5).

Explanatory variables

Explanatory variables include indicators of demographic characteristics of households to which the women belong to, socioeconomic status of households, geographic location of the women, health status of the women and access to infrastructure. Some of these indicators are: age, educational level, marital status, employment status, household economic status (wealth index), place of residence, region, number of children, and source of water supply of the women.

Method of Data Analysis

The analysis was made in two stages. In the first stage a single level analysis was fitted using standard ordinary logistic regression ignoring the hierarchical structure of the data and the possible correlation that may exist across the regions. In the second stage, we recognized the hierarchical structure of data and that attempt made to separately identify regional effects using multilevel modeling approaches.

Standard logistic regression model

Key determinants of nutritional status were first analyzed using standard ordinary logistic regression model. the response variable, women nutritional status measured in bmi and dichotomized as malnourished or not as can be seen below:

$$\text{That is, BMI} = \begin{cases} 1, & \text{if woman is malnourished} \\ 0, & \text{otherwise} \end{cases}$$

The logistic regression model is given as follows (Hosmer and Lemissow, 2000):

$$\operatorname{logit}(\pi_{ij}) = \ln\left(\frac{\pi_{ij}}{1-\pi_{ij}}\right) = \beta_0 + \sum_{i=1}^{K} \beta_p X_{ij} \quad \text{.................................. (1)}$$

where x_{ij}'s the predictor variables and π_{ij} were denoted the probability.

Multilevel models

Advnatage of multilevel analysis is that it adequetly represents unexplained variability of nested structure, which is often difficult to represent in multiple regression analysis such as standard ordinary logit regression indicated above. In multiple regression analysis the unexplained variability is assumed to be a single level and that it emantes only from the variance of the residual term. Whereas, in multilevel analysis the variability has more complicated structure related to several populations involved in modelling (Snijders and Bosker, 1999).

Random coefficients logistic regression model

Multilevel logistic regression analysis is the method of examining hierarchical data structures and finding the relationship between two or more variables. The outcome variable of multilevel logistic regression is the dichotomous variable and has the Bernoulli distribution $(n_{ij} = 1)$. A dichotomous random effects model has a binary outcome (Y=0 or Y=1) and regresses the log odds of the outcome probability on various predictors to estimate the probability that Y=1 happens, given the random effects. The simplest dichotomous is a 2-level model that is given as follows:

Assume there are k explanatory variables $X_1,\ldots,X_k$. The values of $X_{p,}(p=1,2,\ldots k)$are indicated by X_{pij}, ($p=1,2,\ldots k$; $i=1,2,\ldots,N_i$ and $j=1,2,\ldots,N$). Since some or all of these variables are level-one variables, the success probability is not necessarily the same for all individual in a given group. The success probability depends on both the individual and the group that the individual belongs to. It is denoted by π_{ij}. The outcome variable is expressed as the sum of the success probability (expected value of the outcome variable) and a residual term ε_{ij}. That is, $Y_{ij} = \pi_{ij} + \varepsilon_{ij}$ the residual term ε_{ij} *is* assumed to have mean zero and variance σ_{ε}^2. The logistic regression model with random coefficients express the logs-odds (i.e. the logit of π_{ij},) is the sum of a linear function of the explanatory variables with randomly varying coefficients.

That is,

$$\text{logit}(\pi_{ij}) = \beta_0 + \sum_{p=1}^{K} \beta_{pj} X_{pij} + U_{oj} + \sum_{p=1}^{K} U_{pj} X_{pij}$$

In the equation, $\beta_0 + \sum_{p=1}^{K} \beta_{pj} X_{pij}$ is the fixed part of the model, whereas $U_{0j} + \sum_{p=1}^{K} U_{pj} X_{pij}$ is the random part. The term $\sum_{p=1}^{K} U_{pj} X_{pij}$ represents the random interaction between group and the explanatory variables.

Intercept-only model

Intercept-only model sometimes referred as empty model. This is the simplest form of multilevel logistic regression model without explanatory variables. The model only contains random groups and random variation within groups. It can be expressed as a model where the dependent variable is the sum of a general mean, a random effect at the group level, and a random effect at individual level.

It can be expressed as:

$$\text{logit}(\pi_{ij}) = \ln\left(\frac{\pi_{ij}}{1-\pi_{ij}}\right) = \beta_{0j} = \beta_0 + U_{0j}$$

Where β_0 is the overall mean and U_{0j} the variance component between regions. This will be used as parametric version for assessing heterogeneity among regions with respect to nutritional status of women.

Random intercept logistic regression model

Random intercept logistic regression model has all its lower level explanatory variables are fixed. This means that the corresponding variance components of the slope are fixed at zero. It is used to assess the contribution of each individual explanatory variable.

$$\text{logit}(\pi_{ij}) = \log\left(\frac{\pi_{ij}}{1-\pi_{ij}}\right) = \beta_{0j} + \sum_{p=1}^{K} \beta_p X_{pij}$$
$$= \beta_0 + \sum_{p=1}^{K} \beta_p X_{pij} + U_{0j}$$

The first part, $\beta_0 + \sum_{p=1}^{K} \beta_p X_{pij}$ 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.

the two prevailing approximation procedures for estimating multilevel logistic regression models are marginal quasi likelihood (mql) and penalized quasi likelihood (pql) (goldstein and rasbash, 1996). however, pql has best approximation procedure and is preferred to mql (goldstein, 2003). for this study, second-order pql (pql-2) method is adopted.

III. Results and Discussion

Table1 the percentage of nutritional status among women by selected socio-economic and demographic characteristics, EDHS 2016.

	Well nourished BMI=18.5-24.99	Undernourished BMI<18.5	P –value
age			**0.000**
15-19	65.5%	34.5%	
20-24	72.4%	27.6%	
25-29	76.0%	24.0%	

30-34	74.6%	25.4%	
35-39	73.3%	26.7%	
40-49	70.1%	29.9%	
place of Residence			**0.000**
Urban	77.5%	22.5%	
Rural	68.9%	31.1%	
Educational Status			**0.000**
No education	70.2%	29.8%	
Primary	71.8%	28.2%	
Secondary and above	73.5%	26.5%	
Source of drinking water			**0.000**
Unprotected	72.0%	28.0%	
Protected	70.3%	29.7%	
Economical Status			**0.000**
Poor	64.5%	35.5%	
Middel	73.0%	27.0%	
Rich	77.1%	22.9%	
Marital Status			**0.000**
nevermaried	68.9%	31.1%	
Married/living together	72.3%	27.7%	
Widdowed/divorsed/Separated	72.9%	27.1%	
Employment Status			**0.000**
Unemployed	67.8%	32.2%	
Employed	75.2%	24.8%	
No of Children			**0.000**
No children	72.5%	27.5%	
one to two children	70.5%	29.5%	
3 or more children	71.4%	28.6%	

Source: Own computation using EDHS 2016

Levels of under-nutrition

Table 1 shows BMI scores of women undernourished (severely thin, moderately thin, and thin) based on background characteristics. More specifically, women who were unemployed (32.2 percent), never married (31.1 percent), belonged to poor household (35.5 percent) are most affected by severe undernourishment. Slightly large portion of women who are in the age between 15 and 19 and above 40years found to be in severely thin category.

Model Estimation

Intercept Only Multilevel Logistic Model (Empty model)

Table 2 presents parameter estimates, standard errors of a standard logistic and a multilevel logistic regression models without explanatory variables. The maximum likelihood estimates from the standard logit model of the ratio between undernourished and nourished women is $\exp(-756)=0.470$, which is the ratio of 4,238 malnourished by 9,030 nourished women. In the intercept only model, the average log-odds of malnourished women in PQL-2 parameter is -0.752 that corresponds to odds of $\exp(-0.752)=0.471$. Similarly, in MQL-2, PQL-2 and MCMC parameter estimate the odds of $\exp(-752)=0.471$, $\exp(-752)=0.471$ and $\exp(-7)=0.474$ respectively.

Compared to the odds-ratios estimate obtained by all multilevel methods except PQL-1, the standard logistic model has underestimated and shown significant different odds-ratio estimates.

Table 2 Parameters and standard errors of an intercept-only logit model and an intercept-only multilevel model predicting the probability of under-nutrition.

Model Effect	Standard Logit	Multilevel Models				
	Logit	MQL-1	MQL-2	PQL-1	PQL-2	MCMC
Fixed effect						
Intercept, β_0	-0.756	-0.717	-0.752	-0.784	-0.752	-0.746
S.E	0.019	0.133	0.135	0.137	0.138	0.138
P value	**0.000*** **	**0.000*** **	**0.000*** **	**0.000*** **	**0.000*** **	**0.000*** **
Random Effect						
Level-two variance Var(U_{oj})= σ_0^2		0.191	0.193	0.203	0.205	0.244
S.E		0.083	0.085	0.088	0.089	0.134
P value		0.021**	.023**	0.021**	0.021**	.069*
-logL Dviance	15808.731					16118.66
N	13268	13268	13268	13268	13268	13268

Note: *= significant at10%, **= significant at 5%, and ***= significant at 1%

The region level variation is estimated to 0.191, 0.193, 0.203, 0.205, and 0.204 from the multilevel model by the MQL-1, MQL-2, PQL-1, and PQL-2 and MCMC methods on the logit scale respectively. The chi-square value of 5.222 on 1 degree of freedom is significant, so we reject the null hypothesis $\left(H_0 : \sigma_0^2 = 0\right)$ and conclude that there is an evidence of unobserved heterogeneity among region. This means there is a considerable variation in women nutrition across regions.

When the multilevel second order Penalized Quasi Likelihood (PQL-2) is applied the expected log-odds of malnutrition is found to be -0.752, which corresponds to odds of $\exp(-752) = 0.471$. This corresponds to a predicted probability of $\pi_{ij} = \frac{\exp(-752)}{1+\exp(-752)} = 0.3201$. But for the standard logistic model the predicted probability is $\pi_{ij} = \frac{\exp(-756)}{1+\exp(-756)} = 0.3196$. Assuming the region's log-odds of malnutrition, β_{0j} to be approximately normally distributed with mean -0.752 and Var(β_{0j})=0.205. When multilevel model is fitted with no predictor, at 95% confidence interval, β_{0j} for malnutrition varies from 20 percent to 45 percent across regions.

Figure 1 plots the region level residual. The residuals $\mathbf{U_{oj}}$ are plotted in ascending order of magnitude with their confidence intervals. When this confidence interval crosses the dotted line (the origin 0.0), under-nutrition for this region (from top to bottom Dire Dawa, Amhara, Ben-Gumuz, Oromia and Harari) is not significantly different from the overall under-nutrition in Ethiopia. If the confidence interval is entirely below the dotted line, under-nutrition is significantly lower for that region (SNNPR and Addis Ababa) and if the confidence interval is entirely above the dotted line (colored red/yellow) under-nutrition is significantly higher for that region (Affar, Gambela, Tigray, and Somalia).

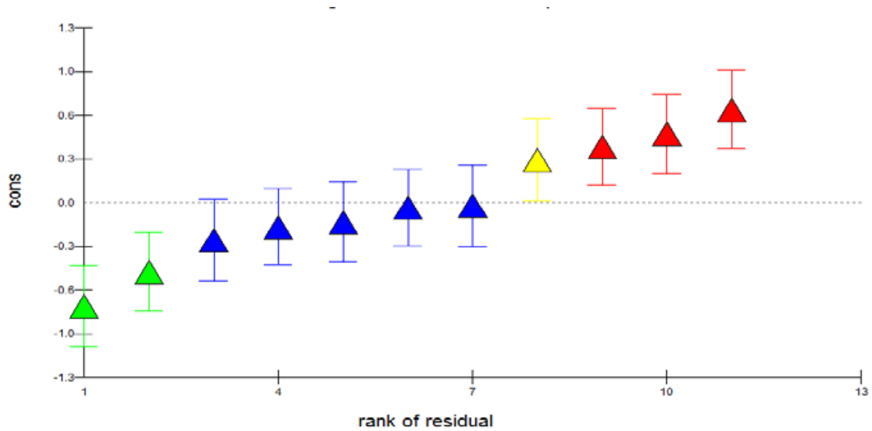

Figure 1 the region level residual plots

A multilevel analysis for determinants of nutritional status of women

Table 2 indicates that nutritional status of women differs across regions; in order to capture this variation a two-level structure multilevel analysis is employed. Region is taken as the second-level unit and woman as the first-level unit.

A chi-square test is run to assess heterogeneity in the proportion of undernourishment of women in the 11 regions. The *p-value* of the chi-square test is $p<0.01$ that is evident for the presence of heterogeneity in (women) undernourishment across the regions.

The significant level-two variance ($Var(U_{oj})=\sigma_0^2$) in the intercept of multilevel mode ($p = 0.000$) is 0.205 using PQL-2, which suggests the presence of variation in women nutritional status across regions. The univariate model is fitted for each covariate **Y** to check the significance of the random effect across regions, but no variable is found to be significant ($p>0.10$). This means the model does not allow intra-regional difference to vary across inter-regions. This tells the best fitness of the random coefficient (intercept) with fixed explanatory variables.

Table 2 presents the multilevel univariate analysis and each models indicates a random intercept and a fixed slope for the variable. The 5th column presents odds ratios of the multilevel logistic regression; unlike in the standard logistic regression converting parameter estimates into odds ratios is difficult in multilevel logistic regression (Hasinur and Ewart, 2011).

The β coefficients of the explanatory variables for multilevel and standard models are significantly different, because of the random effects used in multilevel model. The significant value of the random effects suggests the distortion of estimated values from true values. It depicts variation that would have been evaded had the multilevel model had not been used. For example, in the single level model the β coefficients for the number of children and source of drinking water are underestimated, while the coefficients for place of residence and wealth index are overestimated. Estimated coefficient for the number of children is underestimated by almost 52 percent and 41 percent for no-children and 1-2 children, respectively.

The multilevel model result in Table 2 shows that nutritional status of women varies across regions. Partly this variation is significantly determined by age, marital status, employment status, place of residence and number of children that a woman has, and that of economic status of a household, access to toilet facilities and partner's educational level.

Younger women-age between 15 and 19 years-are in slightly higher risk (OR=1.05) of malnourishment than older women whose age between 40 and 49 years. However, women whose age are between 20 and 29 years are less likely to be malnourished than older women (age between 40 and 49 years).

Partner's educational level is found to be an important determinant to explain undernourishment of women in Ethiopia. A woman who is partnered with a man with no education or only educated to primary level is more likely to be malnourished than a woman who is partnered with man who has secondary or above level of education. This partly is because women in poor countries are economically dependent on their partners. A low level of partner's education reflects a low-level of income earning, which negatively affects both the household and individual nutritional status. Fikrewood and Daniel (2010) have documented a similar finding that depicts women nutritional status improves with the level of partner educational. Similarly, women from poor and medium economic status background are 1.5 and 1.2 times more likely to be malnourished than women who are from rich economic status background.

Marital status plays a significant role for women nutritional status**.** Never married women are found to exhibit a higher risk of malnourishment compared to widowed/divorced/separated women. Mores specifically, never married women have 1.33 times more chance of undernourishment than that of divorced/separated/widowed women. This goes with the general fact, in Ethiopia, that women are highly economic dependent on their partners.

Evidences suggest that the risk of undernourishment is high among unemployed women even in households with a relatively better socio-economic status (Girma and Timotiowa, 2002). This study also confirms that the risk of undernourishment for unemployed women is 1.16 times more likely than for employed women.

Women from urban areas are about 20 percent less likely to be malnourished than women from rural areas. This is may be women in urban areas have better access to education and opportunities for making extra income than women from rural areas, which in turn affect their nutrition status.

Malnutrition is often associated with an unhygienic condition that causes communicable diseases, which in turn aggravate malnutrition.

Conclusions

Both the standard logistic and multilevel logistic models are employed to identify the nested effect of women are nested within the different regions in Ethiopia. In the multilevel approach, nonparametric and parametric tests are applied to check whether there is a difference in the nutritional status of women across the regions.

Socio-economic and demographic variables-age, educational level, employment status, household economic status, marital status, place of residence, number of children and access to toilet facilities-are significant determinants of nutritional status of women in Ethiopia. Moreover, there is a significant variation in the nutritional status of women across regions.

The robust conclusion is that nutritional status of women varies across regions. This variation primarily has to do with the disparity in food security status, healthcare facilities, cultural and dietary practices, socio-economic and environmental settings, and inequality in the distribution of services and resources across regions. This calls for an integrated policy intervention, which aims at addressing primary health care, food insecurity and malnutrition problems, improve women's access to education and support women on job creation.

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