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FACTORS ASSOCIATED WITH UNDERWEIGHTS AMONG CHILDREN OF 6-59 MONTHS AGE IN MIESSO DISTRICT, OROMIA, ETHIOPIA

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ABSTRACT

Children are most exposed to under nourishment because of high dietary requirements for their growth and development. The present study was aimed to determine the prevalence of underweight children in age group of 6-59 months in Meisso district, Oromia (Ethiopia) and identify the associated factors responsible for it. A community based cross sectional study was conducted on 296 children. The data was collected by using a well-structured pretested questionnaire. Anthropometric measurements of children were taken to assess their nutritional status. Generalized ordered logit model, proportional odds model and partial proportional odds model were compared and finally the partial proportional odds model was taken as the best model for current study to identify the factors associated with the nutritional status of children. The study showed that underweight was a serious problem in Miesso district with the prevalence of severe underweight as 24.0% and those of mild underweight as 26.7%. The predictors significantly related to the child nutritional status were sex, age, household's food security status and the toilet using status of family, since the child malnutrition in the district was very highly prevalent continuous nutrition supervision and special attention to severely malnourished children is necessary to overcome malnutrition problem.

Keywords: Miesso, malnutrition, partial proportional odds models, underweight, weight for age

Abbreviations: AIC = Akaike Information Criteria; BIC = Bayesian Information Criteria; CSA = Central Statistical Agency; EDHS = Ethiopian Demographic and Health Survey; EIAR = Ethiopian Institute of Agricultural Research; FAO = Food and Agricultural Organization; GOLM = Generalized Ordered Logit Model; LR = Likelihood Ratio; POM = Proportional Odds Model; PPOM = Partial Proportional Odds Model; SPSS = Statistical Packages for Social Science; UNICEF = United Nations International Children Emergency Fund; UNSCN = United Nations System Standing Committee on Nutrition; USAID = United States Agency for International Development; USDA = United States Development Agency; and WHO = World Health Organization;

INTRODUCTION

Underweight generally indicates under-nourishment and is a serious health problem in Africa leading to considerable deaths and sickness (Tosheno *et al.,* 2017). It is caused by an unfitting or inadequate nutrition (WFP and CDC, 2005; Kalu and Etim, 2018). Around 821 million people in the world are undernourished (FAO *et al.*, 2018). United Nations International Children's

Emergency Funds (UNICEF) has estimated that at least 1 in 3 children under 5 year-age were undernourished and about 200 million children under 5 years were undernourished in 2018. The countries in sub-Saharan Africa are among the highly affected areas (UNICEF, 2019).

In Ethiopia malnutrition is main public health problem and the children are its first victim (CSA and ICF, 2017). Ethiopia is one of countries affected by drought with high burden of malnutrition (FAO *et al*., 2015, 2018). Several factors influence the forms of child feeding and nutritional status of women and children (CSA and ICF, 2017). Children are the most affected groups of under-nutrition because of high dietary requirements for their growth and development (Tosheno *et al.*, 2017). It leads to their illness and death, especially in children under 5 year-age in developing countries (FAO *et al*., 2018). In Ethiopia around 24% children are under-weight with 22.5% underweights in Oromia region, of which 6.5% are severe underweight (CSA and ICF, 2017). Malnutrition is more prevalent in the eastern lowlands of Oromia; particularly in the West Hararghe zone (Nkunzimana *et al.*, 2016). The study conducted in Miesso district of Oromia region on pregnant and lactating women revealed that 30% were underweight (Serbesa *et al*., 2019).

Miesso district is highly affected by climate change and drought problems so faces frequent crop failure, losses of livestock and occurrence of new disease and pest (Tamiru *et al*., 2015). Also, Miesso district is one of the most affected areas in internal conflicts and displacement in Ethiopia (Stark *et al*., 2011; Maru, 2017). It is obvious that these problems are basic factors for hunger and malnutrition. Despite these problems there is no published study conducted on under 5-year children underweight and associated factors in Miesso district of Oromia region. Therefore, this study was designed to assess the prevalence of underweight in children of 6-59 months age in Miesso district, Oromia, Ethiopia and to identify the associated factors responsible for malnutrition in children.

MATERIALS AND METHODS

Study area and design

A community based cross-sectional study was conducted in Miesso district (Fig. 1), West Hararghe Zone, Ethiopia. Miesso is one of the Weredas in the Oromia region of Ethiopia. As per population projection values of 2017, the population of Miesso is 174,916 of which 89,052 were men and 23.42% population is urban dwellers (CSA, 2013).

Population of the study area

The source population of this study was all children of age between 6 and 59 months in Miesso district (Ethiopia). The children population (6-59 months age) in Miesso Wereda were randomly included in the study and resided in the selected *Kebeles*. This study included those children in the district which were able to be measured, but not admitted in hospital for any disease, and whose mother/ care-giver were willing for response.

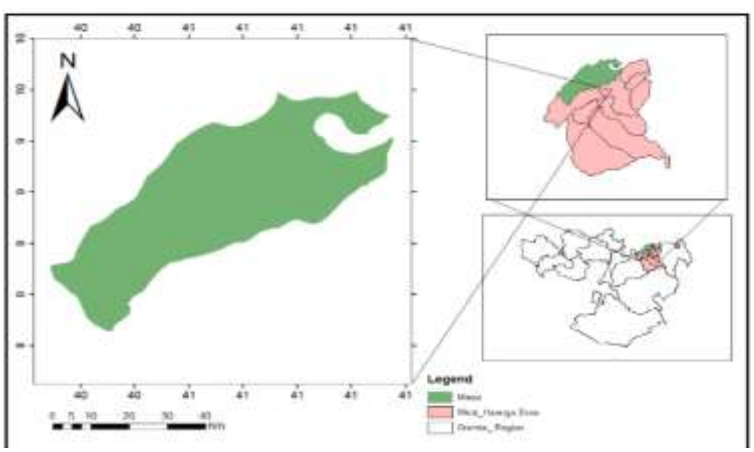

Fig. 1: The map of study area in *Miesso* district (Ethiopia)

Sampling technique & sample size

The sampling technique used in this study was 2-stage systematic random sampling method. In 1st stage, 9 *Kebeles* were randomly selected among 33 *Kebeles* which comprised of about 30% of *Kebeles* in the district. In 2nd stage from the list of households who had children aged between 6 and 59 months in the selected *Kebeles* were selected by using systematic random sampling.

The required sample size was calculated using the formula as under (1).

$$n = \frac{Z_{\alpha/2}{}^{2} p(1-p)}{d^{2}} \qquad (1)$$

Where, $Z_{\alpha/2}$ = the standardized normal distribution value at 95% level of significance which is 1.96; P = prevalence of child malnutrition in Oromia region = 0.226 (CSA and ICF, 2017); d = margin of error = 5%)

Based on equation (1) we could calculate the sample size as follows (Daniel, 1999).

$$n = \frac{Z_{\alpha/2}{}^{2} p(1-p)}{d^{2}} = \frac{(1.96)^{2}(0.226)(0774)}{(0.05)^{2}} = 269$$

By considering 14% non-response rate the sample size [= 269 + 38], 307 children were selected from nine *Kebeles*. The number of children from each selected nine *Kebeles* was determined by proportional to the size algorithm. The sample size taken from the selected *kebeles* were 24, 20, 23, 94, 38, 20, 44, 24 and 20 from Sodoma Goro (population size, 457), Gorbo (320), Gulufa (444), Asebot (1780), Oda Bella (722), Agemsa Chale (370), Oda Roba (842), Burri Mullu (464) and Waltane (377), respectively. Finally for a sample of 296 children, the data were used for analysis.

Data collection

The data used for present study was obtained by cross sectional data collection method using well-structured questionnaires. The data on field was collected from June to September, 2017. The questionnaire was first organized in English and translated into *Afan Oromo* by fluent speakers of both the languages. Experienced health workers who could communicate in *Afan Oromo* were employed for data collection. The data was collected by interviewing the mothers/caregivers of children. To assure quality data collection, the workers were trained about the objective of study, method of data collection, recording and anthropometric measurement techniques. The supervisors and researchers carefully followed the data collection procedure. The anthropometric measurement being inexpensive and non-invasive measure was done as per the procedure specified by WHO (2006). The child weight was measured by spring hanging scale with lowest clothing and without shoes. Oedema status of each child was checked as the children with oedema were severely malnourished even if his/her weight was large. To know about the previous health status of children, mothers were asked about the incidence of infection and occurrence of diarrhoea during past two weeks. The household food access security status was evaluated by using nine questions of Food and Nutrition Technical Assistance standards (USDA, 2012; Hussein *et al*., 2018).

Study variables

Response variable: The dependent variable taken was the underweight status of children aged 6-59 months classified as severely underweight, moderately underweight and nourished (WHO, 2006; WHO and UNICEF, 2009; WHO, 2013).

Explanatory variables: The explanatory variables used in the model were: i) presence of household toilet, ii) family size, iii) mother's education level, iv) father's education level, v) maternal employment status, v) father's employment status, vi) household food security status, vii) drinking water source, viii) age of the child (6-11 months, 12-23 months, 24-35 months, 36-47 months and 48-59 months); ix) sex of the child, x) exclusive breast feeding status of the child for the 1st six months, and xi) prevalence of diarrhoea or fever in child in the two weeks prior to the survey.

Data processing and analysis

The collected raw data was checked for completeness and consistency before data entry. The raw data was coded and entered in SPSS version 20. The descriptive statistics was analyzed by using SPSS 20 and exported to STATA14 for inferential statistical analysis was used to identify the associated factors with underweight status of children. To generate the Z-scores of weight for age of children, the necessary variables were exported to WHO Antro software for generating the Z-scores and again exported to SPSS and Stata14 statistical software for further statistical analysis. The prevalence of underweight for children aged 6 to 59 months in *Miesso* district was estimated based on the weight of children. As per WHO (2006) reference, the Z score of children who fail below minus two standard deviations were taken as underweight and below minus three standard deviations were taken as severely underweight.

In present study, the variance inflation factor(VIF) of predictors was checked using Stata14 software after OLS model was fitted instead of gologit/ologit models. we got less than 5 for all predictors in the model which indicated there is no multicollinearity problem among the predictors in the model.

Ordinal logistic regression

In present study three types of ordinal logistic regression model were used to identify factors associated with the nutritional status of children.

Generalized ordered logit model (GOLM): Generalized ordered logit model is one the models used when the response variable is ordered categories, the model needs to be able to handle the multiple categories, and ideally, account for the ordering. The GOLM (Williams, 2006) can be written as:

$$P(Y_i > j) = \frac{\exp(\alpha_j + X_i'\beta_j)}{1+\exp(\alpha_j + X_i'\beta_j)}, \ j = 1, 2, \ldots, M-1. \quad (2)$$

Where: *M* is the number of categories of the ordinal dependent variable.

In current study Stata14 software generalized logit model fitted through gologit2 command was used. In GOLM the positive coefficients indicate that higher values on the explanatory variable make it more likely that the respondent will be in a higher category of response variable (Williams, 2006; Long, 2014).

Proportional odds model (POM): The proportional odds model is used to estimate the odds of being at or below a particular level of the underweight status of children (Agresti, 1996). For category j the POM is special case of GOLM in the above equation and is written as:

$$\mathbf{P(Y_i \le j)} = \frac{\exp(\alpha_\mathbf{j} + \mathbf{X_i'}\beta)}{1+\exp(\alpha_\mathbf{j} + \mathbf{X_i'}\beta)} \quad \text{for } j = 1,2,\ldots, J-1 \quad (3)$$

Cumulative logits:

$$\log_\mathbf{e}\left[\frac{\mathbf{P(Y_i \le j)}}{1-\mathbf{P(Y_i \le j)}}\right] = \alpha_\mathbf{j} + \mathbf{X_i'}\beta \quad \text{for } j = 1,2,\ldots, J-1 \quad (4)$$

As [28] explained the ordinal logistic regression model is expressed in logit form as follows:

$$\ln(Y_j') = \text{logit}[\pi(x)] = \ln\left(\frac{\pi_j(x)}{1-\pi_j(x)}\right) = \alpha_j + (-ß_1X_1 - ß_2X_2 - \ldots - ß_pX_p) \quad (5)$$

This is the form of a proportional odds (PO) model because the odds ratio of any predictor is assumed to be constant across all categories (Liu *et al.*, 2011). The current study used SPost13 package in Stata14 to test whether the PO assumption is met by using Brant tests for each independent variable and the omnibus test for the total model (Brant, 1990).

Partial proportional odds model (PPOM): PPOM restricts some coefficients of independent variables to be the alike for every separating point while others are tolerable to differ (Williams, 2006). Unconstrained PPOM (Lall, 2004) is expressed as:

$$\ln\left[\frac{P(Y_i \le y_j)}{P(Y_i > y_j)}\right] = \alpha_j + \sum_{k=1}^{p} x_{ik}\beta_k + \sum_{k=1}^{p} T_{ik}\gamma_{jk}, \ j = 1,2,\cdots,c-1 \quad (6)$$

The above equation (6) of PPOM can be written as follows:

$$P(Y_i \le y_j) = \frac{\exp(-\alpha_j - \sum_{k=1}^{p} x_{ik}\beta_k - \sum_{k=1}^{p} T_{ik}\gamma_{jk})}{1+\exp(-\alpha_j - \sum_{k=1}^{p} x_{ik}\beta_k - \sum_{k=1}^{p} T_{ik}\gamma_{jk})}, \ j = 1,2,\cdots,c-1 \quad (7)$$

Where: X_{ik} are subset of p predictors which are fulfills the parallel lines assumption.
β_{ik} are the coefficients linked with the p independent variables in X_k.
T_{ik} subset of the p predictors for which the parallel lines assumption is violated

Deviance goodness-of-fit test

The likelihood-ratio test statistic or deviance can be written as follows:

$$D = -2\log\left[\frac{L_c}{L_f}\right] \sim \chi^2_{(J-p-1)} \tag{8}$$

Where L_c & L_f the likelihood of the null and full model, respectively.

Pseudo-R ^{2}

As explained by (Williams, 2006), McFadden's R^2 is possibly the most common Pseudo R^2 and it is the one that Stata is reporting as default Pseudo R^2. This is written as:

$$Pseudo\,R^2 = 1 - \frac{(L_1 - K)}{L_0} \tag{9}$$

Where K is the number of parameters (including the intercept)

Akaike information criterion (AIC) and Bayesian information criterion (BIC)

The AIC and the BIC are two popular measures for comparing maximum likelihood models. AIC and BIC are defined as:

$$\begin{aligned} AIC &= -2 * ln(likelihood) + 2 * k \\ BIC &= -2 * ln(likelihood) + ln(N) * k \end{aligned} \tag{10}$$

Where, k = number of parameters estimated, and N = number of observations

Given that the two models fit on the same data, the model with smaller AIC or BIC value is considered to be superior (Williams and Quiroz, 2020). Since lower value of AIC and BIC, indicating a comparatively better fit and a model with smaller parameters, was more parsimonious, the current study took PPOM as the appropriate model to identify significant factors associated with underweight status of children aged 6-59 months in *Miesso* district (Williams, 2006; Hardin and Hilbe, 2007; Zelalem, 2014; Adelo and Temesgen, 2015**)**.

RESULTS AND DISCUSSION

Socio-demographic and environmental characteristics of children

A total of 296 children, aged 6-59 months belonging to the 9 *kebeles* in Miesso district, were included in the analysis with a response rate of about 96.4%. Of these, 164 (55.4%) were male and 132 (44.6%) females. The highest numbers of children (32.4%) were in the age group of 24-35 months. About 38% of the families of participating children did not possess a toilet and above 76% families used water from pump source. About 42.3% children were infected by disease and 18.4% infected by diarrhoea two weeks before the survey (Table 1). Child nutritional status indicated the prevalence of severe underweight as 24.0% and those of mild underweight as 26.7%. This showed that the prevalence of underweight in the Miesso district was 50.7%.

Comparison of POM, GOM and PPOM

The PMO was fitted which estimated the parameters of POM in Stata14 software by using maximum likelihood estimation. Brant test for overall predictors produced a significant χ^2 value of 70.84 with 15 degree of freedom (p-value ≤ 0.001) indicating that a parallel line assumption was violated (Table 2). According to the model comparison statistics (Table 3**),** the PPOM has smaller AIC and BIC than GOLM. Finally current study fitted the PPOM model by specifying autofit in gologit2 command of Stata14 and the result was handled through an iterative process. The results for

Table 1: Descriptive statistics of some selected features of children and their families

Parameters	Categories	Frequency	Percent
Sex of children	Male	164	55.4
	Female	132	44.6
Age category (months)	6-11	37	12.50
	12-23	92	31.08
	24-35	96	32.43
	36-47	57	19.26
	48-59	14	4.73
Occupation of mother	Housewife only	252	85.1
	Mother has additional work	44	14.9
Occupation of father	Farmer	238	80.4
	Pastoralist	15	5.1
	Government employee	8	2.7
	Daily laborer	13	4.4
	Merchant	22	7.4
Toilet using status	No	115	38.9
	Yes	181	61.1
Drinking water source	Pipe water	226	76.4
	Others	70	23.6
vaccination status of children	Yes	262	88.5
	No	34	11.5
Incidence of diarrhea 2 weeks before survey	No	225	76.0
	Yes	71	24.0
Presence of edema in children	No	283	95.6
	Yes	13	4.4
Infection status of children 2 weeks before survey	No	209	70.6
	Yes	87	29.4
Current breast feed status of children	No	175	59.1
	Yes	121	40.9

for the PPMO with logit function were presented in (Table 4). Global Wald test for final model indicated that the final model does not violate the proportional odd assumption with p value = 0.9417.

Factors associated with underweight children aged 6-59 months

Since PPOM has smaller AIC and BIC than GOLM and POM, the current study used PPOM as the best model to identify the significant associated factors with the underweight status of children (Table 3). A child from household food insecure family 2.67 times higher risk of being mild or severe underweight status compared with those children from food secured family, holding all other variables constant (Table 4). The results of PPOM revealed that the children belonging to the age group of 24-35 and 36-47 months were 4.64- and 4.09-times higher risk of mild and severe underweight status, respectively, as compared to the children of 6-11 months age, holding all other variables constant. This indicated that the children in the age group of 24-35 and 36-47 months were significantly more likely to be affected by underweight when compared with the children of 6-11 months age group.

Child sex is a significant factor responsible for underweight child. Holding all other variables constant, the female children were 0.21 times less likely to be severe underweight rather than nourished or mildly underweight as compared to the male children (Table 4).

Consequently, the male children, controlling all other variable constant, male children were 4.76 times severely/ mildly underweight as compared to the female children. Consequently, holding all other variable constant, the male children were 4.76 times severely/mildly underweight as compared to the female children.

The underweight was a serious problem in Miesso district. The prevalence of severe underweight was 24% and that of mild underweight 26.7%. This indicated that the overall prevalence of underweight in Miesso district was 50.7%. The overall prevalence of underweight was higher than those of Mecha district with the prevalence of 34% in Tigray region at Medebay-Zana district with prevalence of 45.3%, and prevalence of 23.6% in Haramaya, Ethiopia (Alemayehu *et al*., 2015; Abebe *et al.*, 2016; Redi *et al*., 2017); and it was less than the study conducted in a backward district of the West Bengal, India with prevalence of 67.7% (De and Chattopadhyay, 2019). This may

Table 2: Brant test of parallel regression assumption for Proportional odds model

Parameters	χ^2	$P > \chi^2$	Df
All over test	70.84	<0.001	15
Family size	8.58	0.003	1
Mother school (yes)	0.80	0.371	1
Father school (yes)	1.76	0.185	1
Mother work (yes)	1.07	0.301	1
Father employed (yes)	0.46	0.500	1
Has toilet (yes)	0.00	0.945	1
Pump water source (yes)	0.83	0.363	1
Food security status (insecure)	21.56	≤0.001	1
Child sex (female)	1.29	0.256	1
Child age (12-23)	0.06	0.802	1
Child age (24-35)	0.41	0.519	1
Child age (36-47)	0.00	0.989	1
Child age (48-59)	1.57	0.211	1
Exclusive breast feed (yes)	0.36	0.549	1
Diarrhea incidence (yes)	2.46	0.117	1

be because of the prevalent conflicts in Miesso area (Mohamed, 2018) as well as because of draught and climate change due to less March-May rains in past decade (Stark *et al*., 2011; Tamiru *et al*., 2015).

The predictors significantly related to the child nutritional status were the sex of child, child age (24-35 months), child age (36-47 months), household's food security status and the toilet using status of the family. The study revealed that children aged 24-47 months were more likely to be affected by underweight as compared to the children aged 6-11 months. Also, the study conducted in Ethiopia based on the CSA data children up to 11 months months (infants) have better nutrition status than other age groups (Adelo and Temesgen, 2015). In addition, the present findings are similar to those observed in Somali region of Ethiopia (Demissie and Worku, 2013). A study in Bangladesh has revealed that the odds ratios for children aged 12-23 and 24+ months as compared to infants were 6.9 and 5.4, respectively (Das and Rahman, 2011).

Table 3: Comparison of the three models in terms of goodness fit statistics

Type		POM	GOLM	PPOM
Log-likelihood	Model	-265.461	-242.478	-244.705
	Intercept-only	-316.516	-316.516	-316.516
χ^2	Deviance (df = 264)	530.922	484.955	489.410
	LR	102.11 (df = 15)	148.077 (df = 30)	143.623 (df = 20)
	p-value	≤0.001	≤0.001	≤0.001
R^2	McFadden	0.161	0.234	0.227
	McFadden (adjusted)	0.108	0.133	0.157
	McKelvey & Zavoina	0.342	-	-
	Cox-Snell/ML	0.292	0.394	0.384
	Cragg-Uhler/Nagelkerke	0.331	0.446	0.436
	Count	0.581	0.615	0.615
	Count (adjusted)	0.244	0.305	0.305
IC	AIC	564.922	548.955	533.410
	AIC divided by N	1.909	1.855	1.802
	BIC (df = 32)	627.658	667.047	614.598
Variance	e	3.29	-	-
	y-star	4.997	-	-

The male children were significantly more affected by underweight. It was consistent to the study conducted at national level EDHS 2016 (CSA and ICF, 2017). The study conducted in Walaita Sodo town of Ethiopia concluded that male children were more likely to be underweight than females (Tosheno *et al*., 2017) The study conducted in Somali region of Ethiopia has shown that malnutrition was more prevalent among boys than girls (Demissie and Worku, 2013). In India male children reportedly suffer more than their female children (De and Chattopadhyay, 2019); also in Indonesia the number of underweight boys was significantly higher than the number of underweight girls (Syahrul *et al*., 2016).

Table 4: Partial proportional odds model outputs to determine the factors associated with child nutritional status (underweight)

Parameters	Coefficients	Odds ratio	Standard error	Z	P- value	95% confidence interval	
Nourished v/s mildly underweight and severe underweight							
Family size	0.088578	1.09262	0.067962	1.3	0.192	-0.04462	0.221781
Mother had joined the school (“No” is considered as reference group)							
Yes	0.0379099	1.038638	0.3595403	0.11	0.916	-0.666776	0.742596
Father had joined school (“No” is considered as reference group)							
Yes	0.531209	1.700988	0.3614346	1.47	0.142	-0.177189	1.239608
Mother had additional work other than housewife (“No” is considered as reference group)							
Yes	0.4269253	1.532538	0.3631242	1.18	0.24	-0.284785	1.138636
Father employed (“No” is considered as reference group)							
Yes	0.6648885	1.944274	0.774087	0.86	0.39	-0.852294	2.182071
Family had a toilet (“No” is considered as reference group)							
Yes	-0.5784119	0.5607883	0.3057847	-1.89	0.059	-1.177739	0.020915
Households drinking water source is pipe (“No” is considered as reference group)							
Yes	-0.1406943	0.8687549	0.3365214	-0.42	0.676	-0.800264	0.518876
Household food security status (Secure is considered as reference group)							
Insecure	2.66894	14.42467	0.342542	7.79	≤0.001	1.99757	3.34031
Child sex (Male is considered as reference group)							
Female	-0.5325045	0.5871326	0.2904329	-1.83	0.067	-1.101743	0.036734
Age of the child (“6-11 mon” is considered as reference group)							
12 -23 months	0.3051599	1.356842	0.4719073	0.65	0.518	-0.619761	1.230081
24- 35 months	1.535127	4.641915	0.5588799	2.75	0.006	0.4397426	2.630512
36-47 months	1.408196	4.088574	0.618713	2.28	0.023	0.1955412	2.620851
48-59 months	0.2772439	1.319488	0.7453861	0.37	0.71	-1.183686	1.738174
Exclusive breast feed for the first six months (“No” is considered as reference group)							
Yes	0.111881	1.11838	0.4042715	0.28	0.782	-0.680476	0.904238
Incidence of diarrhea within 2 weeks (“No” is considered as reference group)							
Yes	0.1694205	1.184618	0.2963759	0.57	0.568	-0.411465	0.750306
Intercept	-2.755721	0.0635632	0.7761998	-3.55	≤0.001	-4.277045	-1.23439
Nourished and mildly underweight v/s Severe underweight							
Family size	-0.1110684	0.8948775	0.0686984	-1.62	0.106	-0.245715	0.023578
Mother had joined school (“No” is considered as reference group)							
Yes	0.0379099	1.038638	0.3595403	0.11	0.916	-0.666776	0.742596
Father had joined school (“No” is considered as reference group)							
Yes	-0.3481805	0.7059714	0.3785453	-0.92	0.358	-1.090116	0.393755
A mother had additional work other than housewife (“No” is considered as reference group)							
Yes	0.4269253	1.532538	0.3631242	1.18	0.24	-0.284785	1.138636
Father was employed (“No” is considered as reference group)							
Yes	0.6648885	1.944274	0.774087	0.86	0.39	-0.852294	2.182071
Had a family toilet (“No” is considered as reference group)							
Yes	-0.5784119	0.5607883	0.3057847	-1.89	0.059	-1.177739	0.020915
Households drinking water source is pipe (“No” is considered as reference group)							
Yes	-0.1406943	0.8687549	0.3365214	-0.42	0.676	-0.800264	0.518876
Household food security status (Secure is considered as reference group)							
Insecure	0.6189955	1.857062	0.3824249	1.62	0.106	-0.130543	1.368534
Child sex (Male is considered as reference group)							
Female	-1.569258	0.2081997	0.3227115	-4.86	≤0.001	-2.201761	-0.93675
Age of the child (“6-11 mon” is considered as reference group)							
12 -23 mon	0.3051599	1.356842	0.4719073	0.65	0.518	-0.619761	1.230081
24- 35 mon	1.535127	4.641915	0.5588799	2.75	0.006	0.4397426	2.630512
36-47 mon	1.408196	4.088574	0.618713	2.28	0.023	0.1955412	2.620851
48-59 mon	0.2772439	1.319488	0.7453861	0.37	0.71	-1.183686	1.738174
Exclusive breast feed for the first six months (“No” is considered as reference group)							
Yes	0.743641	2.103581	0.418931	1.78	0.076	-0.077449	1.564731
Incidence of diarrhea within 2 weeks (“No” is considered as reference group)							
Yes	0.1694205	1.184618	0.2963759	0.57	0.568	-0.411465	0.750306
Intercept	-0.9028029	0.4054317	0.7760215	-1.16	0.245	-2.423777	0.618171

Dependent variable = Underweight status; Log likelihood = -244.70483; LR chi-square = 143.62 with df = 20, p-value ≤ 0.001; Pseudo R2 = 0.2269; Wald test of parallel lines assumption for the final model: Chi-square = 4.12, df = 10, P-value = 0.9417

The male children were significantly more affected by underweight. It was consistent to the study conducted at national level EDHS 2016 (CSA and ICF, 2017). The study conducted in Walaita Sodo town of Ethiopia concluded that male children were more likely to be underweight than females (Tosheno *et al*., 2017). It was also similar to the study conducted in Somali region of Ethiopia revealed that malnutrition was more prevalent among boys than girls (Demissie and Worku, 2013). Also, the study conducted in India revealed that male children are suffering more than their female counter part (De and Chattopadhyay, 2019); and the study conducted in Indonesia revealed that the number of underweight boys was significantly higher than the number of underweight girls (Syahrul *et al*., 2016).

A child from a family of food insecure was more likely affected by underweight significantly in the study area. This was consistent with the study conducted by in Tigray (Kahsay *et al*., 2015). The current study revealed that children of families who have toilet were significantly less probably affected by malnutrition relative to children of families did not use toilet in the study area. This is similar to the previous study conducted on primary school adolescents in Somali region (Awel *et al*., 2016). This might be because of lack of sanitary facilities poses a serious public health problem (Adane *et al*., 2017). Since the child underweight in the district was very highly prevalent continuous nutrition supervision and special attention to severely malnourished children is necessary to attempt the problem of malnutrition. Efforts should be made on training of the community on child feeding practices proportional to children's nutritional requirements with their age; and improving environmental sanitation and culture of using toilet.

Conclusion: The current study showed that child underweight was very high prevalence in Miesso district in which more than the half children participated in the current study were malnourished. A child from food insecure household, male children, the children who were aged 24-35 months and aged 36-47 months and children of toilet non-user families were more likely to be malnourished compared to their corresponding counterparts in the Miesso district.

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REFERENCES

Abebe, Z., Haki, G.D. and Baye, K. 2016. Health extension worker's knowledge and knowledge-sharing effectiveness of optimal infant and young child feeding are associated with mother's knowledge and child stunting in rural Ethiopia. *Food and Nutrition Bulletin*, **37**(3): 353-363.

Adane, M., Mengistie, B., Medhin, G., Kloos, H. and Mulat, W. 2017. Piped water supply interruptions and acute diarrhea among under-five children in Addis Ababa slums, Ethiopia: A matched case-control study. *PLoS ONE*, **12**(7): e0181516 [*https://doi.org/10.1371/journal.pone.0181516*].

Adelo, B. and Temesgen, S. 2015. Undernutritional status of children in Ethiopia: Application of partial proportional odds model. *Turkiye Klinikleri Journal of Biostatistics*, **7**(2):77-89.

Agresti, A. 1996. *An Introduction to Categorical Data Analysis*. John Wiley, New Jersey, USA.

Alemayehu, M., Tinsae, F., Haileslassie, K., Seid, O., Gebregziabher, G. and Yebyo, H. 2015. Undernutrition status and associated factors in under-5 children, in Tigray, Northern Ethiopia. *Nutrition*, **31**(7-8): 964-970.

Awel, A.A., Lema, T.B. and Hebo, H.J. 2016. Nutritional status and associated factors among primary school adolescents of pastoral and agro-pastoral communities, Mieso Woreda, Somali region, Ethiopia: A comparative cross-sectional study. *Journal of Public Health and Epidemiology*, **8**(11): 297-310.

Brant, R. 1990. Assessing proportionality in the proportional odds model for ordinal logistic regression. *Biometrics*, **1**: 1171-1178.

CSA and ICF. 2017. *Ethiopia Demographic and Health Survey 2016*. Central Statistical Agency, Addis Ababa, Ethiopia/ICF, Rockville, Maryland, USA.

CSA. 2013. *Population Projection of Ethiopia for All Regions at Wereda Level from 2014-2017.* Central Statistical Agency, Addis Ababa, Ethiopia.

Daniel, W. 1999. *Biostatistics: A Foundation for Analysis in the Health Sciences* (7th edn.). Wiley, New York, USA.

Das, S. and Rahman, R.M. 2011. Application of ordinal logistic regression analysis in determining risk factors of child malnutrition in Bangladesh. *Nutrition Journal*, **10**(1): 1-3.

De, P. and Chattopadhyay, N. 2019. Effects of malnutrition on child development: Evidence from a backward district of India. *Clinical Epidemiology and Global Health*, **7**: 439-445.

Demissie, S. and Worku, A. 2013. Magnitude and factors associated with malnutrition in children 6-59 months of age in pastoral community of Dollo Ado district, Somali region, Ethiopia. *Science Journal Public Health*, **1**(4): 175-183.

FAO, IFAD and WFP, 2015. The state of food insecurity in the world: meeting the 2015 international hunger targets: taking stock of uneven progress. Rome: FAO, 2015. Advanced Nutrition; 6(5): 623-4.

FAO, IFAD, UNICEF, WFP and WHO, 2018. *The State of Food Security and Nutrition in the World 2018: Building Climate Resilience for Food Security and Nutrition.* Food & Agriculture Organization, Rome, Italy.

Hardin, J. and Hilbe, J. 2007. *Generalized Linear Models and Extensions.* A Stata Press Publication, Texas, USA.

Hussein, F.M., Ahmed, A.Y. and Muhammed, O.S. 2018. Household food insecurity access scale and dietary diversity score as a proxy indicator of nutritional status among people living with HIV/AIDS, Bahir Dar, Ethiopia, 2017. *PLoS One*, **13**(6): e0199511 [*doi: 10.1371/journal.pone.0199511*].

Kahsay, A., Mulugeta, A. and Seid, O. 2015. Nutritional status of children (6-59 months) from food secure and food insecure households in rural communities of Saesie Tsaeda-Emba district, Tigray, North Ethiopia: Comparative study. *International Journal of Nutrition and Food Science*, **4**: 51-66. [*doi: 10.11648/j.ijnfs.20150401.18*].

Kalu, R.E. and Etim, K.D. 2018. Factors associated with malnutrition among under five children in developing countries: A review. *Global Journal of Pure and Applied Sciences*, **24**(1): 69-74.

Lall, R. 2004. *The Application of Ordinal Regression Models in Quality of Life Scales used in Gerontology*. Doctoral Dissertation, University of Sheffield, South Yorkshire, England.

Liu, X., O'Connell, A.A. and Koirala, H. 2011. Ordinal regression analysis: Predicting mathematics proficiency using the continuation ratio model. *Journal of Modern Applied Statistical Methods*. **10**(2): 513-527. [*doi: 10.22237/jmasm/1320120600*].

Long, J. 2014. Regression models for nominal and ordinal outcomes. pp. 173-204 **In:** *The SAGE Handbook of Regression Analysis and Causal Inference* (eds. H. Best and C. Wolf), SAGE Publ. Ltd., London, England. [*https://dx.doi.org/10.4135/9781446288146*].

Maru, M.T. 2017. *Causes, Dynamics and Consequences of Internal Displacement in Ethiopia. Working Paper.* Stiftung Wissenschaft and Politik German Institute for International and Security Affairs, Berlin, Germany.

Mason, J. and Shrimpton, R. 2010. *Progress in Nutrition: 6th Report on the World Nutrition Situation*. United Nations Standing Committee on Nutrition, Geneva, Switzerland.

Mohamed, A.A. 2018. Assessment of conflict dynamics in Somali national regional state of Ethiopia. *Journal of Public Policy Administration*, **2**(4): 40-48.

Nkunzimana, T., Custodio, E., Thomas, A.C., Tefera, N., Perez, H.A. and Kayitakire, F. 2016. *Global Analysis of Food and Nutrition Security Situation in Food Crisis Hotspots. Report Prepared in Collaboration with the FAO and the WFP*. European Commission, Brussels, Belgium [*https://dx.doi.org/10.2788/669159*].

Redi, F., Egata, G. and Kedir A. 2017. Prevalence of malnutrition among children aged 6-59 months in Haramaya district, Oromia, Ethiopia. *Journal of Biometrics and Biostatistics,* **8**(4): 357-360.

Serbesa, M.L., Iffa, M.T. and Geleto, M. 2019. Factors associated with malnutrition among pregnant women and lactating mothers in Miesso Health Center, Ethiopia. *European Journal of Midwifery*, **3**: 13-17. [*https://doi.org/10.18332/ejm/110131*].

Stark, J., Terasawa, K. and Ejigu, M. 2011. Climate change and conflict in pastoralist regions of Ethiopia: Mounting challenges, emerging responses. Conflict Management and Mitigation (CMM) Discussion Paper 4. United States Agency for International Development. Washington, USA.

Syahrul, S., Kimura, R., Tsuda, A., Susanto, T., Saito, R. and Ahmad, F. 2016. Prevalence of under-weight and overweight among school-aged children and its association with children's socio-demographic and lifestyle in Indonesia. *International Journal of Nurse Science,* **3**: 169-177.

Tamiru, S., Kindie Tesfaye, K. and Mamo, G. 2015. Analysis of rainfall and temperature variability to guide sorghum (*Sorghum bicolar*) production in Miesso areas, Eastern Ethiopia. *International Journal of Sustainable Agricultural Research*, **2**(1): 1-11.

Tosheno, D., Adinew, Y.M., Thangavel, T. and Workie, S.B. 2017. Risk factors of underweight in children aged 6–59 months in Ethiopia. *Journal of Nutrition and Metabolism*, **2017**. [*https://doi.org/10.1155/2017/6368746*].

UNICEF. 2019. *The State of the World's Children 2019. Children, Food and Nutrition: Growing Well in a Changing World*. UNICEF, New York, USA.

USDA. 2012. *Household Food Security Survey Module: Three-Stage Design, with Screeners. Economic Research Service*. USDA, Washington, USA.

WFP and CDC. 2005. *A Manual, Measuring and Interpreting Malnutrition and Mortality. A Joint Collaboration Between the World Food Programme (WFP) and the Centers for Disease Control and Prevention (CDC)*. World Food Programme, Rome, Italy.

WHO and UNICEF. 2009. *WHO Child Growth Standards and the Identification of Severe Acute Malnutrition in Infants and Children.* World Health Organization, Geneva, Switzerland.

WHO, 2006. *WHO Child Growth Standards: Length/Height-for-Age, Weight-for-Age, Weight-for-Length, Weight-for-Height and Body Mass Index-for-Age: Methods and Development*. World Health Organization, Geneva, Switzerland.

WHO, 2013. *Global Nutrition Policy Review: What Does it Take to Scale up Nutrition Action.* World Health Organization, Geneva, Switzerland.

Williams, R. 2006. Generalized ordered logit/partial proportional odds models for ordinal dependent variables. *Stata Journals*; **6**: 58-82.

Williams, R.A. and Quiroz, C. 2020. Ordinal regression models. SAGE Pub., London, England.

Zelalem, B. 2014. *Risk Factors for Anaemia Levels among Women of Reproductive Age in Ethiopia: A Partial Proportional Odds Model Approach*. Doctoral Dissertation, Addis Ababa University, Addis Ababa, Ethiopia.