Multilevel Analysis of Determinants of Stunting Prevalence among Children under Age Five in Ethiopia

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Abstract: *Background*: Stunting is a well-established child health indicator of chronic malnutrition related to environmental and socio-economic circumstances. In Ethiopia, childhood stunting is the most widely prevalent among children under the age of five years.

Objective: To estimate the prevalence of stunting and model the determinants of stunting prevalence among children under age five in Ethiopia.

Methods: Data were extracted from 2016 EDHS, and samples of 8487 children under age five were used in this study. The sample was selected using a two-stage stratified sampling process, and a multilevel logistic regression model was used to determine the factors associated with childhood stunting in Ethiopia.

Results: This study revealed that the prevalence of stunting among children under age five years in Ethiopia was around 39.39%. The multilevel binary logistic regression analysis was performed to investigate the variation of predictor variables of stunting prevalence among children under age five. Accordingly, it has been identified that the ages of the child above 12 months, male gender, children from poor households, and no mother education significantly affect the prevalence of stunting in Ethiopia. It is found that variances related to the random term were statistically significant, implying a variation in the prevalence of stunting across Ethiopia's regional states.

Conclusion: The current study confirmed that the prevalence of stunting among children under aged five years in Ethiopia was a severe public health problem. Therefore, governmental or stakeholders should pay attention to all the significant factors mentioned in this study's analysis.

Keywords: Children under age five, Stunting, Multilevel logistic regression, Ethiopian Demographic, and Health Survey.

1. BACKGROUND

Stunting is a well-established child health indicator of chronic malnutrition related to environmental and socio-economic circumstances [1]. Childhood is a period of active growth, covering the major transformations from birth to adulthood. Adequate nutrition is needed to ensure optimum growth and development of children. Normal growth is dependent on adequate nutrition, and the human body can use carbohydrates, protein, and fat as a source of energy. Inadequate intake of energy may lead to malnutrition in the long run [2]. A stunted child is a child below his or her appropriate height for age [3]. A child with a height for age Z score less than minus two standard deviations below the median of a reference height for age standard is referred to as stunted [4]. It reflects a process of failure to achieve linear growth potential as a result of prolonged or repeated episodes of undernutrition starting before birth [4]. It is further indicated as the irreversible outcome of inadequate nutrition and a major cause for morbidity during the first 1000 days of a child’s life [5], which is considered a better overall predictor of undernutrition in children.

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Stunting affects large numbers of children globally and has severe short and long-term health consequences, including poor cognition and educational performance, low adult wages, lost productivity, and increased risk of nutrition-related chronic diseases when accompanied by excessive weight gain later in childhood [6]. In sub-Saharan Africa, the prevalence of stunting is declining but remains over 30% [7]. Ethiopia is a sub-Saharan country where stunting is one of the foremost necessary health and welfare issues among children under age five [8]. No matter the economic process and therefore the substantial decline of impoverishment within the past decades within the country, childhood stunting remains high and continues to be a serious public health problem within the country [9].

Within Ethiopia, there is a regional variation in stunting. Amhara, Benishangul-Gumuz, Afar, and Dire Dawa are the most affected by child stunting [10]. The reason may be hard to reach areas of Afar, Somali, Benishangul-Gumuz, and Gambella were characterized by drought-related public health and nutrition problems [10]. The current progress rate is not fast enough to reach the World Health Organization (WHO) global target of a 40% reduction in the number of stunted children by 2025 [11].

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Thus to achieve this global target for 2025 in Ethiopia, a situational analysis is required to determine the prevalence of stunted determinants among children under age five. There is a lot of research conducted regarding this area focused on individual-level factors affecting stunting rather than community-level factors. Studies focusing only on individual fixed-effects factors could ignore group membership and focus exclusively on inter-individual variations and individual-level attributes. If outcomes for individuals within groups are correlated, the assumption of independence of observations is violated, resulting in incorrect standard errors and inefficient estimates [12]. Therefore, the researcher's main concern was to identify the major determinants and assess the prevalence of stunting among children under age five in Ethiopia using individual and community levels.

2. MATERIALS AND METHODS

2.1. Data

This study used data from the 2016 Ethiopia Demographic and Health Survey (EDHS), which was conducted by Ethiopian Central Statistical Agency (ECSA), with technical support from ICF from January 18, 2016, to June 27, 2016 [13]. The EDHS sample was selected using a stratified, two-stage cluster design, and EAs were the sampling units for the first stage. A proportional sample of 15,683 households from 645 clusters was enclosed within the data assortment.

The samples were stratified, clustered, and designated in two stages. In the first stage, 645 clusters, 202 urban and 443 rural, were selected from the list of enumeration areas based on the sampling frame. In the second stage, a complete listing of households was carried out in each selected cluster. For this study, 8487 children under age five years were included in the analysis after all incomplete observations have been deleted from the data among 10,641 total children under age five years.

2.2. Variables in the Study

Response Variable

The response variable of this study was the stunting status of children aged five years in Ethiopia. For the current analysis, the response variable was dichotomized, indicating whether one is stunted (if z score<-2*SD*) or normal (if z score$\geq$-2*SD*) using the WHO child growth standards.

Explanatory Variables

The explanatory variables that might determine stunting of children under age five were socio-economic, demographic, health, and environmental factors. From the source of data, we classified the variables into individual level:- child's age, sex of the child, mother education, wealth index, mother marital status, number of children under age five in the household, maternal age at first birth, mother' working status and community level:- region, place of residence, the source of drinking water.

2.3. Methods of Statistical Analysis

Multilevel models allow the relationship between the explanatory variables at a different level and response variables at a lower level to be estimated, enabling the extent of variation in the outcome of interest to be measured at each level assumed in the model both before and after the inclusion of the explanatory variables in the model. Two levels of data hierarchy were stated (for instance, individual children of households and communities) in a multilevel logistic regression model. Units at one level are nested within units at the next higher level. In this study, the basic data structure of the two-level logistic regression is a collection of N groups (communities) and within-group j (j = 1, 2, . . . N) a random sample nj of level one units (individual children of households). The response variable is denoted by

$$Yij = \begin{cases} 1 \; stunted \; children \\ 0 \; not \; stunted \; children \end{cases} \quad (1)$$

with probability $Pij = P(Yij = 1/Xij,\ uj)$ being the probability of children with any stunted for the *ith* household in the *jth* communities and the probability $1\text{-}Pij = P(Yij\text{-}1/Xij,\ uj)$ being the probability of not stunted (normal) *ith* children for the households in the *jth* communities. Here, *Yij* follows a Bernoulli distribution.

The Variance Components Model

The variance component two-level model for a dichotomous outcome variable refers to a population of groups (level-two units (communities) and specifies the probability distribution for group-dependent probabilities *Pj* in $Yij = Pj + \in ij$ without taking further explanatory variables into account. We focus on the model that specifies the transformed probabilities (*Pj*) to have a normal distribution. This is expressed, for a general link function (*Pj*), by the formula.

$$\log\left[\frac{Pij}{1-Pij}\right] = \beta 0j + U0j, \quad (1)$$

where $\beta 0$ is the population average of the transformed probabilities and $U0j$ the random deviation from this average for group *j*. The intraclass correlation coefficient (ICC) represents the proportion of the total variance attributable to between-group differences. It provides an assessment of whether or not significant between-groups variation exists.

The Random Intercept Model

The random intercept model is used to model unobserved heterogeneity in the overall response by introducing random effects. In the random intercept model, the intercept is the only random effect meaning that the groups differ concerning the average value of the response variable, but the relationship between explanatory and response variables cannot differ between groups. The random intercept model expresses the log odds, i.e., the logit of *Pij,* as a sum of linear functions of the explanatory variables. That is

$$\log it(Pij) = \log\left[\frac{Pij}{1-Pij}\right] = \beta 0 + \sum_{h=1}^{k}\beta_h x_{hij}, \quad (2)$$

The Random Coefficients Model

In the random coefficient model, both the intercepts and slopes are allowed to differ across the communities' level. Suppose that there are k level one explanatory variable $X1$, $X2$, . . . Xk, and consider the model where all X-variables have varying slopes and random intercept. That is,

$$\log it(Pij) = \log\left[\frac{Pij}{1-Pij}\right] = \beta 0 + \sum_{h=1}^{k}\beta_{hj} x_{hij} + U0j + \sum_{h=1}^{k}U_{1j}X_{1ij}, \quad (3)$$

Here the first part of (8), $\beta 0 + \sum_{h=1}^{k}\beta_{hj} x_{hij}$, is called the fixed part of the model, and the second part, $U0j + \sum_{h=1}^{k}U_{1j}X_{1ij}$, is called the random part of the model.

Once weight every variable, descriptive statistics were reported with frequency and proportion. The degree of crude association for individual and community characteristics was checked by employing a $\chi 2$ test. The fixed effects of individual determinant factors and community distinction on stunting prevalence were measured using an adjusted odds ratio. Within the multilevel multivariable logistical regression analysis, four models were fitted for the result variable, such as empty model was fitted without explanatory variables, the individual model fitted with individual-level variables, community model fitted with community-level variable, and the final model fitted with a combination of individual and community-level variables. The ultimate model was used to check for the independent effect of the individual and community discourse variables on childhood stunting. SPSS and STATA were used for statistical analysis in this study. SPSS was used for the descriptive analysis, while STATA was used for the multilevel analysis part. In this study, the Akaike information criterion and Bayesian information criterion were used as regression diagnostics to determine the model's goodness of fit.

3. RESULTS AND DISCUSSIONS

3.1. Socio-Economic Demographic Characteristics

The current study aimed to assess the prevalence and determinant factors associated with stunting among children under age five in Ethiopia using a multilevel logistic regression model. A total sample of 8487 children aged under five years was included in this study.

As of the result of Table **1**, the proportion of stunted children differs by type of place of residence: urban and rural. Accordingly, more than 85.6% of the stunted children reside in rural areas, while a relatively smaller proportion of the stunted children, 14.4%, reside in urban centers. The prevalence of childhood stunting was recorded in 52.6% of male children, which was higher than females, 47.4%. Moreover, the proportion of stunted children varied from one region to the other. For example, the highest prevalence of stunted children was observed in Tigray, 17.1%, followed by Ben-gumuz, 15%, as opposed to the lowest prevalence, which was recorded in Addis Ababa, 2.2 %, and followed by Dire Dawa, 5.6%.

Comparing children's age groups, the highest prevalence of stunting was seen among children aged 12–23 months with the prevalence of 27.7% and the lowest among children aged 24–59 months with the prevalence of 6.6%. The proportion of the children found stunted varies by the household wealth index. The highest proportion of stunted children was from poor households, 49.7%, whereas the lowest proportion of stunted children, 17.1%, was recorded from children residing in rich households.

Among the variables entered into bivariate logistic regression analysis, the individual characteristics,

Table 1: Percent Distribution and Results of Bivariate Analysis of Sampled Children Under Age Five by Individual and Community Level Characteristics

Individual and Community Level Characteristics	No. of Stunted Children	Percent	Total no. of Children	P-Value
Region				
Addis Ababa	47	2.2%	403	0.001
Afar	185	8.5%	833	
Amhara	232	10.7%	640	
Oromia	190	8.7%	977	
Somali	209	9.6%	585	
Benishangul	327	15%	1302	
SNNPR	213	9.8%	978	
Gambella	145	6.7%	784	
Harari	133	6.1%	403	
Tigray	373	17.1%	1416	
Dire Dawa	123	5.6%	430	
Place of residence				
Urban	313	14.4%	904	0.001
Rural	1864	85.6%	7583	
Sex of child				
Male	1146	52.6%	4318	0.002
Female	1031	47.4%	4169	
Child's age in months				
0 – 5	919	12.2%	1721	0.001
6 – 11	308	14.1%	1656	
12 – 23	604	27.7%	1844	
24 – 59	167	6.6%	2600	
No. of children U5 in household				
< = 2	463	21.3%	2008	0.093
> = 3	1714	78.8%	6479	
Age of mother at first birth				
15– 24	1745	37.8%	919	0.001
25 – 34	2265	.45.6%	105	
35 – 46	3015	58.0%	123	
Mother's marital status				
Single	445	37.50%	105	0.979
Married	384	38.23%	7108	
Divorced/Separated	406	40.62%	653	
Size of child at birth				
Large	1450	34.83%	2998	0.001
Medium	2074	37.28%	1507	
Small	3265	44.66%	2487	

(Table 1). Continued.

Individual and Community Level Characteristics	No. of Stunted Children	Percent	Total no. of Children	P-Value
Mother education level				
No education	1514	69.5%	6156	0.001
Primary education	553	25.4%	2069	
Secondary and above	110	5.1%	262	
Mother working status				
Not working	1512	69.5%	6012	0.540
Working	665	30.5%	2472	
Source of drinking water				
Not improved	1861	44.3%	2980	0.002
Improved	498	38.1%	1404	
Wealth index				
Poor	1082	49.7%	4559	0.001
Middle	370	17%	1495	
Rich	725	33.3%	2433	

children under age five in the household, mother's marital status, and mother working status were not significantly associated with childhood stunting whereas the community characteristics region, place of residence, and source of drinking water were found to be significantly associated with stunting at 5% level of significance.

After controlling for potential confounders, the final multivariable multilevel logistic regression analysis of individual-level factors presented in Table **2** revealed that the sex of the child, child's age in months, mother education level and wealth index were found to be independently associated with the odds of childhood stunting. The likelihood of childhood stunting were 88% (AOR = 1.88, 95%CI: 1.16–3.07), 76% (AOR = 1.76, 95%CI: 1.01– 2.92), and 75% (AOR = 1.75, 95%CI: 1.10–2.76) higher from the regions of Amhara, Tigray, and Benishangul respectively compared to those from Addis Ababa. And children from the rural communities were also 29% (AOR: 1.29, 95%CI: 1.06–1.58) more likely stunted compared to children from the urban communities, after controlling other variables of individual and community level within the model. The log odds of stunting was higher among children in the age group of 12–23 months and 24–59 months (AOR = 5.04, 95%CI: 3.95–6.41) and (AOR = 10.00, 95%CI: 7.71– 12.98) respectively as compared to the age group of 0–5 months ago. Moreover, female children were less likely to be stunted (AOR = 0.85, 95%CI: 0.75–0.94) as compared to males.

Similarly, mothers with secondary and above education were 27% (AOR = 0.73, 95%CI: 0.57–0.95) less likely to have stunted children compared to those with no education. Children from rich households were 34% (AOR = 0.66, 95%CI: 0.54–0.79) less likely to be stunted compared to children from poor households. Whereas the age of the mother at first birth had no significant effect on childhood stunting after adjusting for alternative individual and community level variables within the model. From the results of Table **2**, multivariable multilevel logistic regression analysis of community-level factors region, and place of residence were independently associated with log odds of childhood stunting among children under age five.

As shown in Table **2**, the empty model had no individual and community level variables, and it examined only the random and intercept variable. The result indicated that there was significant variation in the log odds of childhood stunting across the communities, i.e., the community level variance is 0.37 (P-value < 0.001), and the variation remained significant after controlling the individual and community level factors in all models. The result found in the individual model shows a significant variation in log odds of being stunted across the communities, i.e., the community level variance is 0.21 (P-value < 0.001). It is found that the intracommunity correlation coefficient implied only 6% of the variance in the childhood stunting could be attributed to clustering effects. Whereas 44% of the variance was explained by

Table 2: Results of Multilevel Logistic Regression Model of Sampled Children Under Age Five by Individual and Community Level Characteristics

Individual and community-level characteristics	Empty model	Individual model AOR(95% CI)	Community model AOR (95% CI)	Individual and community model AOR(95% CI)
Region (Addis Ababa)				
Afar			1.84***(1.19–2.85)	1.00(0.58–1.72)
Amhara			3.11***(2.09–4.63)	1.88*(1.16–3.07)
Oromia			1.54*(1.04–2.29)	1.04(0.64–1.69)
Somali			0.87(0.57–1.34)	0.71(0.42–1.22)
Benishangul			2.11***(1.38–3.21)	1.75*(1.10–2.76)
SNNPR			2.01*(1.34–3.02)	1.35(0.82–2.22)
Gambella			1.13(0.73–1.77)	0.86(0.50–1.49)
Harari			1.39(0.89–2.15)	0.92(0.54–1.57)
Tigray			1.99**(1.29–3.01)	1.76*(1.01–2.92)
Dire Dawa			1.41*(1.01–1.97)	1.23(0.72–2.11)
Place of residence (Urban)				
Rural			1.49***(1.22–1.83)	1.29*(1.06–1.58)
Sex of child (Male)				
Female		0.85(0.75–0.96)		0.85*(0.75–0.94)
Child 's age in months (0–5)				
6 – 11		1.29(0.97–1.71)		1.27(0.95–1.69)
12 – 23		5.1***(3.97–6.38)		5.04***(3.95–6.41
24 – 59		10.***(7.78–2.97)		10***(7.71–12.98)
Age of mother at first birth (11–18)				
19 – 25		0.99(.87–1.14)		1.02(0.90–1.17)
26 – 32		1.07(0.76–1.52)		1.06(0.74–1.52)
33 – 40		1.02(0.39–2.65)		1.01(0.36–2.80)
Size of child at birth (Large)				
Medium	1.19*(1.02–1.38)		1.20*(1..02–1.40)	1.19*(1.02–1.38)
Small	1.7***(1.44–2.02)		1.68***(1.40–2.00)	1.7***(1.44–2.02)
Mother education level (No education)				
Primary education		0.95(0.80–1.12)		0.95(0.80–1.13)
Secondary and above		0.69*(0.51–0.93)		0.73*(0.57–0.95)
Source of drinking water (Not improved)				
Improved		1.01(0.90–1.13)	1.05(0.90–1.22)	
Wealth index (Poor)				
Middle		0.89(0.75–1.1)		0.83(0.68–1.01)
Rich		0.72***(0.6–0.85)		0.66***(0.54–0.79)
Random effect				
Community level variance (SE)	0.37***(0.28-0.47)	0.21***(0.13-0.33)	0.19***(0.13-0.26)	0.17***(0.10-0.29)
Intra community correlation (%)	10.10	6.00	5.40	5.00
Median odds ratio	1.78	1.54	1.51	1.47
Proportional change in variance (%)		44	49.80	53.6

Note: *significant at *P< 0.05; **P< 0.01; ***P< 0.001.

Table 3: Model Diagnostics (Goodness of Fit Test) Sampled Children Under Age Five by Individual and Community Level Characteristics

	Empty model	Individual variables model	Community variables model	Individual and community model
Log-Likelihood	5708.045	3155.693	5504.414	3069.278
Akaike Information Criterion	11,420.09	6373.387	11,050.830	6234.555
Bayesian Information Criterion	11,434.27	6578.387	11,199.350	6551.946

individual-level factors in the log odds of being stunted across communities.

Similarly, the results of the community model indicated the community-level factors of interest. It showed that there was a significant difference in the log odds of being stunted across the communities, i.e., the community level variance is 0.19 (P-value < 0.001). It is found that the intra-community correlation coefficient implied only 5.40% of the variance in the childhood stunting could be attributed to clustering effects. Whereas 49.80% of the variance was explained by community-level factors in the log odds of being stunted across communities. And the result found in the individual and community level factors model show that there was a significant difference in the log odds of being stunted in the communities, i.e., the community level variance is 0.17 (P-value < 0.001 and 53.6% of the variance were explained by individual and community level factors in the log odds of being stunted across communities.

In this study, the researcher used the Akaike information and Bayesian information criterion that assesses the goodness of fit of the multilevel model, and the lower value of criterion suggests a better model. As the results of Table **3** indicated in the individual and community variables model, childhood stunting was a better explanatory model, and it tells the performance of the multilevel model in explaining the variation in childhood stunting between the communities is increased due to the addition of the community-level factors in the model.

4. DISCUSSION

4.1. Summary of the Findings

This study aimed to determine the determinants of the prevalence of stunting children under age five in Ethiopia. This study shows that in Ethiopia, the prevalence of stunting was found to be 38.39%.

In this study, there was regional variation in stunting in Ethiopia. The present findings suggested that children from Amhara, Benishangul, and Tigray communities were more stunted compared to children from Addis Ababa, which is similar to previous studies that compared regional variations in nutritional status. This could be because stunting is characterized by acute malnutrition that can because by temporary increased food insecurity from extreme weather events, drought, and shifts in agricultural practices [14, 15]. This difference may be from the differential nutritional intake, the difference in the environment, socio-economic, and cultural differences [16].

The study showed that children whose parents reside in rural areas had higher odds of childhood stunting than the urban areas. Possible explanations may be due to better equipped urban health-care systems and higher access to health care facilities. Urban populations usually have a higher educational level, economic status, and employment opportunities [17]. This finding is similar to results from a cross-sectional study carried out in Mozambique [18].

In this study, the sex of the child was associated with stunting among study children. This means that male children were more likely to be stunted compared to their female groups of a comparable socio-economic background. This could partially be explained due to the fact that boys are more vulnerable to health inequalities than their female counterparts in the same age groups [19]. A systematic review conducted in Ethiopia and other developing countries also showed that male children were highly vulnerable to stunting when compared with female children due to a difference in the frequency of eating, energy expenditure, and exposure to health problems than female children [20, 21]. The study also shows that the variable mother's education level was found significantly related to childhood stunting under age five in Ethiopia. The reason might be due to the fact that educated mothers would have proper management of resources, practice better health-promoting behaviors, and might develop better children centered caring practices. This result is in line with other studies conducted in Hawassa Zuria, Ethiopia [22]. This study revealed that children from rich mothers in wealth index were also positively associated with reducing childhood stunting. Studies conducted in Kenya found that less stunted children were born to women with a high education level and women from high wealth households [23].

5. CONCLUSIONS AND RECOMMENDATIONS

The current study confirmed that the prevalence of stunting among children under age five in Ethiopia was a severe public health problem. The consequences of childhood stunting are grave and include poor performance in school and low adult economic productivity. The findings imply that a multi-sectoral and multidimensional approach is important to address stunting in a county like Ethiopia. The education sector should promote maternal education and policies to reduce cultural and gender barriers. Thus, stakeholders should pay attention to all significant factors mentioned in the analysis of this study to improve or reduce the rate of childhood stunting.

ABBREVIATIONS

AOR = Adjusted Odds Ratio

CI = Confidence Interval

EAs = Enumeration Areas

ECSA = Ethiopian Central Statistical Agency

EDHS = Ethiopian Demographic and Health Survey

SD = Standard Deviation

SPSS = Statistical Package for Social Science

UNICEF = United Nations Children's Fund

WHO = World Health Organization

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DATA AVAILABILITY

The analysis in this study is based on data available from the Ethiopian Demographic and Health Survey EDHS, 2016.

AUTHORS' CONTRIBUTIONS

YWB conceived and designed the study, performed analysis, interpreted the data, and prepared the manuscript.

CONSENT FOR PUBLICATION

Not applicable.

COMPETING INTERESTS

The author declares that they have no competing interests.

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