

Determinants of nutritional status of children aged 6-59 months in the case of Itang special woreda, Gambella, Ethiopia: A community-based cross-sectional study

Chekol Alemu^{1*}, Habitamu Wudu¹ and Meseret Abeje²

¹Department of Statistics, College of Natural and Computational Sciences, Gambella University, Ethiopia

²Department of Biostatistics, Pharo Foundation, Assosa, Ethiopia

*Corresponding author: E-mail: chekol2011@gmail.com

ORCID: <https://orcid.org/0000-0002-0443-7133>

Abstract

Background: Malnutrition remains a major contributor to inadequate physical and mental development in children. This study aims to assess the factors influencing the severity of malnutrition in children aged 6-59 months, using the weight-for-age anthropometric index (z-score), and to explore variations in nutritional status determinants across different kebeles.

Methods: A community-based cross-sectional study was conducted from October 12 to November 12, 2022. A sample of 397 children aged 6-59 months was selected through a multi-stage clustered sampling technique to capture heterogeneity. Data were collected and entered into SPSS for analysis, which was performed using R version 3.4.0 and STATA 14.2. A multilevel ordinal logistic regression model was applied, with statistical significance set at 5%.

Results: The analysis identified several factors that significantly affect the nutritional status of children, including birth interval, economic status, and maternal employment, type of toilet facilities, household size, breastfeeding practices, paternal education, and geographical location (kebeles). Notably, 15% of the overall variation in malnutrition severity was attributed to kebele-level differences, with a variance estimate of 0.569 and an intraclass correlation coefficient of 0.15, derived from the two-level multilevel ordinal logistic regression model.

Conclusion: The random intercept model with random coefficients effectively predicted the severity of malnutrition among children aged 6-59 months. It is recommended that primary health care and nutrition interventions be tailored to address the specific needs of each kebele within Itang Special Woreda to mitigate nutritional deficiencies among children.

Keywords: Child malnutrition, Anthropometric index, Primary data, Ordinal logistic regression, multilevel ordinal logistic analysis.

Introduction

Nutritional status results from the complex interplay between food consumption and overall health and healthcare practices within a population. A variety of socioeconomic and cultural factors significantly influence children's eating habits and the nutritional status of both women and children (Girma and Genebo 2002). The term "malnutrition" encompasses both undernutrition and overnutrition, but this study focuses specifically on nutritional deficiencies (Smith and Haddad, 2000). Malnutrition's impact extends beyond individual health, with substantial economic consequences such as lost GDP and increased healthcare costs. On the other hand, improved nutrition enhances productivity and economic development by fostering better physical capacity, cognitive development, academic achievement, and overall health, ultimately decreasing disease prevalence and mortality rates (Smith and Haddad 2000).

Malnutrition is a complex issue that contributes to child mortality (Woldetsadik 2011). The causes of malnutrition are interrelated and can be categorized into immediate, underlying, and basic factors (UNICEF 2006). A regional analysis of child malnutrition trends across 63 developing countries from the 1990s to the 2010s revealed significant disparities. South Asia had the highest prevalence of

underweight children (61%), followed by Sub-Saharan Africa (31%), East Asia (23%), Latin America and the Caribbean (12%), and the Near East and North Africa (11%) (Smith and Haddad, 2000). Notably, Sub-Saharan Africa was the only region that did not experience a decline in malnutrition levels during this period.

In Ethiopia, the Central Statistical Authority conducts biannual welfare monitoring surveys to assess children's nutritional status. According to the 2016 Ethiopian Demographic and Health Survey (EDHS), among 10,752 children under the age of five, 38% were stunted (short for their age), 10% were wasted (thin for their height), and 24% were underweight (thin for their age). The persistently high rates of malnutrition in Ethiopia emphasize the misconception that malnutrition is absent in food-surplus areas. Therefore, preventive policies targeting child malnutrition must also address regions where food availability is not a concern (Girma and Genebo 2002).

Adequate nutrition is a critical determinant of health outcomes in any nation, including Ethiopia (Fenta et al. 2020). However, malnutrition remains a significant issue across the country, particularly in the Gambella region, which has one of the highest rates of child stunting at 24% (CSACE 2016). Itang Special Woreda, within this context, faces

considerable challenges in achieving improved child health outcomes. To address these challenges, it is essential to understand the underlying causes of malnutrition. The aim of this study is to assess the nutritional status of children aged 6-59 months and examine the differences in determinants of nutritional status across kebeles. Additionally, the research seeks to determine whether the findings align with existing literature on the determinants of malnutrition in Itang Woreda, utilizing a multilevel ordinal logistic regression model.

Study Design and Setting: A community-based cross-sectional study was conducted from October 12 to November 12, 2022, in Itang Special Woreda, Gambella, Ethiopia.

Study Population: The study population consisted of mothers and caregivers of children aged 6-59 months residing in the study area for at least six months prior to data collection. Participation required informed consent. Children under six months were excluded due to the contraindication of Ready-to-Use Therapeutic Food (RUTF) therapy for this age group (Binns and Myatt 2018). In households with multiple children aged 6-59 months, the youngest child was selected to minimize recall bias. Children with critical health issues or those who had not resided in the study area for at least six months were excluded.

Sample Size Determination: At the time of the survey, there were 8,685 mothers and caregivers in Itang Special Woreda with children aged 6-59 months. A total of 3,652 children from 23 kebeles were included in the sampling frame, using a multi-stage sampling technique. The 23 kebeles were divided into two major clusters: the first cluster included twelve kebeles located before the Baro

River, and the second cluster included eleven kebeles located after the Baro River. Six kebeles from the first cluster (BILJAKOK, PILUAL, BAZIEL, DRONG, WAAR, and OKURA) and five kebeles from the second cluster (EBAGO, ADONG, ELIA, ALAHA, and ADIMA) were randomly selected, considering their heterogeneity. A proportionate allocation based on the number of mothers and caregivers in each kebele was used to determine the sample size for each selected kebele.

The sample size was calculated using Yamane's (1967) formula:

$$n = \frac{N}{1 + N(e)^2} = \frac{3652}{1 + 3652(0.05)^2} = 361$$
 Where, n = the sample size, N= the population size (N= 3652), e = sample size for precision (5% margin of error was used; considering the homogeneity of the study population).

Using this formula, the required sample size was 361. To account for potential non-response and missing data, the sample size was increased by 10%, resulting in a final sample size of 397. This adjustment is consistent with Naing et al.'s (2006) recommendation to oversample by 10% to 20% in cases of non-response. The final sample of 397 children was selected for structured interviews, based on sampling frames from the Itang Special Woreda's 2015 catchment population health offices (see Table 1). For stratum h (each year of a department), the number of samples is calculated by using proportional allocation. This leads to the

following outcomes. $n_{hs} = \frac{N_{hd} \times n}{N}$ (Cochran,

1950) and these samples in each selected kebeles are selected using simple random sampling.

Table 1: Statistical population and sample size of the study area

No	Name of Kebeles	Numbers of children below 5 years	Sample size
1	EBAGO	114	12
2	ADONG	386	42
3	ELIA	229	25
4	ALAHA	117	13
5	ADIMA	87	10
6	BILJAKOK	414	45
7	PILUAL	556	60
8	BAZIEL	509	55
9	DRONG	547	60
10	WAAR	436	47
11	OKURA	257	28
Total		3652	397

Source: Itang special woreda 2015 catchment population health offices

Methods of Data Collection: Data were collected using two primary instruments: a structured questionnaire developed by the researcher and anthropometric measurements of weight and age for healthy children aged 6-59 months during the study period. Portable weighing scales (Seca Model 881) were used to measure children's weight. Children were weighed while wearing light clothing, and their

weight was recorded to the nearest 0.1 kg (Debeko and Goshu 2015). For children unable to stand on the scale, the mother or caregiver was first weighed, followed by a second weighing of the mother or caregiver alone. The child's net weight was then calculated as the difference between the two measurements. Heights were measured using a standard length scale while the child wore minimal

clothing. The headpiece was lowered until it made contact with the child's head, and measurements were conducted by trained health extension workers.

Study Variables: Several methods are commonly employed to assess the nutritional status of children aged 6-59 months, including anthropometric, clinical, dietary, and biochemical measurements. Among these, anthropometric measurements, which assess body dimensions and composition, are often used as proxies for determining the extent and severity of malnutrition. The weight-for-age anthropometric index is a widely recognized measure of a population's nutritional health. It serves as a composite index derived from both weight-for-height and height-for-age metrics (Niport 2007; Wolde et al. 2014; Das and Rahman 2011).

In this study, the dependent variable was the severity status of malnutrition in children aged 6-59 months, categorized using the weight-for-age z-score. Malnutrition severity was classified as follows: severely undernourished (< -3.0 z-score), moderately undernourished (-3.0 to -2.01 z-score), and nourished (≥ -2.00 z-score). Independent variables included a range of socio-economic, demographic, maternal, and child health characteristics such as maternal education, maternal and paternal employment status, marital status of the mother, household economic status, father's education, household size, area of residence, geographical area (kebele), child's sex, child's age, maternal age at first birth, birth interval, birth type, vitamin A supplementation, iron tablet/syrup intake during pregnancy, availability of toilet facilities, source of water supply, occurrence of diarrhea in the two weeks prior to the survey, and incidence of fever in the two weeks preceding the survey.

Data Analysis: After data collection, the data were checked for accuracy and entered into SPSS for initial processing. Data analysis was conducted using R version 3.4.0 and STATA 14.2 statistical software packages. The analysis focused on three outcomes of nutritional status for children aged 6-59 months: severely undernourished, moderately undernourished, or nourished. Two logistic regression models were performed. First, an ordinal

logistic regression model was employed to identify determinants of malnutrition among children and to predict the probability of malnutrition. Following this, a multilevel ordinal logistic regression model was used to assess the impact of determinant factors on kebele-level differences in malnutrition prevalence. All statistical inferences were conducted at a 5% significance level.

Ethical Considerations

All procedures for this study were conducted in compliance with relevant regulations and journal standards. Ethical clearance was obtained from the Gambella University Institutional Review Board Research Directorate Ethical Approval Committee (reference number: 258/GmU/2014; approval valid until 15/11/2014). Data were collected using a structured questionnaire developed by the researcher, along with anthropometric measurements, including weight and age, from healthy children aged 6 to 59 months, conducted by trained health workers during the study period. Informed consent was obtained from all participants and their legally authorized representatives. All methods were performed in accordance with the Declaration of Helsinki, ensuring the ethical treatment of all subjects involved in the research.

Results

According to the WHO classification of children's nutritional status, as presented in Table 2, 185 children aged 6-59 months were classified as severely malnourished (46.6%), 111 children (27.9%) as moderately malnourished, and 101 children (25.4%) as nourished.

Results of cross-tabulation of data analysis:

The study included a total of 397 children, comprising both males and females. Of these, 215 children (54.2%) were male, and 182 children (45.8%) were female (see Table 3). The prevalence of severe malnutrition varied significantly across the kebeles. The highest proportion of severely malnourished children was observed in DRONG (55.8%), followed closely by ADIMA (55.7%) and BILJAKOK (55.4%). In contrast, the lowest prevalence was found in ALAHA (24.3%) and ADONG (24.6%).

Table 2: WHO classification of nutritional status of children aged 6-59 months in Itang special woreda

Nutritional status	N	%
Severely malnourished (< -3.0 z-score)	185	46.63
Moderately malnourished (-3.0 to -2.01 z-score)	111	27.93
Nourished (≥ -2.00 z score)	101	25.44
Total	397	100.00

The analysis further indicated a notable correlation between maternal education and child malnutrition. Among children of non-educated mothers, 51.8% were severely malnourished, while 24.7% of children born to mothers with primary education fell

into the same category. Only 5.9% of severely malnourished children had mothers who had completed secondary school or higher. Similarly, the educational status of fathers showed a similar pattern: 53.4% of severely malnourished children had uneducated fathers, compared to 24.7% with

fathers who had completed primary education, and 5.5% with fathers who had completed secondary education or higher. This trend illustrated that as

educational attainment increased for both mothers and fathers, the prevalence of severe malnutrition among their children decreased.

Table 3: Results of descriptive analysis of socio-economic and demographic factors

Covariates		nutritional status			Total n (%)
		Severely malnourished n (%)	Moderately malnourished n (%)	Nourished n (%)	
Place of residence	Rural	175(50.2)	96(27.6)	78(22.2)	349(87.93)
	Urban	10(20.6)	15(30.4)	23(49.0)	48(12.07)
Mother's education level	No education	173(51.8)	94(28.1)	67(20.1)	334(84.13)
	Primary	11(24.7)	14(30.9)	21(44.4)	46(11.48)
	Secondary+	1(5.9)	3(17.6)	13(76.5)	17(4.28)
Sex of child	Male	112(51.9)	57(26.5)	46(21.6)	215(54.20)
	Female	73(40.3)	54(29.5)	55(30.2)	182(45.80)
Mother's Employment status	Unemployed	184(47.8)	110(28.5)	92(23.7)	386(97.16)
	Employed	1(4.2)	1(8.3)	9(87.5)	11(2.84)
During pregnancy, given iron tablets/ syrup	No	182(48.6)	105(27.9)	88(23.5)	375(94.84)
	Yes	3(13.0)	6(28.3)	13(58.7)	22(5.44)
Economic status of the household	Poor	144(72.4)	50(25.2)	5(2.4)	199(50.18)
	Medium	35(27.6)	44(34.7)	47(37.7)	126(31.72)
	Rich	6(8.4)	17(24.1)	49(67.5)	72(18.10)
Vitamin A supplement	No	176(49.2)	102(28.4)	79(22.4)	357(89.94)
	Yes	9(23.5)	9(23.5)	22(53.0)	40(10.06)
Father's education level	No education	172(53.4)	92(28.6)	58(18.0)	322(81.07)
	Primary	11(24.7)	12(29.2)	19(46.1)	42(10.53)
	Secondary+	2(5.5)	7(22.5)	24(72.0)	33(8.40)
Child's age in month	6-11	28(65.1)	8(18.6)	7(16.5)	43(10.77)
	12-23	114(56.5)	39(19.6)	48(23.9)	201(50.65)
	24+	43(28.2)	64(41.7)	46(30.1)	153(38.58)
Number of household members	1-4	30(35.3)	26(30.6)	29(34.1)	85(21.42)
	5-9	150(52.0)	77(26.9)	61(21.0)	288(72.54)
	10+	5(21.6)	8(33.3)	11(45.1)	24(6.04)
Birth interval in month	<24	107(61.5)	41(23.6)	26(14.9)	174(43.83)
	>=24	78(34.8)	70(31.4)	75(33.8)	223(56.17)
Age of the mother at the first Birth	<18	136(48.2)	80(28.1)	67(23.7)	283(71.24)
	>=18	49(42.8)	31(27.6)	34(29.6)	114(28.76)
Geographical area(kebele)	EBAGO	6(53.5)	4(31.9)	2(14.6)	12(21.89)
	ADONG	10(24.6)	13(30.3)	19(45.1)	42(14.44)
	ELIA	14(54.3)	6(24.3)	5(21.4)	25(8.40)
	ALAHA	3(24.3)	4(26.2)	6(49.5)	13(12.07)
	ADIMA	6(55.7)	2(24.0)	2(20.3)	10(9.35)
	BILJAKOK	25(55.7)	11(24.6)	9(19.7)	45(7.22)
	PILUAL	33(55.4)	17(27.8)	10(17.8)	60(6.51)
	BAZIEL	15(27.3)	15(27.3)	25(44.5)	55(5.21)
	DRONG	32(55.8)	19(32.5)	9(16.3)	60(5.09)
	WAAR	26(55)	13(27.5)	8(17.5)	47(4.85)
	OKURA	15(54.8)	7(23.8)	6(21.4)	28(4.97)
Availability of toilet facility	No facility	161(57.0)	76(27.0)	45(16.0)	282(71.01)
	Have facility	24(21.2)	35(30.2)	56(48.6)	115(28.99)
Had diarrhea in the last two weeks before the survey	No	157(45.4)	96(27.8)	92(26.8)	345(86.98)
	Yes	28(54.5)	15(29.1)	9(16.4)	52(13.02)
Had fever in the last two weeks before the survey	No	178(46.8)	107(28.1)	96(25.1)	381(96.09)
	Yes	7(42.4)	4(24.4)	5(33.3)	16(3.91)
Source of water supply	Unprotected	164(56)	77(26.3)	52(17.8)	293(73.73)
	Protected	21(19.8)	34(32.4)	49(47.8)	104(26.27)
Father's Employment status	Unemployed	183(48.5)	108(28.5)	86(22.8)	377(94.91)
	Employed	2(7.0)	3(16.3)	15(76.75)	20(5.09)

Table 3 further highlights the significant influence of various factors on malnutrition rates. The source of drinking water was found to be a major determinant of malnutrition. Children consuming

unprotected water sources had a higher prevalence of severe malnutrition (56%) compared to those with access to protected water sources, where the prevalence was significantly lower (19.8%).

The availability of toilet facilities was another important factor. A higher rate of severe malnutrition (57%) was observed among children from households without toilet facilities, compared to 21.2% among those from households with toilet facilities. Family size also played a crucial role in

the nutritional status of children. Among households with 5-9 members, 52.0% of children were severely malnourished, while 35.3% of children from smaller households (1-4 members) and 21.6% from larger households (10 or more members) exhibited severe malnutrition.

Table 4: The random coefficients model (Wald $X^2(20) = 211.83$ Prob > $X^2 = 0.0000$)

Nutritional status	Coefficients	Std. Err.	Z	P>z	OR	[95% Conf. Interval]	
Place of residence							
Rural	-.3992752	.3802747	-1.05	0.294	.6708061	0.3183512	1.413473
Main source of water supply							
Unprotected	.4751253	.3212323	1.48	0.139	1.608216	0.856862	3.018406
Toilet facility							
No facility (bush field)	-1.15096	.2805363	-4.10	0.000*	.3163329	0.1825356	0.5481975
Mother's education level							
Primary	-.1787895	.309041	-0.58	0.563	.836282	0.4563487	1.532525
Secondary +	.4234788	.5399556	0.78	0.433	1.527265	0.5300337	4.400737
Father's Education level							
Primary	1.526423	.3146905	3.75	0.000*	4.601687	1.758009	2.22053
Secondary +	4.601687	.4137395	4.21	0.000*	99.65229	2.533502	4.788896
Age of the mother at the first birth							
>=18 years	.0716353	.1686158	0.42	0.671	1.074263	0.7719421	1.494985
Sex of the child							
Female	.2077167	.2840765	0.53	0.595	1.230864	0.8972057	1.688606
Mother's employment status							
Un employed	-1.473445	.7474326	-1.97	0.049*	.2291348	0.0529511	0.9966281
Vitamin A supplement							
No	.1508367	.2840765	0.53	0.595	1.162807	0.3119339	1.688606
Number of household members	-.0942358	.0463571	-2.03	0.042*	.9100682	0.8313481	0.9967315
Breastfeeding							
For <12 months	-.6198347	.2614231	-2.37	0.018*	.53803	0.322315	0.898135
During pregnancy given iron tablets/syrup							
No	.1124242	.5068763	0.22	0.824	1.118987	0.4143538	3.021895
Economic status of the household							
Medium	2.785916	.289548	9.62	0.000*	16.21466	1.221403	1.423929
Rich	5.408452	.4522622	11.96	0.000*	223.2856	1.34295	2.582325
Had fever in last two week							
No	-.37152553	.4693839	-0.79	0.429	.6896816	0.2748579	1.730569
Had diarrhea in last two weeks							
No	.0677843	.2468314	-0.79	0.429	1.070134	0.2748579	1.73056
Birth interval							
>=24 months	.3585501	.08092056	4.431	0.008*	1.431253	1.221337	1.6763421
/cut 1	-.481241	1.096739	-0.44	0.661	-.481241	0.0720202	1.950971
/cut 2	1.995808	1.12405	1.81	0.070	1.995808	0.8480074	1.169785
var(_cons)	.569002	.000508	-4.33	0.000*		0.8319534	0.8327818
Intra kebele Correlation				0.087	0.038	2.34	0.010*
Random-effects Parameters		Estimate	Std. Err.			[95% Conf. Interval]	
RGN: Unstructured							
Var (Economic status)		.256725	.0000517		1.287331		1.287592
var(constant)		.9266952	.0000237		2.524974		2.527321
LR Chi ² (10) = 66.22 p-value = 0.0000							
Model Fit Diagnostics							
N	Model	Df	LL(model)	Deviance	AIC	BIC	
397	Chi	23	-563.9236	1127.8474	1177.84	1296.27	

Note: “*” indicates statistical significance at a 5% significance level

Economic status had a significant impact on malnutrition rates. Among children from poor families, 72.4% were classified as severely malnourished, compared to 27.6% from families with medium economic status. In contrast, only 8.4% of children from wealthy families were severely malnourished. The employment status of

mothers also correlated with the prevalence of malnutrition. Of the severely malnourished children, 47.8% had unemployed mothers. Lastly, the age of the child was an important factor in malnutrition prevalence. The highest prevalence of severe malnutrition (56.5%) was observed in children aged

12-23 months, while the lowest (28.2%) was found among children aged 24 months and older.

The analysis of the hierarchical structure of the data was conducted using multilevel ordinal models to account for variations at both the individual and kebele levels. The random intercept model with random coefficients was employed to examine whether level-one covariates had random or fixed

effects across kebeles. The results of the random slope estimates, as shown in Table 4, indicate a significant overall effect, with a Wald $\chi^2(24) = 211.83$ ($p < 0.001$). The likelihood ratio (LR) test confirmed that the logistic regression model with no intercept was rejected, signifying that the variance-covariance of random effects is significantly different from zero.

Table 5: Parameter estimates of the random intercept proportional odds with fixed predictors

		Wald X^2 (20) = 921.83		Prob > X^2 = 0.0000			
Nutritional status	Coefficients	Std. Err.	Z	P>z	OR	[95% Conf. Interval]	
Place of residence							
Rural	-.0372981	.1562598	-0.24	0.811	0.9633889	0.9662273	1.30861
Mothers' Education Level							
Primary	.0677698	.0765254	0.89	0.376	1.070119	0.4394756	1.243285
Secondary +	-.0836314	.120795	-0.69	0.489	0.9197702	0.7258692	1.165468
Father's Education Level							
Primary	.6316585	.0785182	0.80	0.421	1.880727	0.9132694	1.24242
Secondary +	.0575836	.0968841	0.59	0.552	1.059274	0.8760731	1.025056
Mothers' age at the first							
>18	-.034893	.0393425	-0.87	0.383	0.9657087	0.8945817	1.043751
Sex of the child							
Female	-.0420281	.0376729	-1.12	0.265	0.9588428	0.890595	1.032321
Number of house h. members	.015677	.0078	2.02	0.043	1.015801	1.000389	1.0314494
Economic status of household							
Medium	-.5584807	.0460666	-12.12	0.000	0.5720776	0.5226885	0.6261334
Rich	-1.306645	.0585604	-22.31	0.000	0.2707268	0.2413708	0.3036532
Breastfeeding							
For <12 months	.100011	.0346642	2.88	0.007	1.105183	1.2301680	1.9928964
Availability of toilet facility							
No facility (bush, field)	.3062217	.0709776	4.31	0.000	1.358283	1.181882	1.561013
Main Source of water supply							
Unprotected	.0310264	.1007232	0.30	0.76	1.031513	0.8459564	1.255508
Vitamin A Supplement							
No	-.0328332	.0692191	-0.47	0.635	0.9677	0.8449311	1.108307
Child's mother gets iron syrup							
No	-.0376782	.1149367	-0.33	0.743	0.9630228	0.7687803	1.206343
Had diarrhea in last two week							
No	-.0254628	0.0595064	-0.43	0.669	0.9748586	0.8675404	1.095453
Had fever in last two week							
No	.0452537	.1089729	0.42	0.678	1.046293	0.8675404	1.095453
Birth interval							
>24	-.100011	.0497864	-2.01	0.022	0.904828	0.8207046	0.997573
_cons	2.289504	.2462319	9.30	0.000	9.870041	1.806898	2.772109
Geography	.0155699	.0087913				1.005162	1.048213
Var (-cons)							
Var (e. dependent)	.2849702	.0139771				1.295441	1.368513
Var. Component							
Variance (τ_o) = 0.569							
ICC = $\frac{Var(Uoj)}{Var(Uoj) + (\frac{\pi^2}{3})} = \frac{\tau_o}{\tau_o + 3.29} = \frac{0.569}{0.569 + 3.29} \approx 0.15$							
LR test. linear model: Chibar2(01) = 22.17 prob >= chibar2 = 0.0000							
Model Fit Diagnostics							
N	Model	Df	LL(model)	Deviance	AIC	BIC	
397	chi	23	-675.633	1351.266	1397.266	1506.216	

The fixed intercept estimate was 0.569, representing the log-odds of nutritional status when all level-one covariates are zero for kebele j. The variance of the random intercept (between-kebeles variance) was

estimated at 0.926, indicating substantial variability in nutritional status across different kebeles. Additionally, the individual kebele slopes for the economic status of households showed a variance of

0.256, underscoring the impact of economic factors on child malnutrition across different kebeles.

Fitting multilevel proportional odds model: We fitted a two-level multilevel proportional odds model to estimate the response variable, nutritional status, accounting for hierarchical structures in the data. The model allows for varying cut points at different levels of hierarchy, with the total random variation partitioned into components associated with each level.

Table 5 presents the outcomes from the multilevel model, where we observed that the Maximum Quasi-Likelihood (MQL) method yielded biased estimates. To address this issue, we employed the Penalized Quasi-Likelihood (PQL) method for parameter estimation in our multilevel models. The Intra-Class Correlation (ICC) was calculated at 0.15, indicating that 15% of the variation in nutritional status can be attributed to differences at the division level (level two).

Our analysis revealed that the random intercept model with fixed predictors resulted in a division-level variation estimate of 0.569. Multilevel ordinal logistic regressions were performed, incorporating both fixed and random effects. The fixed effects at level one (individual child level) yielded results consistent with those obtained from a standard ordinal logistic regression.

When fitting the two-level random intercept model for nutritional status, we found that the odds ratios were similar to those derived from the level-one ordinal logistic regression model, with interpretations aligning accordingly. Notably, for the multilevel model, the emphasis is on the variation at the higher level. In this case, the random variation at the division level (kebele level) was significant, with a variance of $\tau_0 = 0.569$ and an ICC of 0.15. Additionally, the level one residuals followed a standard logistic distribution, with a variance of $\pi^2/3 \approx 3.29$, indicating that a substantial portion of the total variation is situated at the higher level (division level).

Overall, these findings underscore the importance of recognizing and quantifying hierarchical structures when assessing nutritional status within the population studied.

Discussion

The findings of this study reveal a high prevalence of severe malnutrition among children aged 6 to 59 months in the rural areas of Itang Special Woreda. Specifically, the highest rates of severe malnutrition were recorded in DRONG kebele (55.8%), followed by ADIMA (55.7%) and BILJAKOK (55.0%). Conversely, ALAHA kebele exhibited the lowest prevalence at 24.3%, with ADONG kebele at 24.6%. These discrepancies highlight significant inequalities, which may stem from uneven

infrastructure development and varying socio-economic and demographic conditions across the kebeles.

Our analysis indicates that access to protected drinking water is a crucial factor in child nutritional status. Children relying on unprotected water sources were found to have a higher likelihood of severe malnutrition compared to their peers with access to safe drinking water. Additionally, children without access to toilet facilities were more severely malnourished than those with adequate sanitation. These findings emphasize the critical role of water and sanitation infrastructure in mitigating malnutrition risks, consistent with previous research (UNICEF, 2006; Fenta et al., 2020).

Maternal employment status was identified as a significant determinant of child malnutrition, with children of unemployed mothers being at greater risk. The educational level of mothers was strongly associated with nutritional outcomes. Children whose mothers had no education or only primary education were significantly more likely to be severely malnourished than those whose mothers had completed secondary education or higher. This is in line with existing literature, which underscores the relationship between caregiver education and improved child nutritional status (Oyekale and Oyekale 2009; Smith and Haddad, 2000). Educated mothers often possess greater health awareness and have more resources to care for their children effectively (Rayhan and Khan 2006). The literature further supports the notion that improvements in women's education can significantly reduce child malnutrition rates. A comprehensive study across 63 developing countries identified women's education as a key determinant, attributing a notable reduction in malnutrition rates to increased female secondary school enrollment (Das and Rahman, 2011). Furthermore, the prevalence of stunting was found to be highest among children whose fathers had low educational levels, indicating that parental education plays a vital role in addressing children's nutritional needs (Das and Rahman 2011).

This study also revealed that children from poorer households are at a heightened risk of severe malnutrition compared to their wealthier counterparts, aligning with findings from Girma and Genebo (2002). Additionally, health factors such as the presence of fever or diarrhea within two weeks prior to the survey were significantly associated with malnutrition, consistent with previous research by Sommerfelt and Stewart (1994). Children without these health issues were less likely to be severely malnourished, highlighting the interplay between health status and nutrition.

In examining individual and community-level factors as determinants of malnutrition, our study underscores the importance of kebele-level

variations. The use of multilevel ordinal logistic regression allowed for a more comprehensive analysis of these variations. While the model revealed differences in malnutrition prevalence among kebeles, it also indicated that individual-level factors were the primary drivers of these variations. This supports findings from other studies that distinguish between contextual and compositional effects on health outcomes (Subramanian et al. 2003).

Conclusions

This study confirms that both individual and community-level factors significantly influence the nutritional status of children in rural Itang Special Woreda. Key determinants identified include maternal education, household economic status, access to basic services (such as sanitation and safe drinking water), and geographical location (kebele). Addressing these determinants will be crucial in efforts to combat child malnutrition in the region. Interventions aimed at improving infrastructure and expanding educational opportunities for women could play a critical role in enhancing child health outcomes.

The study also demonstrates that the multilevel ordinal logistic regression model, with random intercepts and random coefficients, effectively predicts the severity of malnutrition among children aged 6 to 59 months in Itang Special Woreda. Malnutrition in this age group remains a significant public health concern, particularly among children in rural areas and from poorer households. Interestingly, infants under 11 months showed better nutritional status, likely due to the protective benefits of breastfeeding. To effectively combat malnutrition, it is essential for both governmental and non-governmental organizations to prioritize kebeles with high malnutrition rates and tailor health care and nutrition programs to the specific needs of each kebele. Such targeted interventions are essential for preventing nutritional deficiencies and improving overall child health outcomes, ultimately fostering healthier communities.

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Data Availability

The corresponding author will provide the datasets used and analyzed during the current research upon reasonable request.

Competing Interests

The authors declare that there are no competing interests.

Consent for Publication

Not applicable.

References

- Wobse B & Temesgen S (2015). Undernutritional status of children in Ethiopia: Application of partial proportional odds model. *Turkiye Klinikleri Journal of Biostatistics*, 7(2):77-89
- Binns P & Myatt MJ (2018). Does treatment of short or stunted children aged 6–59 months for severe acute malnutrition using ready to use therapeutic food make them overweight? Data from Malawi. *Archives of Public Health*, 76: 78.
- Cochran WG (1950). Estimation of bacterial densities by means of the “most probable number.” *Biometrics*, 6(2): 105-116.
- Csace I (2016). Ethiopia demographic and health survey 2016. Addis Ababa, Ethiopia, and Rockville, Maryland, USA: CSA and ICF.
- Das S & Rahman RM (2011a). Application of ordinal logistic regression analysis in determining risk factors of child malnutrition in Bangladesh. *Nutrition Journal*, 10(1): 1-11.
- Das S & Rahman RM (2011b). Application of ordinal logistic regression analysis in determining risk factors of child malnutrition in Bangladesh. *Nutrition Journal*, 10(1): 1-11.
- Debeko DD & Goshu AT (2015). Nutritional status of under-five children in Hawassa Zuria District, Southern Ethiopia. *American Journal of Health Research*, 3(5):286-292.
- Fenta HM, Workie DL, Zike DT, Taye BW & Swain PK (2020). Determinants of stunting among under-five years children in Ethiopia from the 2016 Ethiopia demographic and health survey: Application of ordinal logistic regression model using complex sampling designs. *BMC Public Health*, 8(1): 404-413.
- Gebrekrstos ZN, Bedada TD, Abdisa FJ & Girma FB (2023). Multilevel logistic regression analysis of factors associated with delivery care service utilization among childbearing women in Ethiopia. *Frontiers in Reproductive Health*, 5, p.1045964.
- Girma W & Genebo T (2002). Determinants of nutritional status of women and children in Ethiopia. *Ethiopian Journal of Health Development*, 16(2), pp.37-48.
- Israel GD (1992). Sampling the evidence of extension program impact. *Citeseer*.
- Israel GD (1996). Sampling the evidence of extension program impact. *Citeseer*.

- Naing L, Winn T & Rusli B (2006). Practical issues in calculating the sample size for prevalence studies. *Archives of Orofacial Sciences*, 1, pp.9-14.
- Niport M & Macro International (2009). Bangladesh Demographic and Health Survey 2007. *Bangladesh Demographic Survey*, 2007.
- Oyekale A & Oyekale T (2009). Do mothers' educational levels matter in child malnutrition and health outcomes in Gambia and Niger? *Social Science*, 4(1): 118-127.
- Rayhan MI & Khan MSH (2006). Factors causing malnutrition among under-five children in Bangladesh. *Pakistan Journal of Nutrition*, 5(6): 558-562.
- Smith LC & Haddad LJ (2000). Explaining child malnutrition in developing countries: A cross-country analysis. *International Food Policy Research Institute*, Washington, D.C.
- Sommerfelt A & Stewart M (1994). Children's nutritional status. *DHS Comparative Studies No. 12*. Calverton, Maryland: Macro International Inc.
- Subramanian SV, Lochner KA & Kawachi I (2003). Neighborhood differences in social capital: A compositional artifact or a contextual construct? *Health & Place*, 9(1): 33-44.
- UNICEF (2006). Progress for children: A report card on nutrition. *UNICEF*, New York.
- Wolde T, Belachew T & Birhanu TJP (2014). Prevalence of undernutrition and determinant factors among preschool children in Hawassa, Southern Ethiopia. *Food Science and Quality Management*, 29: 65-72.
- Woldetsadik T (2011). Nutrition causal analysis: Aweil East County, Northern Bahr el Ghazal State, South Sudan. *ACF*.
- Yamane T (1967). *Statistics: An Introductory Analysis*, 2nd ed. Harper and Row, New York.