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Clustering and determinants of acute undernutrition among under-five children in urban and rural communities of Tigray in Ethiopia

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Abstract

Background

Undernutrition is one of the major public health problem and an important health indicator for under-five children in many developing countries. It causes the death of 3.5 million children under-five years old per year in the world and nearly 45 million are acute malnutrition globally.

Objective

The objective of the study was to assess the distributions and determinants of acute undernutrition among under-five children in all urban and rural areas of Tigray.

Methods

A cross-sectional study design was employed in 18 urban and 34 rural areas of Tigray, northern Ethiopia. A sample of 11,004 children aged 6-59 months was included in this study. Child nutrition status was developed by calculating weight-for-height z score and categorized into three groups as severely undernourished, moderately undernourished, and nourished. Spatial clustering of child undernutrition was determined using SATSCAN and GIS softwares. An ordinal logistic regression model (proportional odds model) was fitted to assess the risk of child nutritional status and odds ratio with 95% confidence interval was used to assess the presence of associations.

Results

The prevalence of acute undernutrition in the rural and urban areas was 9.3% and 7.8%, respectively. High burden of acute undernutrition is concentrated mainly in the central, northwestern, south, and southeast zones of Tigray.

Conclusions

The proportional odds model showed that child sex, mother's education, fever in the last two weeks, timing of child put to the breast after birth, cough in the last two weeks, and regular ANC visits were the significant predictors of child acute undernutrition. The prevalence of acute undernutrition among under-five children in Tigray was high and concentrated mainly in the central, northwestern, south, and southeast zones of the region. To reduce the burden of acute undernutrition in the region, prevention of common childhood illnesses, improving maternal education, and child's feeding practices are recommended.

Keywords: Acute undernutrition, Proportional odds model, Children aged 659 months, Ethiopia.

Introduction

Undernutrition is one of the major public health problem and an important health indicator for under five children in many developing countries around the world [1]. It has been reported as a single greatest risk factor for morbidity and mortality globally. According to the global burden of disease, undernutrition was the main underlying factor for 56% of all deaths in children younger than 5 years and 8,000 deaths each day in 2017 [2, 3]. Based on the 2023 World Health Organzation report, approximately 45 million children under-five worldwide suffered from acute undernutrition [4]. Acute undernutrition is the leading cause of mortality, accounting for about 12% of the total deaths and contributed significantly to the overall disease burden [5]. According to UNICEF report, Africa and Asia accounted for more than a quarter and two thirds of all wasted children globally [6]. Furthermore, another study revealed that, 27% of Sub- Saharan Africa under-five children were acute under- nutrition [1].

According to the Ethiopia demographic health survey (EDHS) reports, in Ethiopia there has been quite a good progress in reducing stunting and underweight, however the prevalence of acute undernutrition changed relatively little over the same time period between 2000 and 2019 [7, 8]. Similarly, the burden of acute undernutrition has remained relatively high in Tigray region. The prevalence of child acute undernutrition of the two survey in Tigray region were 11.1% in 2000 and 9.2% in 2019 based on the regional aggregate data [7, 8]. The drop in percentage prevalence of acute undernutrition has not been rapid to meet the international and national nutrition targets.

In Ethiopia, some studies have been conducted on child acute undernutrition. However, in most of the studies considered acute undernutrition as a binary (normal and low weight-for-height) response [9,10,11]. As a result, the binary logistic model was used to determine the risk factors of wasting in children [9,10,11]. However, the weight-for-height of a child is usually classified as normal, moderate, and severe acute undernutrition. Ignoring the discrete ordinal nature of the outcome variable would lead to the loss of useful information and lead to misinterpretation of the findings.

Understanding factors affecting child acute undernutrition using appropriate statistical models is an important for reducing the burden of child undernutrition. Thus, given the high burden of acute undernutrition in the region, and the slow drop in percentage prevalence initiated this study. Hence, this study assessed the geographic distribution and factors associated with acute undernutrition among 6-59 users urban and rural areas of Tigray region, Northern Ethiopia.

2. Methods and Materials

2.1. Study area, design, and period

In this study a cross sectional design was employed in all woredas (districts) of Tigray region, Ethiopia from June to July 2019. Tigray region is one of the nine regional states of Ethiopia located at latitudes from 120 14’50.50” to 140 53’48.03” and longitudes from 360 26’48.74” to 390 59’ 0.09”. It is the homeland of the Tigray, Erob and Kunama people. The state of Tigray region shares common borders with Eritrea in the north, the State of Afar in the east, the State of Amhara in the south, and the Republic of the Sudan in the west. The region is divided into 7 zones, 52 (34 rural and 18 urban) woredas and 814 tabias/kebeles (kebelle/tabia is the smallest administrative component in the country). In terms of religion, 95.5% of the population are Orthodox Christians, 4.1% and 0.4% are Muslims and Catholics, respectively. Regarding ethnic composition, 94.98% are Tigrians, 2.6% Amhara, 0.7% Erob and 0.05% Kunama. Tigrigna is the working language of the state. According to the Tigray Health Bureau report, the Region has 36 Hospitals, 204 Health Centers, and 712 Health Posts. According to the projection of Central Statistics Agency (CSA) the state's population size was 5,443,000 in 2019 [12] with an estimated area of 54,593 square kilometers. Based on CSA, 73% of the population live in rural areas, while 27% are urban dwellers [12].

2.2. Study population

The study population was 6 – 59 months old children residing in selected households in all woredas of the Tigray region.

2.3. Eligibility Criteria

All children aged 6–59 months residing in the selected households were included. Children aged 6-59 months who had other known illnesses were excluded from participation in the study.

2.4 Sample size determination and sampling technique

The survey sample size was determined by using a single population proportion formula, using 99% confidence interval with 2% margin of error (absolute precision), design effect of 2.5 and using a prevalence of 39.3% stunting from CSA report [13]. The total sample size was calculated to be 9,925 households. Considering 10% none response rate, the final sample was determined to be 10,917 households with 6–59 months old children. This total sample size was allocated to each woredas and urban administrations using proportion to the size of population (PSP). A stratified two stage sampling technique was employed to select the 10,917 households. In this study, all the rural woredas and urban administrations were included in the sample. Using the projected population of under-five children from CSA [12], we have allocated the total sample size (10,917) to each woreda and urban administrations using PSP. A stratified two-stage sampling technique was used to select the study participants. In the first stage, representative tabias/kebeles were selected from each of 52 woredas using simple random sampling. At the second stage, households with under-five children from the selected kebelles/tabias were selected using systematic random sampling technique after allocating proportionally. The sampling frame for the secondary sampling unit was the list of all households in the selected tabias/kebelle, and obtained from the tabia/kebelle administrations. In households with more than one child between the ages of 6-59 months, the youngest child was selected and included in the study. Of the total sample, 8,535 households with under-five were selected from rural woredas and 2,382 households with under-five were drawn from urban administrations.

2.5. Study Variables

2.5.1. Dependent Variable

This study considered weight-for-height anthropometric indices to measure the nutrition status of the children. The dependent variable was child acute undernutrition. The value 1 was recorded as a nourished child (Z score ≥ - 2 standard deviation (SD)), 2 as a moderate acute undernutrition child (Z score between -3 to -2.01 standard deviation (SD)) and 3 as a severe acute undernutrition child (Z score <-3 standard deviation (SD)). Moreover, to assess the severity of acute undernutrition in the population, the following epidemiological criterion was used: low prevalence(<5%), medium prevalence (5-9.9%), high prevalence(10-14.9%) and very high prevalence(>=15%) [14,15].

2.5.2. Independent Variables

In this study the most common determinants reported by several studies were considered [16,17,18,19,20]. The independent variables to be considered as determinants of child undernutrition were residence, household size, child sex, child age, age of mother/caregiver, maternal education, marital status, father education, child feeding practices, household food insecurity, common childhood illnesses, ANC follow-up, and delivery of key essential nutrition action messages.

2.6. Measurements

Height and weight measurements were taken following standard procedures of the Food and Nutrition Technical Assistance Guide [14]. Weight was measured to the nearest 0.1 kg using a salter weighing scale. Each child was weighed with minimum clothing and no foot wear. Height was measured to the nearest 0.1 cm using a portable Stadiometer. For 6 –23 months old children, recumbent length and for children 24 –59 months of age, standing height measurements were measured. Each child's recumbent length or standing height was measured with no foot wear.

The 2006 WHO Multi Centre Growth Standards z-score system was used to calculate weight-for-height (WHZ) z-scores. Children with WHZ below -2 z scores were characterized as wasted.

The Household Food Insecurity Access Scale (HFIAS) questionnaire consists of nine occurrence questions that represent a generally increasing level of severity of food insecurity (access), and nine "frequency-of-occurrence" questions that are asked as a follow-up to each occurrence question to determine how often the condition occurred. The HFIAS was used to classify households into severe, moderate, mild food insecure, and food secure households [21].

2.7. Coordinates

Latitude, longitude, and elevation coordinates were obtained for the nearby health post or outreach center using a mobile phone. Using these coordinates, geospatial clustering of the risk of child undernutrition among 6–59 months old children was determined using GIS.

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2.8. Data collection procedure and quality control

A pre-tested structured questionnaire and anthropometric measurements were used to collect data. Enumerators who have work experience in conducting similar surveys with a minimum of a BSc degree, and who can speak the local language were recruited. Training was given by research team and participation in the training was a prerequisite for employment in the field work. The completeness and consistency of data were assured through direct and daily supervision by the research team and an expert from the Tigray Statistics Agency. The data was collected using Smartphone and sent to the compute server at Mekelle University. The interview was conducted in the native language of study participants. The mobile phones were GPS installed to determine the geospatial clustering of undernutrition in Tigray region.

2.9. Statistical data analysis

In this study the statistical analysis was conducted using STATA software version 16. The data were coded, cleaned and checked for completeness. Weight-for-height (WHZ) z-scores were calculated using the Emergency Nutrition Assessment (ENA) for Standardized Monitoring and Assessment of Relief and Transitions (ENA for SMART) Software. Spatial clustering of child acute undernutrition was determined using SATSCAN and GIS softwares. The association between independent variables and the dependent variable was examined by performing both bivariate and multivariate analyses. In the bivariate setup, in order to measure the strength of association between the ordinal response and independent variables, gamma measure is used when independent variables are in ordinal scale, while chi-square is used when they are measured in nominal scale. Those candidate independent variables with *p* value of less than 0.05 were fitted into multivariate analyses. Since the outcome is ordinal, an ordinal logistic regression (proportional odds) model is considered to assess the adjusted effects of independent variables on the nutritional status of children (nourished, moderate acute undernourished and severe acute undernourished) [22]. Odds ratio with 95% confidence interval was used to assess the strength of the association between the independent variables and outcome variable.

2.9.1 Ordinal Logistic Regression Model

There are several ordinal logistic regression models have been proposed for ordinal responses, such as proportional odds model (POM), partial proportional odds model-without restrictions (PPOM-UR) and partial proportional odds model with restrictions (PPOM-R), continuous ratio model (CRM), and stereotype model (SM). The most frequently used ordinal logistic regression model in practice is the constrained cumulative logit model called the POM [21]. The POM is the most widely used in epidemiological and biomedical applications but POM leads to strong assumptions that may lead to incorrect interpretations if the assumptions are violated [21]. If the data fail to satisfy the proportional odds assumption, a valid solution is fitting a partial proportional odds model (PPOM) [23].

The POM also known as the cumulative logit model, is appropriate when an original continuous response variable is later grouped. Let Yi (i=1, 2, ..., n) be the response variable with ordinal categories. In this study the Yi is the response with three ordered categories 1, 2, 3, i.e., nourished, moderately malnourished or severely malnourished.

$$Y_i = \begin{cases} 1, \text{if } i^{th} \text{ child is nourished} \\ 2, \text{if } i^{th} \text{ child is moderately acute undernourished} \\ 3, \text{if } i^{th} \text{ child is severely acute undernourished} \end{cases}$$

The cumulative probabilities are the probability that the response Y falls in category i or below for each possible i, i=1, 2, ..., k where k is the number of outcome categories. To introduce the model additionally, let $X_i = (X_{i1}, X_{i2}, \ldots, X_{ip})'$ be the vector of p independent variables related to response variable Yi. The functional form of the POM which simultaneously consider k-1 cumulative logits can be expressed as

$$\text{logit}\left[P(Y_i \le j)\right] = \log\left[\frac{P(Y_i \le j)}{P(Y_i > j)}\right] = \log\left\{\frac{P(Y=1|\mathbf{X}_i)+....+P(Y=j|\mathbf{X}_i)}{P(Y=j+1|\mathbf{X}_i)+....+P(Y=k|\mathbf{X}_i)}\right\}$$

$$= \alpha_j + \beta_1 x_{i1} + \beta_2 x_{i2} + \ldots + \beta_p x_{ip}, j = 1,2,\ldots k-1$$

where β= $(\beta_1, \beta_2, \ldots, \beta_p)'$ is the vector of regression parameters related with X_i and α_j represents the intercept for j^{th} cumulative logit. The proportional odds model, the effect of each covariate (independent variable) is assumed to be same for any cumulative logits. The assumption of POM can be checked by statistical test such as test based on deviance or score test [23].

In this paper, the brant test of parallel regression assumption based on deviance was performed to check the assumption. When proportional odds assumption is violated, a legal alternative is to develop a PPOM. When the proportional odds assumption applies to some but not all of the covariates, the PPOM may be used. The PPOM releases the constraint of having a common parameter across the response logits for all the predictors considered in the model.

3. Results

3.1 Socio-demographic characteristics of caregivers

Among the total of 10, 917 children expected to be included in this study, 11,004 had participated with the response rate of 100.8%. Data for 11,004 children from their care takers (mothers, fathers and relatives) were gathered and used for analysis. Majority of the children were lived in rural areas (77.2%) and slightly higher proportions of female children 5,635 (51%) were included in this study. The average age (standard deviation) of the children and care givers and the average (SD) household size were 26.0 ±14.0 months, 29.3 ± 7.1 years and 4.6 ±1.7, respectively. Moreover, 37.7% of children had mothers with no formal education and 32.9% had mothers with primary education. Significant proportions of the mothers (83.1%) were married [Table 1].

Table 1. Socio-economic and demographic characteristics of caretakers of children in the study areas from Tigray region,

Characteristics	Frequency	Percent
Caregivers		
Mother	10224	92.9
Father	269	2.5
Relatives	511	4.6
Child sex		
Male	5369	48.8
Female	5635	51.2
Child age, months		
6-11	1799	16.3
12-23	3522	32.0
24-35	2638	24.0
36-47	1892	17.2
48-59	1153	10.5
Age caregiver, years		
≤20	782	7.1
21 – 30	6404	58.2
31-40	3249	29.5
41-50	447	4.1
>50	122	1.1
Household size		
≤5	8245	74.9
6 – 12	2759	25.1
Marital status		
Married	9157	83.2
Single	284	2.6
Divorced	1065	9.7
Widowed	142	1.3
Separated	344	3.1
Others	12	0.1
Mother education		
No formal education	4148	37.7
Primary education (1-8)	3623	32.9
Secondary education (9-10)	2324	21.1
Preparatory (11-12)	220	2.0
College or above	680	6.2
Don't know	9	0.1
Father education		
No formal education	3499	31.8
Primary education (1-8)	3240	29.4
Secondary education (9-10)	2106	19.1
Preparatory (11-12)	292	2.7
College or above	1227	7.5
Don't know	640	5.8
Residence		
Rural	8499	77.2
Urban	2505	22.8

3.2. Maternal and child health and feeding characteristics

In the study communities, ever (96.6%) and exclusive (97%) breastfeeding were almost universal. Similarly, more than 80% of the mothers did initiate breastfeeding with the first one hour of birth and gave colostrums to their newborns. About 97% of mothers ever breastfed their children. Close to 80% of the care givers initiate the provision of complementary foods at six months of age of the child. About 11% of the children had mothers who did not visit any antenatal clinic during pregnancy and 43.9% of mothers/caregivers did not ever heard nutrition information through media. Higher proportion (91%) of children were exempted from fasting, the contamination of kitchen utensils with animal source foods was a concern during the fasting periods. Exemption from fasting was relatively lower during pregnancy (62%) and lactation (63%). The occurrence of common childhood illnesses namely diarrhea, cough/pneumonia and fever in the past two weeks prior to the date of data collection were 1684(15.3%) for fever, 1120(10.2%) for diarrhea and 1525(13.9%) for cough/pneumonia [Table 2].

Table 2. Infant and young child feeding practices of mothers of children from the households in the study areas from Tigray region, Ethiopia, 2019 (n = 11004).

Characteristics	Frequency	Percent
Breastfeeding status		
Never breastfed	134	1.2
Ever breastfed but not currently	5112	46.5
Still breastfed	5738	52.1
Don't know	20	0.2
Exclusive breastfeeding		
No	347	3.2
Yes	10588	96.2
Don't know	69	0.6
Timing of child put to the breast after birth		
< 1 hour	8794	80.9
Between 1 and 23 hours	1576	14.5
>24 hours	186	1.7
Don't know	448	4.1
Breastfed frequency		
1-7 times a day	2358	21.4
8-12 times a day	3149	28.6
More than 12 times a day	1174	10.7
Don't know	4323	39.3
Breastfeeding practices till two years and beyond		
No	2345	21.3
Yes	4698	42.7
Not applicable	3880	35.3
Don't know	81	0.7
Received vitamin A		
No	1703	15.5
Yes	8479	77.0
Not sure	822	7.5
Had any signs of cough or pneumonia in the last 2 weeks?		
No	9479	86.1
Yes	1525	13.9
Had fever in the last two weeks?		
No	9320	84.7
Yes	1684	15.3
Had diarrhea in the last two weeks?		
No	9884	89.8
Yes	1120	10.2
Had received deworming tablets in the last six months?		
No	4764	43.3
Yes	4484	40.7
Not sure	1756	16.0
Have you ever heard nutrition information through mass media		
No	4832	43.9
Yes	6172	56.1

Table 2. Infant and young child feeding practices of mothers of children from the households in the study areas from Tigray region, Ethiopia, 2019 (n = 11004). *(Continued . . .)*

Characteristics	Frequency	Percent
Regular antenatal visits		
No	1200	10.9
Yes	9804	89.1
Child exemption from fasting		
No	1041	9.5
Yes	9963	90.5
Pregnant women exemption from fasting		
No	4140	37.6
Yes	6864	62.4
Lactating women exemption from fasting		
No	4035	36.7
Yes	6969	63.3
Time of complementary food start		
Before six months	289	2.7
6 months	8547	79.0
After six months	1985	18.3

3.3. House hold food insecurity

Using household food insecurity access scale (HFIAS), 6461(58.7%), 1273(11.6%), 2544(23.1%), and 726(6.6%) of the households were found to be food secure, mildly food insecure, moderately food insecure, and severely food insecure, respectively [Figure 1]. The burden of acute undernutrition was found to be almost similar in food secure, mildly food insecure and moderately food insecure. Acute undernutrition among children was high in the severely food insecure households. The prevalence of acute undernutrition was 8.5% and 11.6% in food secure and severely food insecure households, respectively [Figure 2].

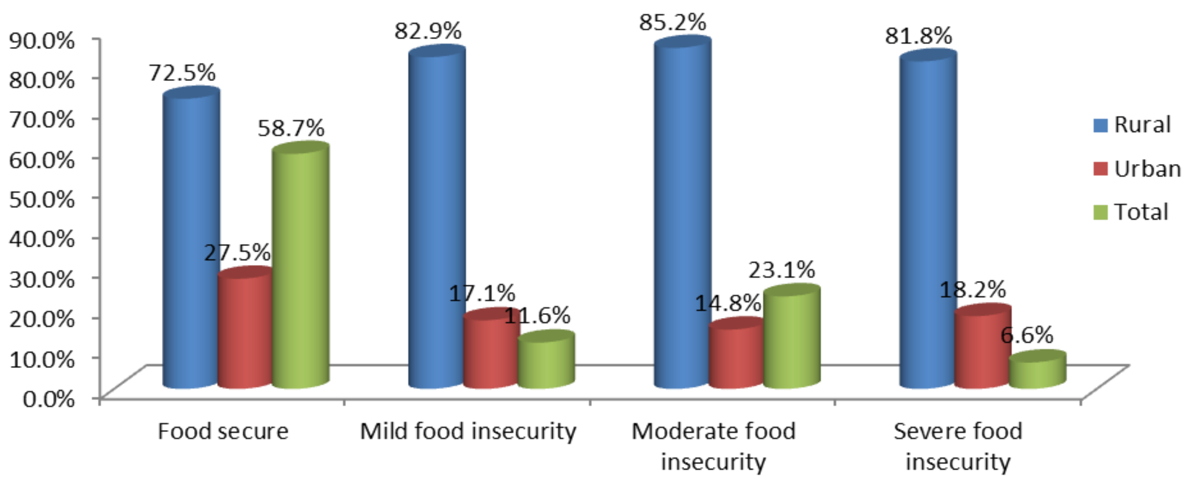

Figure 1: Food insecurity level of households in the study areas (n=11,004).

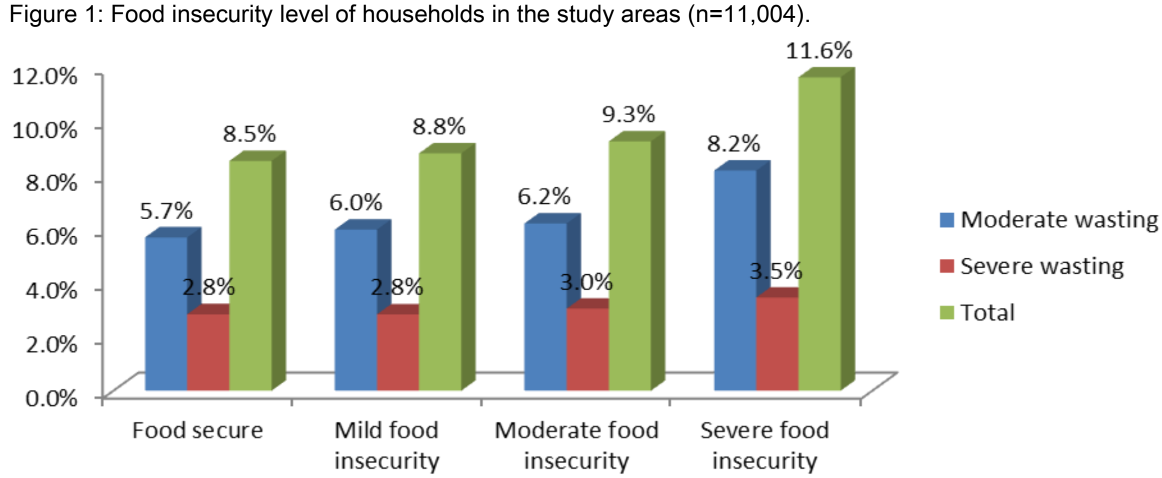

Figure 2: Acute undernutrition among 6 – 59 months old children by household food insecurity level in the study areas (n = 11,004).

3.4. Geographic distribution of acute undernutrition among under-five children

Our anthropometric data is reported using the WHO flags based on standard population as opposed to the SMART flags based on the observed population. The cut point was -5 to +5 standard deviations for weight-for-height (Simon, 2014). As a result, 69 z scores of weight-for-height were not included in the analysis. The overall prevalence of acute undernutrition among the children in Tigray region was 8.9% (95% CI: 8.7% – 9.8%). Of the acute undernourished, 2.9% were severe acute undernutrition and 6.0% were moderate acute undernutrition. The prevalence of acute undernutrition in the urban towns of Tigray region was found to be 7.8%. It was ranged between 2.6% in Kedamay Weyane, Mekelle to 18.8% Adi-Haqi, Mekelle [Table 3]. The burden of acute undernutrition in the rural areas of Tigray region was found to be 9.3%. The lowest and highest burden of acute undernutrition was found in Ganta Afeshum (3.1%) and in Mereb Lekhe (17.7%) respectively [Table 4].

Table 3. Distribution of acute undernutrition among 6 – 59 months old children from urban woredas of Tigray region, Ethiopia, 2019 (n = 2,487).

Zone	N	Acute undernutrition					
		Severe		Moderate		Total	
		n	%	n	%	n	%
Central							
Abyi Adi	121	2	1.7	3	2.5	5	4.1
Adwa Town	138	7	5.1	6	4.4	13	9.4
Axum	167	2	1.2	8	4.8	10	6.0
East							
Adigrat	222	6	2.7	11	5.0	17	7.7
Wukro	119	4	3.4	8	6.7	12	10.1
Mekelle							
Adi Haqi	117	10	8.5	12	10.3	22	18.8
Ayder	111	2	1.8	3	2.7	5	4.5
Hadnet	169	1	0.6	15	8.9	16	9.5
Hawelti	153	5	3.3	4	2.6	9	5.9
Kedamay Weyane	116	2	1.7	1	0.9	3	2.6
Quiha	130	0	0.0	4	3.1	4	3.1
Semien	129	8	6.2	8	6.2	16	12.4
South							
Alamata	133	7	5.3	10	7.5	17	12.8
Korem	144	4	2.8	4	2.8	8	5.6
Maichew	146	3	2.1	3	2.1	6	4.1
West							
Humera	116	0	0.0	8	6.9	8	6.9
North west							
Sheraro	92	5	5.4	7	7.6	12	13.0
Shire Endasellasie	164	6	3.7	5	3.0	11	6.7
Total	2487	74	3.0	120	4.8	191	7.8

Table 4. Distribution of acute undernutrition among 6 – 59 months old children from rural woredas of Tigray region, Ethiopia, 2019 (n = 8,448).

Zone	N	Acute undernutrition					
		Severe		Moderate		Total	
		n	%	n	%	n	%
Central							
Adwa	220	7	3.2	14	6.4	24	9.6
Ahferom	370	9	2.4	20	5.4	29	7.8
Laelay Maichew	172	2	1.2	8	4.7	10	5.8
Mereb Lekhe	277	17	6.1	32	11.6	49	17.7
Naeder Adet	254	6	2.4	9	3.5	15	5.9
Qola Tembien	297	9	3.0	27	9.1	36	12.1
Wereai Lekhe	329	6	1.8	16	4.9	22	6.7
North west							
Asgede Tsimbila	259	13	5.0	26	10.0	39	15.1
Laelay Adiabo	273	6	2.2	21	7.7	27	9.9
Medebay Zana	212	6	2.8	16	7.5	22	10.4
Tahtay Maichew	240	11	4.6	23	9.6	34	14.2
Tanqua Abergele	225	4	1.8	15	6.7	19	8.4
Tahtay Adiabo	196	1	0.5	11	5.6	12	6.1
Tahtay Koraro	170	2	1.2	5	2.9	7	4.1
Tselemti	305	21	6.9	29	9.5	50	16.4
East							
Atsbi Wemberta	270	3	1.1	14	5.2	17	6.3
Erob	98	1	1.0	3	3.1	4	4.1
Ganta Afeshum	194	1	0.5	5	2.6	6	3.1
Gulo Mekheda	238	5	2.1	12	5.0	17	7.1
Hawzen	311	7	2.3	20	6.4	27	8.7
Kilte Awlaelo	208	6	2.9	9	4.3	15	7.2
Saesie Tsaeda Emba	271	9	3.3	16	5.9	25	9.2
South east							
Deguae Tembien	267	8	3.0	9	3.4	17	6.4
Enderta	149	10	6.7	14	9.4	24	16.1
Hintalo Wejerat	334	12	3.6	14	4.2	26	7.8
Seharti Samre	276	7	2.5	21	7.6	28	10.1
South							
Emba Alaje	302	13	4.3	31	10.3	44	14.6
Enda Mekhoni	223	7	3.1	22	9.9	29	13.0
Ofla	282	11	3.9	18	6.4	29	10.3
Raya Alamata	220	3	1.4	7	3.2	10	4.5
Raya Azebo	273	7	2.6	13	4.8	20	7.3
West							
Kafta Humera	239	3	1.3	10	4.2	13	5.4
Tsegedie	222	10	4.5	12	5.4	22	9.9
Welkait	272	3	1.1	15	5.5	18	6.6
Total	8448	246	2.9	537	6.4	783	9.3

Acute undernutrition in 6 –59 months old children was found to be high (above the average) North West (10.8%), South (9.5%), Central (9.4%) and South East (9.3%) zones of Tigray region [Figure 3].

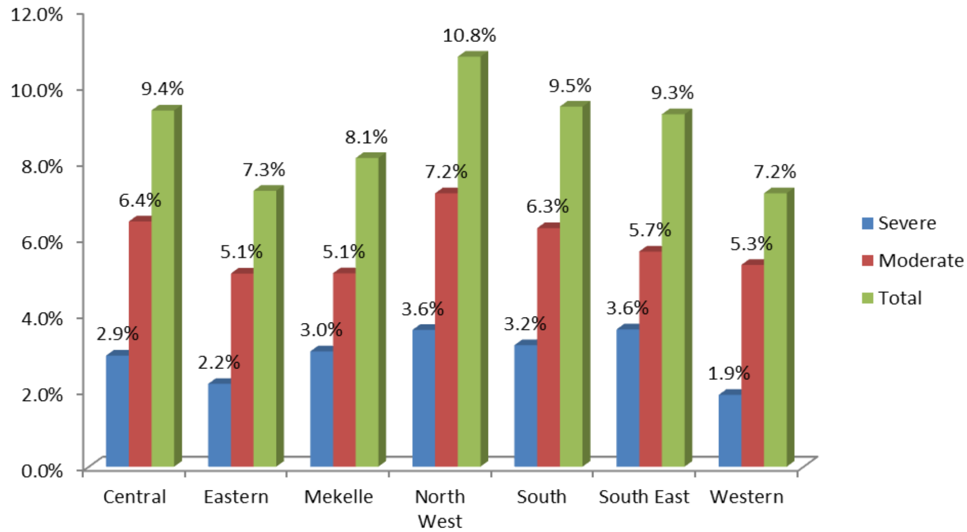

Figure 3: Distribution of acute undernutrition among 6- 59 months old children by zone of Tigray, Ethiopia, 2019 (n = 10,935).

3.5. Geospatial distribution of child acute undernutrition

High burden of acute undernutrition is concentrated mainly in the central, northwestern, south and southeast zones of Tigray region [Figure 4].

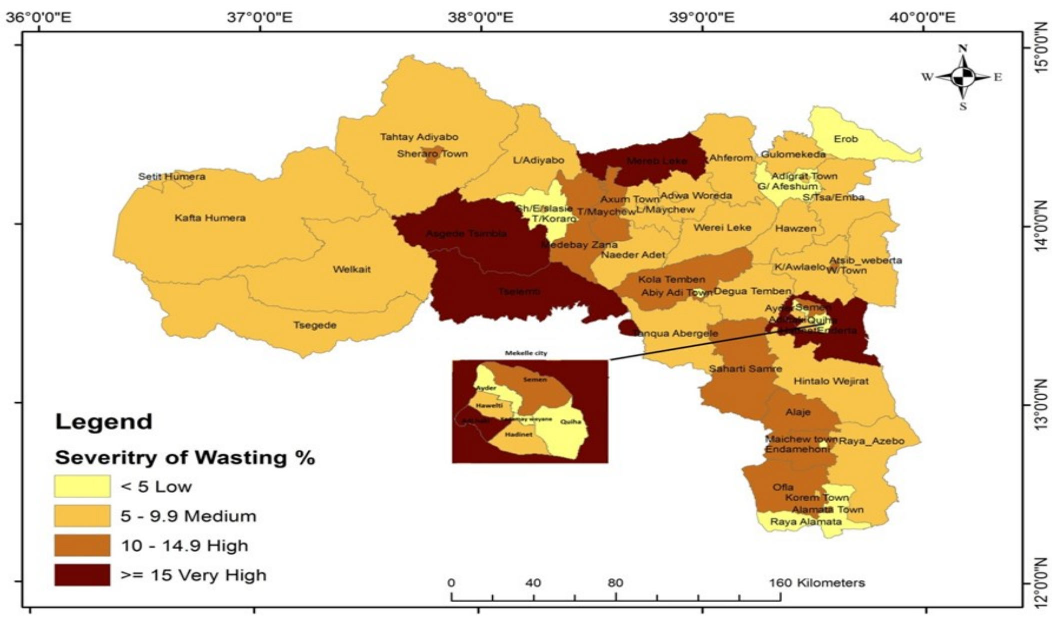

Figure 4: Geospatial distribution of level severity of acute undernutrition among children aged 6-59 months by Woredas.

3.6. Determinants of acute undernutrition among under-five children

The multivariable ordinal logistic model (POM) was fitted based on the chi-square and gamma test result of bivariate analysis [Table 5]. Based on results displayed in Table 5 those independent variables that are associated with outcome at 5% level significance were selected for multivariable ordinal regression analysis. One of the assumptions underlying ordinal logistic regression is that the relationship between each pair of outcome groups is the same. This can be checked using the test of parallel lines in which the null hypothesis states that the slope coefficients in the model are the same across response categories [23]. The test results shown in Table 6 revealed that all the variables were found insignificant (Chi-square = 8.42, *p*-value = 0.393). Therefore, there is no enough evidence to reject the null hypothesis for the ordinary regression model. Thus, the proportional odds assumption appears to have held for the model.

Table 5. Assessing the association between selected covariates and nutrition status of under-five children (n=10,935).

Variables	N (%)	Weight-for-Height Z-score (Acute undernutrition)			γ *p*-value	X^2 *p*-value
		Severe (%)	Moderate (%)	Nourished (%)		
Residence						
Urban	2487(22.74%)	74(2.98%)	120(4.83%)	2293(92.20%)		
Rural	8448(77.26%)	246(2.91%)	537(6.36%)	7665(90.73%)		0.018
Child sex						
Male	5329(48.73%)	177(3.32%)	349(6.55%)	4803(90.13%)		
Female	5606(51.27%)	143(2.55%)	308(5.49%)	5155(91.96%)		0.003
Child Age (in months)						
6-11	1778(16.26%)	57(3.21%)	118(6.64%)	1603(90.16%)	0.024	
12-23	3499(32.00%)	103(2.94%)	231(6.60%)	3165(90.45%)		
24-35	2623(23.99%)	78(2.97%)	147(5.60%)	2398(91.42%)		
36-47	1885(17.24%)	48(2.55%)	97(5.15%)	1740(92.31%)		
48-59	1150(10.52%)	34(2.96%)	64(5.57%)	1052(91.48%)		
Mother’s age (in years)						
≤20 years	780(7.13%)	18(2.31%)	53(6.79%)	709(90.90%)	0.029	
21-30 years	6358(58.14%)	190(2.99%)	389(6.12%)	5779(90.89%)		
31-40 years	3232(29.56%)	99(3.06%)	190(5.88%)	2943(91.06%)		
>40 years	565(5.17%)	13(2.30%)	25(4.42%)	527(93.27%)		
Mother education						
No school	4132(37.79%)	140(3.40%)	277(6.70%)	3715(89.91%)		
Primary	3594(32.87%)	97(2.70%)	233(6.48%)	3264(90.82%)		
Secondary	2530(23.14%)	66(2.61%)	117(4.62%)	2347(92.77%)		0.001
College or above	679(6.21%)	17(2.50%)	30(4.44%)	632(93.08%)		
Father education						
No school	3484(33.79%)	116(3.33%)	223(6.40%)	3145(90.27%)		0.164
Primary	3220(31.23%)	89(2.76%)	199(6.18%)	2932(91.06%)		
Secondary	2385(23.13%)	64(2.68%)	136(5.70%)	2185(91.61%)		
College or above	1222(11.85%)	31(2.54%)	57(4.66%)	1134(92.80%)		
Food insecurity level of households						
Food secure	6413(58.65%)	182(2.84%)	365(5.69%)	5866(91.47%)		0.196
Mild food insecurity	1271(11.62%)	36(2.83%)	76(5.98%)	1159(91.19%)		
Moderate food insecurity	2529(23.13%)	77(3.04%)	157(6.21%)	2295(90.75%)		
Severe food insecurity	722(6.60%)	25(3.46%)	59(8.17%)	638(88.37%)		
Breastfeeding status						
Never breastfed	132(1.21%)	3(2.27%)	8(6.06%)	121(91.67%)		
Ever breastfed but not currently	5093(46.66%)	137(2.69%)	269(5.28%)	4687(92.03%)		0.019
Still breastfed	5691(52.13%)	180(3.16%)	379(6.66%)	5132(90.18%)		
Timing of child put to the breast after birth						
Within 1 hour	8741(83.30%)	241(2.76%)	503(5.75%)	7997(91.49%)		
After 1 hour	1752(16.70%)	71(4.05%)	122(6.96%)	1395(88.98%)		0.002
Had fever in the past 2 weeks						
No	9267(84.75%)	244(2.63%)	536(5.78%)	8487(91.58%)		
Yes	1681(15.25%)	76(4.56%)	121(7.25%)	1471(88.19%)		<0.001
Had diarrhea in the last 2 weeks						
No	9822(89.82%)	276(2.81%)	581(5.92%)	8965(91.27%)		
Yes	1113(10.18%)	44(3.95%)	76(6.83%)	993(89.22%)		0.042
Counsel on infant feeding						
No	919(8.40%)	19(2.07%)	72(7.83%)	828(90.10%)		
Yes	1016(91.60%)	301(3.01%)	585(5.84%)	9130(91.15%)		0.017
Had any signs of cough or pneumonia in the last 2 weeks?						
No	9422(86.16%)	254(2.70%)	549(5.83%)	8619(91.48%)		
Yes	1513(13.84%)	66(4.36%)	108(7.14%)	1339(88.50%)		<0.001

Table 5. Assessing the association between selected covariates and nutrition status of under-five children (n=10,935). *(Continued . . .)*

Variables	N (%)	Weight-for-Height Z-score (Acute undernutrition)			γ *p*-value	X^2 *p*-value
		Severe (%)	Moderate (%)	Nourished (%)		
Regular antenatal visits						
No	1190(10.88%)	43(3.61%)	91(7.65%)	1056(88.74%)		
Yes	9745(89.12%)	277(2.84%)	566(5.81%)	8902(91.35%)		0.012
Has received deworming tablets in the last six month						
No	6468(59.15%)	199(3.08%)	415(6.42%)	5854(90.51%)		0.046
Yes	4467(40.85%)	121(2.71%)	242(5.42%)	4104(91.87%)		
Ever heard nutrition information through mass media						
No	4799(43.89%)	137(2.85%)	340(7.08%)	4322(90.06%)		<0.001
Yes	6136(56.11%)	183(2.98%)	317(5.17%)	5636(91.07%)		
Last pregnancy planned						
No	2217(20.27%)	64(2.89%)	144(6.50%)	2009(90.62%)		
Yes	8718(79.73%)	256(2.94%)	513(5.88%)	7949(91.18%)		0.556
Zone						
South	1723(15.76%)	55(3.19%)	108(6.27%)	1560(90.54%)		
South Eastern	1026(9.38%)	37(3.61%)	58(5.65%)	931(90.74%)		
Central	2810(25.70%)	82(2.92%)	181(6.44%)	2547(90.64%)		0.027
West	849(7.76%)	16(1.88%)	45(5.30%)	788(92.82%)		
East	1931(17.66%)	42(2.18%)	98(5.08%)	1791(92.75%)		
North western	1671(15.28%)	60(3.59%)	120(7.18%)	1491(89.23%)		
Mekelle	925(8.46%)	28(3.03%)	47(5.08%)	850(91.89%)		

Table 6. Brant test of parallel regression assumption.

Variable	Chi-square	*P* > chi-square	df
All	8.42	0.393	8
Child Sex	0.28	0.595	1
Mother education level	0.56	0.453	3
Timing of child put to the breast after birth	0.87	0.351	1
Had signs of fever in the past 2 weeks	1.37	0.242	1
Had signs of cough in the last 2 weeks	1.08	0.299	1
Regular ANC visits	0.04	0.833	1

The results displayed in [Table 7] are the estimated effects of multivariable analysis. The results showed that child sex, mother's education, fever in the last two weeks, cough or pneumonia in the last two weeks, timing of child put to the breast after birth and regular ANC visits were found to be significant predictors of child acute undernutrition. The result of ordinal logistic regression analysis describes that the estimated odds ratio for male children were 1.28 times more likely to be severely acute undernutrition as compared to female children holding all other variables constant (AOR=1.28, 95% CI: 1.12-1.46). The study also revealed that children whose mothers with secondary education are less likely to be severely wasted than children whose mothers with no education (AOR=0.70, 95% CI: 0.58-0.85). Children whose mothers having college or above education were 0.33 times less likely to be severely acute undernutrition than children whose mothers had no education (AOR=0.67, 95% CI: 0.49-0.92). Children those who put to the breast an hour later after birth were 1.30 more likely to be severely acute undernutrition as compared to those who put to the breast within one hour after birth (AOR=1.30, 95% CI: 1.10-1.54). Moreover, children who experienced fever and cough/pneumonia within the last two weeks of the survey had 1.37 and 1.22 times higher risk of being acute undernutrition respectively when the comparison is made with the children having no such problems. Children whose mothers had visited antenatal clinics during pregnancy (AOR=0.76, 95% CI: 0.62–0.93) were less likely to be undernutrition.

Table 7. Multivariate POM of factors associated with acute undernutrition in children under five in Tigray region, Ethiopia, 2019 (n = 10,935).

Variables	Estimate	Std. Err	AOR (95%CI)	*P*-value
Intercept (α_1)	2.19	0.125	-	
Intercept (α_2)	3.365	0.124	-	
Child sex				
Female (ref)				
Male	0.244	0.069	1.28(1.12-1.46)	<0.001
Mother education				
No school (ref)				
Primary	-0.123	0.080	0.88(0.76-1.03)	0.122
Secondary	-0.353	0.094	0.70(0.58-0.85)	<0.001
College or above	-0.399	0.162	0.67(0.49-0.92)	0.014
Timing of child put to the breast after birth				
Within 1 hour (ref)				
After 1 hour	0.264	0.086	1.30(1.10-1.54)	0.002
Had fever in the past 2 weeks				
No (ref)				
Yes	0.317	0.093	1.37(1.14-1.65)	0.001
Had any signs of cough or pneumonia in the past 2 weeks				
No (ref)				
Yes	0.199	0.098	1.22(1.01-1.48)	0.043
Regular ANC visits				
No (ref)				
Yes	-0.278	0.104	0.76(0.62-0.93)	0.007

Std. Err: Standard error, AOR: Adjusted odds ratio, CI: Confidence interval.

4. Discussion

This study presents the spatial distribution and risk factors associated with child acute undernutrition among children aged 6-59 months in all urban and rural areas of Tigray region, Northern Ethiopia. Our study showed that 8.9% of the sampled children were acute undernutrition, of these 2.9% were severe acute undernutrition and 6.0% were moderate acute undernutrition. This is consistent with the results reported in the recent 2019 mini EDHS [8]. But the current magnitude was lower than the prevalence reported from Bule Hora district south Ethiopia (13.4%) and Afar (16.2%) [24,25]. The discrepancy in findings could be due the difference in settings. The trend of child acute undernutrition among children from Tigray region has remained high in the last 20 years, 11.1% in 2000 and 9.2% in 2019 [7, 8]. This suggested that child undernutrition was widespread public health problem in Tigray region. In this study when the data is further disaggregated, the prevalence of acute undernutrition in the urban towns of Tigray region was found to be 7.8%. With a range of 2.6% in Kedamay Weyane, Mekelle to 18.8% Adi-Haqi, Mekelle. The burden of acute undernutrition in the rural areas was found to be 9.3%. The lowest and highest burden of acute undernutrition was being in Ganta Afeshum (3.1%) and in Merb Lekhe (17.7%) respectively.

In the present study, the POM is found appropriate model for analyzing the considered data because the *p*-value of chi-squared score test for the overall model is insignificant at 5% level of significance indicating that proportional odds assumption is not violated [23].

The results of multivariable analysis show that child sex, mother' s educational, timing of child put to breast after birth, fever, cough/pneumonia, and regular ANC visits were found to be significant risk factors of child acute undernutrition. The odds of staying in a worse state (severely acute undernourished and moderately acute undernourished) were higher for male children compared to female children. This is because male children are more vulnerable to develop undernutrition as they require more calories for growth and development [26]. There are differences in body weight and composition from the first few months of life and hence the energy requirements of females and males are different with higher requirements for male over female children.

Our study also showed that children whose mothers were educated were less likely to be undernourished, which is in agreement with previous studies [20,27,28,29]. Higher educated mothers were less likely to staying in a worse state (severely acute undernourished and mild acute undernourished), compared to the children of mothers with no formal education. This is because educated mothers are well informed about the nutritional and health needs of their children. Children experienced with fever or cough/pneumonia within the last two weeks of the survey were more likely to staying in a poor nutritional state (severely acute undernourished and moderately acute undernourished) than children who had not fever or cough in the last two weeks of the survey. The findings from this study was in line with previous studies, which showed that children who had fever significantly associated with undernutrition [30,31,32]. Moreover, this study showed that children those who put to the breast an hour later after birth were more likely to be in worse state (severely undernourished and moderate undernourished) as compared to those who put to the breast within one hour after birth. This finding is supported by a study done in Sheka, Ethiopia, showing under–five children who put to the breast immediately after birth were less likely to be severely malnourished as compared to those who put to the breast an hour later after birth [30]. Finally, the POM indicated that mothers receiving antenatal care service during pregnancy had lower odds of staying in the worst state of child nutritional status, compared to the mothers not receiving the service, which is consistent with previous study [33].

4.1. Strengths and Limitations

This research study was conducted at the community level with relatively a large sample size using a design effect to increase the power of the study and the probability of generalizability to the entire population from which the sample was drawn. As the study was based on a cross-sectional design, causal inference might not be strong between the outcome and independent variables. Moreover, there might be the possibility of recall and reporting bias in some child feeding indicators such as timing of child put to breast after birth, timing of complementary food starts and breastfeeding patterns. Some important variables are missing which are directly related to undernutrition such as living conditions, safe water supply for drinking and vaccination records.

4.2. Conclusions

This study showed prevalence rates of acute undernutrition among children aged 6-59 months in Tigray region was high and concentrated mainly in the central, northwestern, south, and southeast zones of the region. Child sex, mother's education, fever, cough/pneumonia, timing of child put to the breast after birth and regular ANC visits were significantly associated with child acute undernutrition. To reduce the burden of child acute undernutrition among 6 –59 months old children in the region, improving maternal education, child's feeding practices, and prevention of common childhood illnesses are recommended.

Declarations

Ethical considerations

This study was reviewed and approved by Institutional Review Board of College of Health Sciences, Mekelle University with approval number IRB1365/2019. All participants (or legal guardians) provided verbal consent to participate in the study. Confidentiality of individual client information was recorded anonymously and confidentiality was assured throughout the study period.

Abbreviations and Acronyms

CRM:- Continuous Ratio Model; CSA:- Central Statistics Agency; EDHS:- Ethiopia Demographic Health Survey; HFIAS:- Household Food Insecurity Access Scale; POM:- Proportional Odds Model; PPOM-R:- Partial Proportional Odds Model with Restrictions; PPOM-UR:- Partial Proportional Odds Model-without Restrictions; PSP:- Proportion to the Size of Population; SD:- Standard Deviation; SM:- Stereotype Model; WHO:- World Health Organization; WHZ:- Weight-for-Height;.

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Availability of data

The dataset that are generated and analyzed for this study can be obtained from the corresponding author upon request.

Conflict of interest

The authors declare no conflict interests.

Authors' contributions

HT had a major contribution in preparing the manuscript, designing, cleaning and analysis of the data. AM, GR and MA had contribution in reviewing the manuscript and designing. All authors read and approved the final manuscript.

References

1. Agho, K.E., Akombi, B.J., Ferdous, A.J., Mbugua, I., Kamara, J.K. Childhood undernutrition in three disadvantaged East African Districts: a multinomial analysis. BMC Pediatr.2019; 19(1):118. https://doi.org/10.1186/s12887-019-1482-y
2. Ryckman T, Robinson M, Pedersen C. Impact of Feed the Future initiative on nutrition in children aged less than 5 years in sub-Saharan Africa: difference-in-differences analysis. BMJ 2019;367:l6540 http://dx.doi.org/10.1136/bmj.l6540GBD Compare. 2019. IHME Viz Hub. https://vizhub.healthdata.org/gbdcompare
3. GBD Compare. 2019. IHME Viz Hub. https:// vizhub.healthdata.org/gbdcompare
4. WHO. Levels and trends in child malnutrition: UNICEF/WHO/World Bank Group Joint child malnutrition estimates: Key findings of 2023 edition. https://www.who.int/publications/i/item/9789240073791 (accessed 15 November 2023). WHO
5. Jelle M, Grijalva-Eternod CS, Haghparast-Bidgoli H, et al.,. The REFANI-S study a non-randomised cluster controlled trial to assess the role of an unconditional cash transfer, a non-food item kit, and free piped water in reducing the risk of acute malnutrition among children aged 6–59 months living in camps for internally displaced persons in the Afgooye corridor,Somalia. BMC public health. 2017; 17(1):632
6. UNICEF. Levels and trends in child malnutrition: UNICEF/WHO/ World Bank Group Joint Child Malnutrition Estimates, Key findings of the 2018 edition. https://reliefweb.int/report/world/levels- and-trends-child-malnutrition-unicefwhoworld-bank-group-joint- child-malnutrition (accessed 10 June 2020).WHO., 2023:
7. Central Statistics Agency, 2000. Ethiopian Demographic and Health Survey 2000. Addis Ababa, Ethiopia.
8. EDHS., 2019. Ethiopia Mini Demographic and Health Survey 2019: Key Indicators. Rockville, Maryland, USA: EPHI and ICF.Ethiopian Public Health Institute (EPHI) Ethiopia] and ICF.
9. Ewune, H.A., Abebe, R.K., Sisay, D. et al. 2022. Prevalence of wasting and associated factors among children aged 2–5 years, southern Ethiopia: a community-based cross-sectional study. BMC Nutr 8, 160. https://doi.org/10.1186/s40795-022-00657-x
10. Toma, T.M. Andargie, K.T. Alula, R.A. Factors assoacited with wasting and stunting among children aged 06-59 months in South Ari distrct, southern Ethiopia. a community based cross sectional study. BMC Nutr.2023; 9(34). https:// doi.org/10.1186/s40795 023-00683-3
11. Yeshaneh A, Mulu T, Gasheneit A, Adane D. Prevalence of wasting and associated factors among children aged 6-59 months in Wolkite town of the Gurahe zone, Southern Ethiopia, 2020. A cross-sectional study. Plos ONE. 2022;17(1): e0259722.https://doi.org/10.1371/jurnal.pone.0259722
12. Central Statistical Agency. Population Projections for Ethiopia 2007-2037, Addis Ababa, Ethiopia. 2013
13. Central Statistical Agency (CSA), ICF. Ethiopia Demo- graphic and 380 Health Survey 2016: Key Indicators Report.2016. Addis Ababa, Ethiopia, and Rockville, 381 Maryland, USA. CSA and ICF.
14. WHO. WHO bulletin. 1994
15. de Onis M, Borghi E, Arimond M, et al. Prevalence thresholds for wasting, overweight and stunting in children under 5 years. Public Health Nutr. 2019; Jan;22(1):175-179.
16. Das S, Gulshan J. Different forms of malnutrition among under five children in Bangladesh: a cross sectional study on prevalence and determinants. BMC Nutrition. 2017; 3(1):1.
17. Tiwari R, Ausman LM, Agho KE. Determinants of stunting and severe stunting among under-fives: evidence from the 2011 Nepal demographic and health survey. BMC Pediatr. 2014;14(1):239.
18. Akombi BJ, Agho KE, Merom D, Hall JJ, Renzaho AM. Multilevel analysis of factors associated with wasting and underweight among children underfive years in Nigeria. Nutrients. 2017; 9(1):44.
19. Ersino G, Henry CJ, Zello GA. Suboptimal feeding prac- tices and high levels of undernutrition among infants and young children in the rural communities of Halaba and Zeway, Ethio- pia. Food Nutr Bull.206; 37(3): 409–424.
20. Chowdhury, M.R., Rahman, M.S., Khan, M.M., Mondal, M.N., Rahman, M.M., Billah, B. Risk factors for child malnutri- tion in Bangladesh: a multilevel analysis of a nationwide popu- lation-based survey. J Pediatr.2016;172:194–201.
21. Coates, Jennifer, Anne, S., Paula, B. Household Food Insecurity Access Scale (HFIAS) for Measurement of House- hold Food Access: Indicator Guide (v. 3). Washington, D.C.: Food and Nutrition Technical Assistance Project, Academy for Educational Development. 2007
22. Ananth, C.V., Kleinbaum, D.G. Regression models for ordinal responses: A review of methods and applications. Int J Epidemiol.1997; 26:1323-1333.
23. Peterson, B., Harrell, F.E. Partial proportional odds models for ordinal response variables. Appl Stat.1990; 39:205-217.
24. Mandefro Asfaw, M., Wondaferash, W., Taha, M., Dube, L. Prevalence of undernutrition and associated factors among children between six to fifty-nine months in Bule Hora,South Ethiopia. BMC Public Health.2015; 15:41.

25. Gebre, A., Reddy, S., Mulugeta, A., Sedik, Y., Kahssay, M. Prevalence of Malnutrition and Associated Factors among Under-Five Children in Pastoral Communities of Afar Regional State, Northeast Ethiopia: A Community-Based Cross-Sectional Study. Journal of Nutrition and Metabolism. Article ID 9187609, 13 pages. 2019. https://doi.org/10.1155/2019/9187609.

26. Kavosi, E., Rostami, Z.H., Kavosi, Z., Nasihatkon, A., Moghadami, M., Heidari, M. Prevalence and determi- nants of under-nutrition among children under six: a cross- sectional survey in Fars province, Iran. Int J health Policy Manag.2014;3(2):71

27. Khan, S., Zaheer, S., Safdar, N.F. Determinants of stunting, underweight and wasting among children < 5 years of age: evi- dence from 2012-2013 Pakistan demographic and health survey. BMC Public Health. 2019; 19:358. https:// doi.org/10.1186/s12889-019-6688-2

28. Mishra, K., Kumar, P., Basu, S., Rai, K., Aneja, S. Risk factors for severe acute malnutrition in children below 5 y of age in India: a case-control study. Indian J Pediatr. 2014; 81(8):762–765

29. Chisti, M.J., Hossain, M.I., Malek, M.A., Faruque, A.S., Ahmed, T., Salam, M.A. Characteristics of severely malnour- ished under-five children hospitalized with diarrhoea, and their policy implications. Acta Paediatr. 2007;96(5):693–696.

30. Messelu, Y., Trueha, K. Determining Risk Factors of Malnutri- tion among under –Five Children in Sheka Zone, South West Ethiopia Using Ordinal Logistic Regression Analysis. Public Health Research.2016; 6(6): 161-167 DOI: 10.5923/ j.phr.20160606.03.

31. Peninah, K., Masibo.Trends and Determinants of Mal- nutrition among Children Age 0-59 Months in Kenya (KDHS 1993, 1998, 2003, and 2008-09). 2013

32. Das, S., Rahman, R.M. Application of ordinal logistic regres- sion analysis in determining risk factors of child malnutrition in Bangladesh. Nutrition Journal.2014;10:124. http:// www.nutritionj.com/content/10/1/124

33. Talukder, A. Factors Associated with Malnutrition among Under-Five Children: Illustration using Bangladesh Demo- graphic and Health Survey, 2014 Data. Children.204; 4(88). doi:10.3390/children4100088.