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Research Article

Prevalence and Determinants of Stunting and Wasting On Children Under-Five Years in Ethiopia

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Abstract

Background

Children stunting and wasting are the commonest nutritional disorders among children, especially in developing countries. This study aimed to assess prevalence and determinants of stunting and wasting on children under-five years in Ethiopia.

Methods

A total of 3880 under-five children in the survey were considered in this study analysis. Multivariate multiple linear regression analyses were used to identify significant factors associated with stunting and wasting on under-five years children on this study. Factor analysis was done to reduce the data and components with Eigen value of stunting and wasting was considered for further investigation.

Results

The analysis of this study revealed that the significant factors affecting the children stunting and wasting was type of toilet facility, Sex of child, Preceding birth interval (in months), Region, Type of place of residence, Mother's educational level, Wealth index of mothers, father education level, mothers occupational status, Birth order number, Duration of breastfeeding, Child's age (in months, and Number of under-five children in the household are simultaneously significant factors on the under-five years children stunting and wasting.

Conclusion

This study shows that the prevalence of stunting and wasting is not decreasing as well as type of toilet facility, birth interval, and duration of breast feeding are preventable factors of stunting and wasting among under five years children in Ethiopia Good implementation of essential nutrition action that are exclusive breast feeding, complementary feeding , improve women's nutrition by increasing birth interval using modern family planning methods and proper utilization of latrine is recommended.

Keywords: Ethiopian Mini Demographic and Health Survey; Ethiopia Stunting; wasting

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Abbreviations

EDHS: Ethiopian Demographic and Health Survey

Introduction

In developing countries, child stunting and wasting is the leading public health problem and is a major cause of child morbidity and mortality. For stunting and wasting, under-five children are the most vulnerable. The nutrition of infants and young children is a major concern to any society [1]. According to World Health Organization (WHO), child stunting and wasting is considered by height for age and weight for height indexed respectively [2].

In sub Saharan Africa the prevalence of stunting is declining but is still over 30% [3]. Several African countries have updated their national nutrition policies, strategies and action plans [4] in order to address malnutrition. Ethiopia has known shows potential progress in dropping levels of malnutrition over two past decades. However, the baseline levels of malnutrition remain so high that the country still needs to continue substantial investment in nutrition. According to Ethiopian Demographic and Health Survey (EDHS), there is a substantial variation of under-five children nutrition in Ethiopia [5-6].

At the policy and program level, Ethiopia has many strategies and programs to reduce levels of stunting and wasting as part of its national development agenda. The Government of Ethiopia through the Ministry of Health also launched the health extension program in 2003 to achieve the country's progress in meeting the Millennium Development Goals (MDGs). The health extension workers are mainly to improve access to care in rural communities. They spend 15% of their time with infants and children under age 5 [7]. All of these listed efforts have brought positive impact in improving food and nutrition security [8].

In Ethiopia, child malnutrition is one of the most serious public health problems and the highest in the world [9] and has a significant impact on communities, in particular for women and children. Millions of children die of severe acute malnutrition each year and poor nutrition prevents many children and adults from ever reaching their full mental and physical capacity. Among the factors that cause child malnutrition in Ethiopia are insufficient availability of food, inadequate provision of a healthy environment, such as sanitation and hygiene, women's status concerning decision-making power, and factors related to political economy [10]. By the taking the problem into the consideration, child stunting and wasting problem is faced by complex interaction of a multitude of factors. Especially, social factors such as educational influence. That means, children born from uneducated women not suffer from stunting and wasting problems. The determinants of stunting and wasting include the place of residency, the number of under-five children in households, birth order, sources of improved drinking water, and toilet facility [11]. Most studies also found that sex of a child, child age, and household wealth index were found to be significant factors on under-five children stunting, wasting, and underweight [12]. Therefore, the main objectives of this study were to assess the prevalence and the determinants of stunting and wasting on children under-five in Ethiopia using the Ethiopian Mini Demographic and Health Survey [13].

Methodology

Data Source

The study used cross-sectional secondary data which is obtained from the Ethiopian Mini Demographic and Health Survey [13]. The survey was conducted from March 21, 2019, to June 28, 2019 [13].

Study population

Thus, the study populations for this study were all children under-five in Ethiopia. From total of 5,753 under five children, the researchers used 3880 under five children with complete anthropometric measurements for the final analysis by making the rearrangements in terms of height-for-age and weight for height of the children's [13].

Study variables

As demonstrated in the literature review, socio-economic, demographic, health and environmental characteristics are considered as the most important determinants of stunting and wasting among under-five children in Ethiopia.

Outcome variable

For this study, the outcome variable was the two anthropometric indicators mostly used for monitoring malnutrition in children under-five: stunting (height for-age) and wasting (weight-for height) [14].

$$Z = \frac{\text{Child measurement's} - \text{Reference median}}{\text{Reference SD}}$$

Where,

Child's measurement = height or weight of a given child at age X

Reference median = mean or 50th percentile of the reference population at age X

Reference SD = standard deviation of the reference population at age X

Independent variables

To analyze the child stunting and wasting among under-five, the study considers the following characteristics as independent variables

Variables	Code
Sex of child	0 = "Male", 1 = "Female"
Birth Order Number	0="First", 1="2-4", 2=">4"
Size of child at birth	0 = "Large",1 = "Medium", 2 = "Small",
Number of children under five in the household	0="1-2", 1="No", 2=">=3"
Mother's educational level	0="No education", 1="Primary", 2="Secondary", 3="Higher"
Preceding birth interval (in months)	0="<24", 1=">=24"
Mother's occupational status	0="No", 1="Yes"
Father's educational level	0 = "No education", 1 = "Primary", 2 = "Secondary", 3 = "Higher"
Duration of breast feeding	0 = "Ever breastfed, not currently breastfeeding", 1= "Never breastfed", 1 = "Still breastfeeding",
Place of residence	0="Urban", 1="Rural"
Region	0 = "Tigray", 1= "Afar", 2 = "Amhara", 3 = "Oromia", 4 = "Somali", 5 = "Benishangul", 6 = "SNNPR", 7 = "Gambela", 8 = "Harari", 9 = "Addis Adaba", 10 = "Dire Dawa"
Source of drinking water	0="Improved Water" 1="Un-Improved Water"
Type of toilet facility	0="Improved toilet/sanitation" 1="Un-Improved toilet/Sanitation"
Sex of household head	0 = "Male", 1 = "Female"
Type of Cooking fuel	0="Modern fuel" 1="Traditional fuel"
Wealth index of Mothers	0 = "Poorest", 1 = "Poorer", 2 = "Middle" , 3 = "Richer", 4= "Richest"
Current Marital Status	0="Never in union",1="Married/Living With Partner", 2="Separated"
Age of Mothers at first birth	0="11-18", 1="19-25", 2="26-32", 3="33-40"
Child Age (in months)	0="<6", 1="6-11", 2="12-23", 3="24-37", 4="38-47", 5="48-59"

Methods of data analysis

In this study both exploratory (descriptive) and inferential statistical data analysis methods were employed.

Exploratory data analysis

Descriptive statistics were used to observe a possible link between explanatory variables and child nutritional outcome variables. Univariate associations between potential covariates and the response variable were assessed using frequency tables and by fitting each predictor with each response univariately. Descriptive statistics was used like frequency table, percent between explanatory variables with stunting and wasting.

Statistical models and Methods

Multivariate Data analysis

Multivariate analysis is a set of techniques used for analysis of data sets that contain more than one variable, and the techniques are especially valuable when working with correlated variables is used to study more complex sets of data than what univariate analysis methods can handle [15]. Most multivariate analysis involves a dependent variable and multiple independent variables [16]. Multivariate response was recommended when there is a correlation between two response variables differs from zero [17].

Principal component analysis

Reducing the number of variables of a data set naturally comes at the expense of accuracy, but the trick in dimensionality reduction is to trade a little accuracy for simplicity. Because smaller data sets are easier to explore and visualize and make analyzing data much easier and faster for machine learning algorithms without extraneous variables to process. So to sum up, the idea of PCA is simple and reduce the number of variables of a data set, while preserving as much information as possible [18].

Mathematical expression of principal component analysis

From P original variables; $X_1, X_2, \ldots\ldots X_p$ produce P new variables $Y_1, Y_2, \ldots\ldots Y_p$.

$$Y1 = a11X1 + a12X2 + \cdots \ldots \ldots a1kXp = a'1X$$

$$Y2 = a21X1 + a22X2 +, \ldots \ldots \ldots + a2kxp = a'2x$$

$$\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

$$\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

$$Yp = ak1x1 + ak2x2 + \cdots \ldots \ldots \ldots + akkxp = a'pX$$

Such that

Y_k's are uncorrelated (orthogonal)

Y_1 explains as much as possible of original variance in dataset

Y_2 explains as much as possible of remaining variance

Proportions of total population variance

$$(\text{Proportions of total variance due to the first Kth component}) = \frac{\lambda_k}{\lambda_1 + \lambda_2 +, \ldots + \lambda_p}, k = 1,2,3, \ldots p$$

$$(\text{Proportion of total variance due to the the first k component}) = \frac{\lambda_1 + \lambda_2 + \cdots + \lambda_k}{\lambda_1 + \lambda_2 +, \ldots + \lambda_p}, k=2, 3, \ldots, p$$

Factor analysis

Factor analysis has been used in two data analytic contexts: in a confirmatory manner designed to confirm or negate the hypothesized structure, or to try to discover a structure, in which case the analysis is called exploratory. The results of factor analysis (with factor loadings greater than 0.4 in an absolute) are presented. The Principal Component Factor Analysis was done considering the socioeconomic, demographic, health and environmental variables. The component loadings represent the correlation between the components and original variables. In this study, we concentrate on loadings above 0.4 or below -0.4 (sometimes 0.5 as a cutoff) and components/factors are named based on the highest loadings [19]. Factor Analysis is closely related to Principal Component Analysis, and often confused with it. Rather than a mapping into lower dimensions, or, equivalently, a rotation, that is PCA, FA aims to fit an explicit model.

$$X = \mu + rf + \varepsilon$$

Or, equivalently

$$\Sigma = r^T + \Psi$$

Where X is the data matrix with covariance matrix **Σ**, ε is the 'error' containing, in FA jargon, the unique factors, f are the common factors, and **Γ** contains the factor loadings. Also, it is assumed that f and ε have mean zero and are uncorrelated.

Unlike the case with PCA, the scores of the first, say, two factors are different when fitting an FA model with two or three factors, a possible difficulty in the interpretation. Unfortunately, there is no analytical way to arrive at the factorial analysis solution, so that a number of different algorithms are in use today. The most important ones are the maximum-likelihood approach and principal factor analysis.

Determining the number of factors

Priori determination

Sometimes, because of prior knowledge, the researcher knows how many factors to expect and thus can specify the number of factors to be extracted beforehand [20].

Determination based on eigenvalues

In this approach, only factors with Eigen values greater than 1.0 are retained. An Eigen value represents the amount of variance associated with the factor. Hence, only factors with a variance greater than 1.0 are included. Factors with variance less than 1.0 are no better than a single variable, since, due to standardization, each variable has a variance of 1.0. If the number of variables is less than 20, this approach will result in a conservative number of factors [20].

Determination based on scree plot

A scree plot is a plot of the Eigenvalues against the number of factors in order of extraction.

Experimental evidence indicates that the point at which the scree begins denotes the true number of factors. Generally, the number of factors determined by a scree plot will be one or a few more than that determined by the Eigenvalue criterion [20].

Goodness of fit test of multivariate model

Manova tests

The following are the principal test statistic for the multivariate analysis of variance Wilk's determinant ratio;

$$\lambda = \frac{|E|}{|E + H|}$$

Roy's greatest root: Here the criterion is the largest eigenvalue of E'H

Pilla'i trace

V=trace [H(H+E)-]

Each test statistic can be converted into F-statistic that allows P-values to be calculated for details. When there are only two groups, all groups four test criteria above are equivalent and lead the same F value as Hotelling's

Canonical correlation analysis

Computationally a canonical correlation analysis was performed to exploring the relationships between multivariate sets of variables (vectors), all measured on the same individual and that determined the successive functions and canonical roots. Classification was then possible from the canonical functions. Individuals were classified in the groups in which they had the highest classification scores [21]. This analysis further provided a percentage of overall correct classification.

Exploratory factor analysis

Factor analysis could be described as orderly simplification of interrelated measures. Traditionally factor analysis has been used to explore the possible underlying structure of a set of interrelated variables without imposing any preconceived structure on the outcome [19]. By performing exploratory factor analysis (EFA), the number of constructs and the underlying factor structure are identified.

Multivariate model building process

The primary part (stages one to stages three) deals with the analysis objectives, analysis style concerns, and testing for assumptions. The second half deals with the problems referring to model estimation, interpretation and model validation.

Parametric estimation of multivariate multiple linear regression model

$$\mathcal{L}(\delta; Y_1, Y_{2,}, \ldots . Y_n) = \prod_{i=1}^{n} P\left(\bigcap Y_{ij} = r_{ij}\right) = \prod_{i=1}^{n} \left(\int f_{i,qi}(\breve{Y}_i, \delta)\, d^{qi}\breve{Y}_i\right)$$

Where Di = ∏_jϵJi (θ_(j,rij-1, θj,rij) is a Cartesian product, $f_{i,qi}$ is the qi-dimensional density corresponding to the distribution function $F_{i,qi}$ and $d^{qi}$is the q_i -dimensional differential.

In order to estimate the model parameters we use a composite likelihood approach, where the full likelihood is approximated by a pseudo-likelihood which will be constructed from lower dimensional marginal distributions, more specifically by "aggregating" the likelihoods corresponding to pairs and triplets of observations, respectively. In the presence of ignorable missing observations, the composite likelihood will be constructed from the available outcomes for each subject i. In contrast to [22-23] for the pairwise approach we include univariate probabilities if only one outcome is observed. Similarly, for the tripletwise approach univariate and bivariate probabilities are included if q_i is less than three.

For the sake of notation we introduce an n ×q binary index matrix Z, where each element z_{ij} takes a value of 1 if $j \in J_i$ and 0 otherwise. The pairwise log-likelihood is given by:

If, for the case of no missing observations, the errors follow a q-dimensional multivariate normal or multivariate logistic distribution, the lower dimensional marginal distributions $F_{i}, _{qi}$ are also normally or logistically distributed.

$$c\ell(\delta; Y_1, Y_{2,}, \ldots . Y_n) = \sum_{i=1}^{n}\left[\sum_{k=1}^{q-1}\sum_{l=k+1}^{q} 1_{\{Z_{ik}, Z_{il}\}} \log(P(Y_{ik} = rik, Y_{il=ril})\right]$$

$$+1_{\{qi=1\}}\sum_{k=1}^{q} 1_{\{Zik=1\}} \log(P(Y_{ik} = r_{ik}))$$

Similarly, the triplet wise log-likelihood is:

$$c\ell(\delta; Y_1, Y_{2,}, \ldots . Y_n) = \sum_{i=1}^{n}\sum_{k=1}^{q-2}\sum_{l=k\neq 1}^{q-1}\sum_{m=l+1}^{q} 1_{\{Z_{ik}, Z_{il}, Z_{im}}$$

$$= 1\}\log\left(p(Y_{ik} = r_{ik}, Y_{il} = r_{il}, Y_{im} = r_{im})\right)$$

$$+ 1\{qi = 2\}\sum_{k=1}^{q-1}\sum_{l=k+1}^{q} 1\{Z_{ik}, Z_{il} = 1\} \log\left(p(Y_{ik} = r_{ik}, Y_{il} = r_{il})\right) + 1\{qi$$

$$+ 1\}\sum_{k=1}^{q} 1\{Z_{ik} = 1\}\log\{p(Y_{ik} = r_{ik})$$

In the sequel we denote by $fi,_1$, $fi,_2$ and $fi,_3$ the uni-, bi- and trivariate densities corresponding to $F_{i},_1$, $F_{i},_2$ and $F_{i},_3$. Hence, the marginal probabilities can be expressed as:

$$p(Y_{ik} = r_{ik}, Y_{il} = r_{il}, Y_{im} = r_{im}) = \int_{\theta_{k,rik-1}}^{\theta_{k,rik}}\int_{\theta_{l,ril-1}}^{\theta_{l,ril}}\int_{\theta_{m,rim-1}}^{\theta_{m,rim}} f_{i,3}\left(\breve{Y}_{ik}, \breve{Y}_{il}, \breve{Y}_{ik}; \delta\right) d\breve{Y}_{ik}, d\breve{Y}_{il}, \widetilde{d\breve{Y}}_{ik}$$

$$p(Y_{ik} = r_{ik}, Y_{il} = r_{il}) = \int_{\theta_{k,rik-1}}^{\theta_{k,rik}}\int_{\theta_{l,ril-1}}^{\theta_{l,ril}} f_{i,2(\breve{Y}_{ik}, \breve{Y}_{il}; \delta)}\, d\breve{Y}_{ik}, d\breve{Y}_{il}$$

$$p(Y_{ik} = r_{ik}) = \int_{\theta_{k,rik-1}}^{\theta_{k,rik}} f_{i,1}\,(\widetilde{Y}_{ik;\delta}) d\breve{Y}_{ik}$$

Point maximum composite likelihood estimates $\boldsymbol{\delta}$c is obtained by direct maximization using general purpose optimizers. In order to quantify the uncertainty of the maximum composite likelihood estimates standard errors are computed, either analytically or by numerical differentiation techniques. Under certain regularity conditions, the maximum composite likelihood estimator is consistent as $n \to \infty$ and q fixed and asymptotically normal with asymptotic mean $\boldsymbol{\delta}$ and covariance matrix:

$$G(\delta)^{-} = H^{-1}(\delta)V(\delta)H^{-1}(\delta)$$

Where denotes the Godambe information matrix. H(is the Hessian (sensivity matrix) and v(is the variability matrix [22]. The sample estimate of H(and v(is given by;

$$\widehat{V(\hat{\delta})}\ \frac{1}{n}\sum_{i=1}^{n}\left(\frac{\partial c\ell i(\hat{\delta}_{cl}; Y_{i)}}{\partial \delta}\right)\left(\frac{\partial c\ell i(\hat{\delta}_{cl}; Y_{i)}}{\partial \delta}\right)^{T}$$

$$\hat{H}(\hat{\delta}) = \frac{1}{n}\sum_{i=1}^{n}\sum_{\substack{k<l \\ k,l\epsilon Ji}}\left(\frac{\partial c\ell i(\hat{\delta}_{cl}; Y_{ik,} Y_{ik,}}{\partial \delta}\right)$$

For all correlation matrices we use the spherical parameterization and transform the constrained parameter space into an unconstrained one. The spherical parameterization for covariance matrices has the advantage over other parameterizations in that it can easily be modified to apply to a correlation matrix.

Variables	Categories	Frequency	%
Place of residence	Urban	689	17.8
	Rural	3191	82.2
Mothers Educational level	No education	2457	63.3
	Primary	967	24.9
	Secondary	294	7.6
	Higher	162	4.2
Wealth index of mothers	Poorest	1400	36.1
	Poorer	650	16.8
	Middle	531	13.7
	Richer	520	13.4
	Richest	779	20.1
Age of Mothers at first birth	15-24	1903	49.0
	25-34	1759	45.3
	35-44	195	5.0
	45 and above	23	.6
Current marital status	Never in Union	7	.2
	Married/living with partner	3755	96.8
	Separated	118	3.0
Father educational level	No education	1881	48.5
	Primary	1217	31.4
	Secondary	409	10.5
	Higher	373	9.6
Region	Tigray	386	10.0
	Afar	366	9.4
	Amhara	415	10.7
	Oromia	470	12.1
	Somalia	597	15.4
	Benishangul-gumuz	310	8.0
	SNNPR	542	14.0
	Gambela	263	6.8
	Harari	155	4.0
	Addis Ababa	206	5.3
	Dire dawa	170	4.38
Mothers Occupational status	No	2794	72.0
	Yes	1086	28.0
Birth Order Number	1(First)	718	18.5
	2-4	1801	46.4
	>4	1361	35.1
Sex of child	Male	1953	50.3
	Female	1927	49.7

Preceding birth interval (months)	<24 months	1007	26.0
	>=24 months	2873	74.0
Duration breastfeeding	Ever breastfed	2025	52.2
	Never breastfed	149	3.8
	Still breastfeeding	1706	44.0
Size of child at birth	Very large	631	16.3
	larger than Average	560	14.4
	larger than Average	1654	42.6
	Smaller than average	389	10.0
	Very Small	646	16.6
Number of under-five children in the household	>2	23	.6
	2-4	3103	80.0
	>=4	754	19.4
Type of cooking fuel	Modern	3067	79.0
	Traditional	813	21.0
Type of toilet facility	Improved toilet	2887	74.4
	Un-improved toilet	993	25.6
Source of drinking water	Improved water	1866	48.1
	Un-improved water	2014	51.9
Sex of Household head	Male	3099	79.9
	Female	781	20.1
Child Age (in Months)	.<6	490	12.6
	6-11	437	11.3
	12-23	726	18.7
	24-37	937	24.1
	38-47	587	15.1
	48-59	703	18.1

Table 1: Results of Descriptive statistics and bivariate analysis.

Results

Descriptive statistics

The main purposes of the present descriptive analysis were to describe the analysis among the categorical explanatory variables on under-five children in Ethiopia through the percentage values. The data were entered into SPSS windows version 20 for the analysis.

Of the total 3880 under-five children included in the study, of them, 1953 (50.3%) were males whereas 1927 (49.7%) females. From the child residency 3191 (82.2%) were children live in rural whereas 689(17.8%) were children live in urban area. From the child mother 2457 (63.3%) were illiterate, 967 (24.9%) were primary levels, 294 (7.6%) were Secondary level and 162(4.2%) were higher education level. With regard to the marital status of the sample respondents, 7 (0.2%) respondents were never in union, 3755 (96.5%) respondent were Married/living with partner, and 118 (3.0%) respondents were separated. When we consider the variable wealth index, the poorest were 1400 (36.1%), poorer were 650 (16.8%), middle were 531 (13.7%), Richer were 520 (13.4%) and richest 779 (20.1%) (See Table 1).

Inferential Statistical Analysis

Correlation between the response variable (Stunting and wasting)

Table 2 shows that the relationship between the response categories. This indicates that there is the correlation between two response variables (Stunting and wasting) because the correlations between the responses are differ from zero. Since there is the correlation between the response categories, then the multivariate analysis are the best fit models for this given EMDHS data.

Correlations			
		Height/Age	Weight/Height
Height/Age	Pearson Correlation	1	-.009
Weight/Height	Pearson Correlation	-.009	1

Table 2: The correlation between the response categories under-five.

Multivariate component data analysis

Factorial analysis

From Table 3 we can just we reject the null hypothesis. On the other hand, the confidence ellipsoid for β can be easily contracted with the one at a time t value t (n – k – 1) at the given significance level. Thus, the data were checked for Bartlett's test of Sphericity to see that the correlation matrix is an identity matrix; the test shows that the factor model is appropriate since (p-value < 0.0001). Therefore, the hypothesis of our correlation matrix is an identity matrix, which would indicate that our variables are unrelated and therefore unsuitable for structure detection. These Small values of the significance level indicate that a factor analysis may be useful with our data.

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.723
Bartlett's Test of Sphericity	Approx. Chi-Square	11953.647
	Df	190
	Sig.	.000

Table 3: KMOs and Bartlett's Tests for Factor Analyses.

For principal components extraction, this initial eigenvalues are equal to 1.0 for correlation analyses. Extraction communalities are estimates of the variance in each variable accounted for by the components. The communalities in this table are all high or suggests the communalities above 0.4 is acceptable [24], which indicates that the extracted components represent the variables well because no any communalities are very low in a principal components extraction, thus the author may not need to extract another component (Tables 4 & 5).

Communalities		
	Initial	Extraction
Region	1.000	.399
Type of place of residence	1.000	.635
Mother's educational level	1.000	.664
Sex of household head	1.000	.637
Wealth index of mothers	1.000	.610
Age of mothers at 1st birth	1.000	.372
Current marital status	1.000	.627
fathers education level	1.000	.566
Mothers occupational status	1.000	.389
Birth order number	1.000	.616
Sex of child	1.000	.645
Preceding birth interval (in months)	1.000	.578
Duration of breastfeeding	1.000	.831
Size of child at birth	1.000	.495
type of cooking fuel	1.000	.599
type of toilet facility	1.000	.662
source of drinking water	1.000	.554
Child's age in months	1.000	.851
Number of under-five children in the household	1.000	.624
Extraction Method: Principal Component Analysis.		

Table 4: Communalities.

Principal Component Analysis

Total Variance Explained						
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.287	16.434	16.434	3.287	16.434	16.434
2	1.770	8.850	25.284	1.770	8.850	25.284
3	1.309	6.543	31.827	1.309	6.543	31.827
4	1.239	6.197	38.024	1.239	6.197	38.024
5	1.163	5.814	43.837	1.163	5.814	43.837
6	1.118	5.588	49.425	1.118	5.588	49.425
7	1.032	5.158	54.583	1.032	5.158	54.583
8	1.012	5.062	59.646	1.012	5.062	59.646
9	.992	4.962	64.608			
10	.913	4.566	69.174			
11	.885	4.423	73.597			
12	.831	4.156	77.753			
13	.787	3.937	81.689			
14	.729	3.646	85.335			
15	.711	3.554	88.889			
16	.667	3.336	92.225			
17	.576	2.881	95.106			
18	.366	1.828	96.934			
19	.335	1.675	98.609			
20	.278	1.391	100.000			
Extraction Method: Principal Component Analysis.						

Table 5: Total Variance Explained.

Depending on the correlation matrix and communalities, of all 3880 observed items, using principal component extraction and Varimax rotation, the study found that eight underlying common factors for factor analysis that constituted or explained 59.646% of the total variability in the corresponding original observed variables with only a 40.354% loss of information. This suggests that eight latent influences are associated with service usage, but there remains room for a lot of unexplained variation (Table 6).

In the above table, the values that we consider large are in boldface. The following statements are based on this criterion:

Factor 1 is correlated with Region (and Mother's educational level, Type of place of residence, Wealth index of mothers, Fathers education level, and Birth order number. The author can say that the first factor is primarily a measure of these variables.

Factor 2 is correlated with Duration of breastfeeding and Child's age (in months). The author can say that the second factor is primarily a measure of these variables.

pattern Matrix								
	Component							
	1	2	3	4	5	6	7	8
Region	**.510**	.098	-.077	.241	-.207	.106	.077	.186
Type of place of residence	**-.782**	-.094	.010	-.036	.015	-.072	-.045	-.164
Mother's educational level	**.803**	.018	-.096	.021	.083	-.047	-.005	-.042
Sex of household head	.103	.099	**.615**	.344	.342	.037	-.048	.054
Wealth index of mothers	**.744**	.045	-.026	-.109	-.160	.029	.110	.116
Age of mothers at 1st birth	.359	.038	-.136	.198	.318	.017	-.290	-.031
Current marital status	.023	.141	**.721**	.140	.166	.160	-.081	.109
Fathers education level	**.744**	.025	-.069	.064	.009	-.038	.028	.008
Mothers occupational status	.277	.164	.285	.038	-.242	.222	.293	-.135
Birth order number	**-.477**	-.014	.175	.099	**-.437**	.271	.298	.150
Sex of child	-.012	-.038	-.075	-.031	.264	-.214	**.702**	.399
Preceding birth interval (in months)	.182	-.200	.340	**-.574**	-.141	-.184	.080	-.010
Duration of breastfeeding	.120	**-.878**	.084	.012	.006	.196	-.022	.012
Size of child at birth	-.187	-.127	-.049	-.002	**.570**	-.228	.245	.041
type of cooking fuel	-.145	-.041	-.033	-.117	-.092	-.008	-.394	**.831**
type of toilet facility	.087	.054	-.161	-.297	.237	**.683**	.109	-.042
source of drinking water	-.133	.257	-.091	-.385	.327	**.467**	-.045	.086
Child's age (in months)	-.129	**.888**	-.012	-.129	-.055	-.165	.005	.006
Number of under-five children in the household	-.268	.048	-.306	**.615**	-.023	.245	.118	.081
Extraction Method: Principal Component Analysis.								
a. 8 components extracted.								

Table 6: Factor loadings (pattern matrix) and unique variances.

Factor 3 is correlated with Sex of household head and Current marital status. The author can say that the third factor is primarily a measure of these variables.

Factor 4 is correlated with Preceding birth interval (in months) and Number of under-five children in the household. The author can say that the fourth factor is primarily a measure of these variables.

Factor 5 is correlated with birth order number and Size of child at birth. The author can say that the fifth factor is primarily a measure of these variables.

Factor 6 is correlated with type of toilet facility and source of drinking water. The author can say that the sixth factor is primarily a measure of these variables.

Similarly **Factor 7** is correlated with sex of child. The author can say that the seventh factor is primarily a measure of these variables.

Factor 8 is correlated with type of cooking fuel. The author can say that the eighth factor is primarily a measure of these variables.

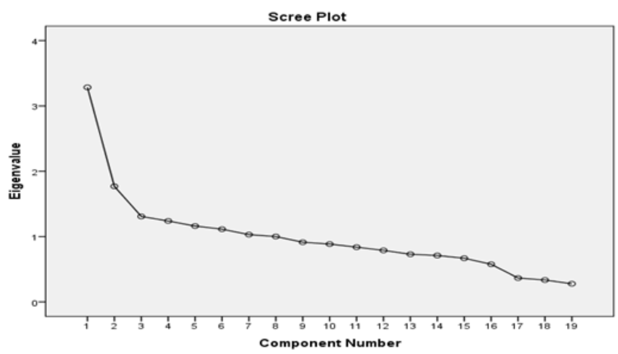

Figure 1: Scree plot of Eigen values after PCA.

The scree plot in Figure 1 reveals that the first eight components have Eigen values above 1, explaining at least as much of the variation as the original variables or visualizes the Eigenvalues we just saw. Again, we see that the first eight components have Eigenvalues over 1. We consider these "strong factors" and after that -component nine and onwards- the Eigenvalues drop off dramatically.

Results of multivariate multiple linear regression analysis

From the given covariates, the variables such as type of toilet facility, Sex of child, Preceding birth interval (in months), Region, Type of place of residence, Mother's educational level, Wealth index of mothers, fathers education level, mothers occupational status, Birth order number, Duration of breastfeeding, Child's age (in months), and Number of under-five children in the household are simultaneously significantly associated with stunting (Height/Age) and wasting (Weight/Height) (Table 7).

A one unit change in mother's educational level is associated with a -7.339, 1.103 unit change in the predicted value of Height/Age (stunting) and Weight/Height (wasting), respectively. A one unit change in wealth index of mother's is associated with a -2.059, 1.507 unit change in the predicted value of Height/Age (stunting) and Weight/Height (wasting), respectively. A one unit change in child's age (in months) is associated with a -.724, -1.643 unit change in the predicted value of Height/Age (stunting) and Weight/Height (wasting), respectively.

Dependent Variable	Parameter	B	Std. Error	T	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Z score for Height/Age (stunting)	Intercept	-194.84	33.168	-5.875	.000	-259.876	-129.820
	Region	-.697	.990	-.704	.041	-2.638	1.243
	Type of place of residence	11.561	9.259	1.249	.012	-6.591	29.714
	Mother's educational level	-7.339	4.439	-1.653	.008	-16.042	1.364
	Sex of household head	-4.763	6.526	-.730	.466	-17.558	8.031
	Wealth index of mothers	-2.059	2.186	-.942	.046	-6.346	2.227
	Age of mothers at 1st birth	-.191	4.233	-.045	.964	-8.489	8.107
	Current marital status	13.734	14.690	.935	.350	-15.067	42.535
	fathers education level	6.419	3.389	1.894	.038	-.226	13.063
	Mothers occupational status	7.408	5.751	1.288	.001	-3.868	18.683
	Birth order number	-1.334	3.934	-.339	.003	-9.047	6.379
	Sex of child	1.102	4.993	.221	.025	-8.686	10.891
	Preceding birth interval (in months)	2.409	5.930	.406	.015	-9.218	14.035
	Duration of breastfeeding	.896	3.632	.247	.005	-6.224	8.016
	Size of child at birth	2.265	2.038	1.111	.006	-1.731	6.260
	type of cooking fuel	9.323	6.167	1.512	.131	-2.769	21.414
	type of toilet facility	13.485	5.814	2.319	.020	2.085	24.884
	source of drinking water	-4.153	5.137	-.808	.419	-14.225	5.920
	Child's age (in months)	-.724	2.235	-.324	.026	-5.106	3.658
	Number of under five children in the household	5.524	6.567	.841	.002	-7.352	18.399
Z-score for Weight/Height (wasting)	Intercept	-40.061	24.907	-1.608	.108	-88.894	8.772
	Region	.464	.743	.624	.033	-.994	1.921
	Type of place of residence	-10.468	6.953	-1.506	.014	-24.100	3.164
	Mother's educational level	1.103	3.333	.331	.041	-5.432	7.639
	Sex of household head	.136	4.901	.028	.978	-9.472	9.744
	Wealth index of mothers	1.507	1.642	.918	.019	-1.712	4.726
	Age of mothers at 1st birth	.448	3.178	.141	.888	-5.784	6.680
	Current marital status	-1.596	11.031	-.145	.885	-23.224	20.032
	fathers education level	-1.680	2.545	-.660	.009	-6.670	3.309
	Mothers occupational status	-1.384	4.319	-.320	.044	-9.851	7.083
	Birth order number	3.274	2.954	1.108	.016	-2.518	9.066
	Sex of child	-.024	3.749	-.006	.002	-7.375	7.327
	Preceding birth interval (in months)	2.061	4.453	.463	.031	-6.670	10.792
	Duration of breastfeeding	-.258	2.727	-.094	.025	-5.604	5.089
	Size of child at birth	1.984	1.530	1.296	.195	-1.016	4.984
	type of cooking fuel	-.180	4.631	-.039	.969	-9.259	8.900
	type of toilet facility	-7.393	4.366	-1.693	.001	-15.953	1.168
	source of drinking water	6.560	3.858	1.700	.089	-1.004	14.124
	Child's age (in months)	-1.643	1.678	-.979	.028	-4.934	1.648
	Number of under five children in the household	-5.652	4.932	-1.146	.042	-15.321	4.018

Table 7: Parameter estimates of multivariate multiple liner regression.

Assessing multivariate multiple models goodness of ft

The F-value column reveals that the three models are good fit or each of the two univariate models are statistically significant because the significance value or P-value ≤ 0.001.

Canonical correlation

The first canonical correlation coefficient is 9.66% with an explained variance of the correlation 79.45% and an eigenvalue of 0.00942. The second canonical correlation coefficient is 4.93% with an explained variance of the correlation % and eigenvalue of 0.00244. This is the proportion of explained variance in the canonical variates attributed to a given canonical correlation. That means, the 9.66% variation of stunting was explained by the canonical covariates, 4.93% variation of wasting was explained by the canonical covariates. Thus indicating that our hypothesis is correct – generally the variable stunting (height for age), wasting (weight for height) are positively correlated (Tables 8 & 9).

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	Height/Age	639779.455a	19	33672.603	1.405	.113
	Weight/Height	259761.296b	19	13671.647	1.012	.443
Intercept	Height/Age	826986.244	1	826986.244	34.511	.000
	Weight/Height)	34957.869	1	34957.869	2.587	.108
Error	Height/Age	92496805.738	3860	23962.903		
	Weight/Height	52161818.736	3860	13513.425		
Total	Height/Age	185033661.000	3880			
	Weight/Height	63685388.000	3880			
Corrected Total	Height/Age	93136585.194	3879			
	Weight/Height	52421580.032	3879			

Table 8: Multivariate Analysis of Variance (MANOVA) for the fitted model.

Root No.	Eigenvalue	Pct.Cor	Cum. Pct. Sq.	Canon Cor.	Sq. Cor
1	.00942	79.45317	79.45317	.09662	.00933
2	.00244	20.54683	100.00000	.04930	.00243

Table 9: Eigenvalues and Canonical Correlations.

Discussion

Accordingly, this study has tried to look into factors associated with child stunting and wasting in the study area by incorporating as many risk factors as possible. The variables such as type of toilet facility, Sex of child, Preceding birth interval (in months), Region, Type of place of residence, Mother's educational level, Wealth index of mothers, father education level, mother occupational status, Birth order number, Duration of breastfeeding, Child's age (in months), and Number of under-five children in the household are significantly associated with stunting and wasting simultaneously.

Mother educational level is one of the most important determinants of stunting and wasting. Educated parents are more likely to employ better child-care practices as compared to uneducated parents. The study shows that higher level of mothers' educational attainment was positively associated with under-five children stunting and wasting. Similar findings shows that the studies in the Uganda [25], Mozambique [26], and Ghana [27], the reasons include that educated women are better informed about optimal child care practices [28], have better hygiene practices [29-30], feeding [31], and childcare during illness [31-33], have a greater ability to use the health system [34], and are more empowered to make decisions [29]. In our study, however, in about two-thirds of cases (65%), the mothers had not attended formal education. According to a study done in Bangladesh, children of mothers with secondary or higher education were at a lower risk of childhood stunting (risk ratio (RR): 0.86) and wasting (RR: 0.82) as compared to children of uneducated mothers [35]. Maternal education has been associated with the better nutritional condition during pregnancy and after birth. This has been shown to be an indirect predictor of better child's health throughout life [36]. A study done in Pakistan concluded that illiterate mothers are more likely to have poor knowledge about the nutritional requirement of their children, which results in unhealthy feeding practices. This is one of the most common reasons of child stunting and wasting among Pakistani children [37].

The findings of this study showed that preceding birth interval (in months) is a significant predictor of stunting and wasting. Children having birth interval less than 24 months had higher risk of being wasting as compared with children having greater than or equal to 48 month's birth interval. This study was in line with the study conducted in Bangladesh [38]. Similar study which was conducted in Ethiopia, Nigeria, India, and Bangladesh [39] confirms this author paper results. They argued that preceding birth interval is the other important variable which is associated with child stunting and wasting. In particular, there is an inverse relationship between the length of the preceding birth interval and the proportion of children who is malnourished. This finding is also consistent with the report of Ethiopian DHS 2011 [40] and 2016 [6]. For the newborns, the larger birth interval results into better care and more time allocation for the nutrition and wellbeing [41].

This study shoes age of child is the significant factor on child stunting and wasting. Previous studies in Ethiopia have shown similar results [42]. The reason might be that as children grow older they have greater energy needs. Especially, besides stunting reflects chronic malnutrition that can be manifested after long-term nutritional deficiency, while wasting reflects acute under nutrition. As child's age increase, there is the probability that the child will receive childhood vaccinations, which reduce exposure to disease.

The Birth Order number is the significant factor on the under-five children stunting and wasting in Ethiopia. This finding is supported by a similar result from previous study [43]. Overall, our results suggest that high percentage of malnutrition among low birth order children could be avoided with the improvement of birth spacing as better nutritional outcome seen among children with lower birth order and longer birth interval. Although, the finding suggest that the combination of lower birth order [2-3] and lesser birth interval (<24) that often adversely affects child's stunting and wasting.

The factor number of children in the household is also the major significant effect on under-five stunting and wasting in this study. Increasing number children, family size increases, child wasting and stunting increases, reason underlying is this with family increase resources become scare and less nutrition and care focused to children. These findings are consistent with studies of [44] and in contrast the studies of [45]. Additionally, On the other hand, the high number of under-five children in families was more likely to be associated with under-five stunting and wasting. Various literature studies indicated that larger under-five children in households were significantly positively associated with stunting and wasting [46] and this may be because the large household size is widely regarded as a risk factor for stunting and wasting particularly for infants and young children due to food insecurity.

Children of lowest wealth quintile were higher frequency of child stunting and wasting rather than higher wealth quintile family children due to underlying reason of less affordability of healthcare, quality nutrition and hygiene rather than rich families. These results are similar with the studies of [47]. Households with food shortage were higher prevalence of malnutrition in children rather than children adequate access of food. Adequate nutrition promotes health and resistance against diseases, while inadequate nutrition causes to increase severity of stunting and wasting. These findings are consistent with the study of [48].

The factor duration of breast feeding that encompassed ever breast feeding, still breast feeding, never breast feeding had a significant impact on child stunting and wasting. This may be due to the no longer time that a mother feed breast to her child at least for six months the more the child is health and gets balanced nutrients. Breastfeeding can enable eye-to-eye contact, physical closeness and emotional bonding, essential for optimal child growth and development [49]. Early initiation of breastfeeding serves as the starting point for the continuum of care for the mother and the new born that can have long-lasting effects on health and development. The findings in this study showed that more than half of the children were initiated to the breast within one hour of birth. The results do not differ much from those of general population in Kenya 58% [50]. This is because most of the children are delivered in the same hospitals as the general population thus subjected to the same health services. In low-resource settings where infection causes a large proportion of new-born deaths, exclusive breastfeeding can substantially reduce child mortality [49]. Prison set ups have been described as a low-resource setting with high cases of morbidity due to overcrowding and other aggravating factors. Mothers, who 66 deliver while in incarceration, need support to initiate breastfeeding within the first hour of birth. As a global public health recommendation, infants should be exclusively breastfed for the first six months of life to achieve optimal growth, development and health [51]. Based on a 24 hour recall most of the infants less than 6 months of age in this study had been exclusively breastfed. The current study indicated that the place of residence was associated with significant effects under-five stunting and wasting. This finding evens the finding(s) in earlier (previous) studies [51-52].

In this study, the multivariate analysis on stunting and wasting of under-five was considered and there is a dependency between two nutritional responses. The researcher assesses the association between the two nutritional responses and suggests that it is better to take the correlation between the two responses to understand the effects of covariates on those nutritional outcomes simultaneously. The finding is consistent with the findings of the previous studies conducted in Nigeria by [53]. The Multivariate analysis was employed to determine the effects of covariates on stunting and wasting. Based on this model, the significant dependencies between stunting and wasting were noticed given other children and household characteristics. Hence, a better understanding of the association between anthropometric indicators will help in developing focused interventions to improve child health and survival. The previous study also conducted in Ethiopia and India [54-55] reported the significant association between stunting and wasting.

Conclusion

This study shows that the prevalence of stunting and wasting is not decreasing as well as type of toilet facility, birth interval, and duration of breast feeding are preventable factors of stunting and wasting among under five years children in Ethiopia Good implementation of essential nutrition action that are exclusive breast feeding, complementary feeding , improve women's nutrition by increasing birth interval of 2 years and above by using modern family planning methods and in addition proper utilization of latrine is recommended.

Declarations

Ethics Approval and Consent to Participate

Not Applicable

Consent to publication

This manuscript has not been published elsewhere and is not under consideration in any other journal.

Availability of data and materials

The data used in this study can be obtained on the EDHS website.

Competing Interests

The authors declare that they have no conflict of interests.

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Author's Contribution

KAK conceived the study, and analyzed the data. KAK, TKW, BBB, DBG and RHB interpreted the results, drafted, finalized the manuscript to the present form. Both authors have read and approved the manuscript.

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