Determinants of coexistence of stunting, wasting, and underweight among children under five years in the Gambia; evidence from 2019/20 Gambian demographic health survey: Application of multivariate binary logistic regression model

Abebew Aklog Asmare (aklog28@gmail.com)
Mekdela Amba University
Yitateku Adugna Agmas
Mekdela Amba University

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Determinants of coexistence of stunting, wasting, and underweight among children under five years in the Gambia; evidence from 2019/20 Gambian demographic health survey: Application of multivariate binary logistic regression model

Abebew Aklog Asmare and Yitateku Adugna Agmas

AAA: Department of Statistics, Mekdela Amba University, P.O. Box: 32, Tuluawlyia, Ethiopia

YAA: Department of Rural Development and Agricultural Extension, Mekdela Amba University, P.O. Box: 32, Tuluawlyia, Ethiopia

Correspondence should be addressed to Abebew Aklog Asmare; aklog28@gmail.com

Abstract

Background: Malnutrition is a scarcity or inappropriate consumption of energy and nutrients. It comprises both undernutrition and overnutrition. The present study is aimed to evaluate the relationship between undernutrition indicators of stunting, underweight, and wasting among those under five years given other predictors.

Method: The data was obtained from the measure of DHS program. A total of 2,399 in 2019/20 under-five children were involved in this study. A multivariate binary logistic regression model is used to assess the association between stunting, wasting, and being underweight given the effect of other predictors.

Result: Of 2,399 children under-five years considered in this study 13.5, 18.7 and 5.9% of them suffered from stunting, underweight, and wasting respectively. The majority of children (40.1%) were obtained from the Brikama local government area of Gambia, more than half of the children (52.9%) were male, and 63.3% of children were live in urban areas. The association between stunting and underweight, underweight and wasting, and stunting and wasting was measured by odds ratio (OR) 15.87, 46.34, and 0.31 respectively given the other predictors. The estimated odds ratio for children who have an average birth size to become stunted, underweight, and wasted were 0.965, 0.885, and 0.989 times the estimated odds ratio of children who have a small birth size respectively.

Conclusion: The prevalence of stunting and wasting for under-five children in Gambia was lower than the world prevalence. Birth size of children was the important determinant of stunting, underweight, and wasting for children under-five years. Whereas, the birth type of children, anemia level of children, and age of children were significantly correlated with stunting and underweight. But body mass index of a mother is the only predictor significantly correlated with stunting.

Keywords: Gambia, Multivariate binary logistic regression, Under-five children, Undernutrition

Background

Malnutrition is a scarcity or inappropriate consumption of energy and nutrients. It comprises both undernutrition and overnutrition [1, 2]. Malnutrition consequences from the cooperation between poor nutrition and illnesses which leads to nutritional deficiencies observed among under-five children [3, 4]. Undernutrition is a group of disorders that includes stunting, wasting, and being underweight. It is the outcome of insufficient consumption of food, infection, inadequate access to food, inadequate care, and feeding practices, limited health services, an unhealthy environment, and poor financial, human physical, and social capital [5-9]. It also is one of the greatest reasons for illness and death among under-five-aged children in developing countries like Gambia [10]. Additionally, undernutrition remains most significant risk factor for the problem of disease [11, 12], causing long-term hurtful consequences, such as reduced cognitive development, growth deficiency, and reduced academic performance [13]. Kids are most vulnerable to undernutrition in developing countries because of low nutritional intake, lack of suitable care, and unbalanced distribution of food within the household [14]. Indication on undernutrition occurrence in children is a proximate indicator of the entire nutrition and nutrition security conditions in developing and middle-income countries [15].

Worthy nutrition sets children on the trail to survive and thrive. Well-nourished children grow, develop, learn, play, take part and contribute while undernourishment take from children of their full potential, with consequences for kids, nations, and so the world [16].

Stunting, wasting, and underweight are three commonly recognized indicators of a children nutritional status [17]. Stunting and wasting indicate chronic and acute malnutrition respectively, underweight may be a composite indicator and includes both acute (wasting) and chronic (stunting) undernourishment [17]. Though diverse classes of malnutrition may occur concurrently in children

[17]. Stunting has been defined as a baby who is just too short for his or her age (low height-for-age) [18]. Wasting has been also defined as a baby who is just too thin for his or her height (low weight-for-height) Similarly, under-weight refers to a baby who is simply too small for his/her age (low weight-for-age) which is that the weight for age < -2 standard deviation(SD) of the WHO Child Growth Standards median [18, 19].

The sources of malnutrition are complicated and contain illnesses, insufficient diet, ecological, and socioeconomic causes [5]. The age of the child in month [20-23], gender of child [24, 25], birth size of children [26, 27], birth order [4, 28], maternal education [28, 29], mother's body mass index [24, 29], household wealth index [4, 20, 30], source of drinking water [21, 30], family size [24], region [21], residence [24], religion [31], ethnicity [32], sex of household head [30], husband education level [4, 30], breastfeeding status [32, 33], sex of children [34, 35], diarrhea [32, 36], fever and cough [31, 32] in the last two weeks prior to the survey, birth type of children [21, 28], number of under-five children [27], maternal anemia [9] and children anemia [21] have been identified as some of the determinants of children's nutritional status in Gambia.

Worldwide, nearly half of all losses in under-five children are linked to undernutrition (United Nations Children's Fund [16], in 2020. In 2020, 22% of youngsters under the age of 5 years are stunted, 12.6% are underweight and 6.7% are wasted [16]. Stunting affected about 149.2 million under-five children in 2020. Of these 53% of stunted children lived in Asia and 30.7% lived in Africa [16]. In 2020, wasting contributed to threatening the exists of a predictable 45.4 million under-five children. Of these, more than two-thirds of all wasted children are found in Asia and more than one quarter was found in Africa [16]. Yet, a more detailed looking the distribution of undernutrition in the African region shows that Eastern Africa (32.6%) encompasses a greater incidence of stunting as compared to Western Africa (30.9%), Central Africa (36.8%), Northern Africa (21.4%) and Southern Africa (23.3%) [16]. While Western Africa (6.9%) incorporates a higher rate of wasting than the rest of African regions, Southern Africa (3.2%), Central Africa (6.2%, Northern Africa (6.6%), and Eastern Africa (5.2%) [16].

Gambia is one of the poorest Western Africa country in the world, place 165 in the Human Development Index of UNDP [22], lying along 400 kilo meters from the Atlantic Ocean to the east, following the shores of the River Gambia [11]. The newborn mortality rate accounts for 42 per every 1000 live births [37]. The incidence of children under-five years suffering from underweight, wasting and stunting were 12%, 5%, and 18% respectively [37].

Based on researchers' knowledge there is no study done on determinants for the coexistence of undernutrition indicators in Gambia. Worldwide, abundant studies were done on stunting, underweight and wasting at Pakistan, Cameron, Tanzania, East Africa, Gahanna, Mozambique, Nepal, Ethiopia, Uganda and Bangladesh [4, 10, 22, 27, 28, 33, 34, 37-39]. However, slight attention was given on their association and there is a scarcity of literature specially in Gambia. Though, stunting and wasting are commonly presented as two dissimilar kinds of undernutrition demanding different involvements for prevention and/or action, they are closely related and habitually happen together within the same persons, and commonly within identical children. Stunting and wasting are b related to increased death, mainly when both exist within the identical child [40]. A study done in India, Malawi and Ethiopia [41-43] considered the association between stunting, underweight, and wasting. However, the effect of other predictors that correlated with stunting, underweight, and wasting was not included while the relationship is measured. Thus, the aim of this study in Gambia is to judge the association between stunting, underweight, and wasting of under-five children, given other predictors. Two hypothesis were tested during this study. The first hypotheses states that there is no relationship between the three undernutrition indicators among children under-five years and the second hypothesis states that there is no relationship between predictors and undernutrition indicators. Therefore, it is more important for better understanding of the association between stunting, underweight, and wasting will help the concerned body in developing focused interventions to enhance child health and survival. As a consequence, the current study will benefit policymakers at governmental and personal level to make evidence on which interventions and policy actions are often formulated and implemented for under-five years' children.

Method

Data source and sampling method

We used 2019/20 Gambian Demographic and Health surveys (GDHS) data. These GDHSs are nationally representative cross-sectional surveys implemented in 8 local area governments every five years. In this survey, stratified two-stage sampling of clusters was carried out. Stratification was accomplished by separating each local area's government into urban and rural areas. So, a total of 14 sampling strata have been produced. In the 2019/20 GDHS, a total of 281 Enumeration Areas (EAs) were randomly selected proportional to the EA size. In second phase, on average 25 households per enumeration area were selected [37]. The data was retrieved from the Measure DHS website https://dhsprogram.com/Data/terms-of-use.cfm after approval was granted through an online request by stating the objective of this study. Variables in this study (both dependent and independent) were taken out from Kid Record (KR file) data set. Weighted total sample of 2,399 children under-five years was used for this study. The complete technique for sampling was described in the comprehensive GDHS report [37].

Inclusion/exclusion criteria

The inclusion criteria were children aged between less than five years and accomplished relevant forms about the personal information and clinical signs. Therefore, children who had not accomplished all related information or aged greater than or equal to five years were left out.

Study variables and measurements

Three response variables stunting, underweight, and wasting are so called undernutrition indicators were considered in current study. The three undernutrition indicators were measured through standardized score (z-score) for height-for-age (stunting), weight-for-height (wasting), and weight-for-age (underweight). Z-score for the i^{th} child (Z_i) is defined as $Z_i = \frac{AI_i - \mu}{\sigma}$, where $AI_i, \mu \text{ and } \sigma$ is stunting, underweight, and wasting of the i^{th} child, median and standard deviation respectively. After the Z_i for each child is calculated, the response variables were recoded into dichotomies response variables as: stunted ($0 = No\ if\ HAZ \geq -2\ and\ 1 = Yes\ if\ HAZ < -2$), wasted ($0 = No\ if\ WHZ \geq -2\ and\ 1 = Yes\ if\ WHZ < -2$), and underweight ($0 = No\ if\ WAZ \geq -2\ and\ 1 = Yes\ if\ WAZ < -2$) according to WHO 2006 child growth standards [44]. Besides the independent variables that are correlated with the three undernutrition indicators were considered for this study are presented in (Table 6). The parameters in Table 6 were collected using face-to-face interviews of mothers'/care givers.

Ethics approval and consent to participate

Hence, the permission to get access to the data was obtained from the measure DHS program online request from https://dhsprogram.com/Data/terms-of-use.cfm website and the data used were publicly available with no personal identifier.

Statistical analysis

Logistic regression model

Multivariate binary logistic regression is a statistical model used to estimate the effect of predictors for binary outcome variables. In present study, let Y_{1i}, Y_{2i} and Y_{3i} are the dichotomies outcome of stunting, underweight, and wasting of the i^{th} children under-five years, respectively. For dichotomies outcome Y_{ji} and a vector of independent variables X, multivariate binary logistic regression model is given by [46]:

$$\pi_{j(X)} = \frac{e^{\beta_{j0}+\beta_{j1}X_1+\beta_{j2}X_2+\cdots+\beta_{jp}X_p}}{1+e^{\beta_{j0}+\beta_{j1}X_1+\beta_{j2}X_2+\cdots+\beta_{jp}X_p}} = \frac{e^{X\beta_j}}{1+e^{X\beta_j}}, j = 1,2,3 \quad (1)$$

Where $\pi_{j(X)} = P(Y_{ji} = {}^{1}/_{X})$, the probability of the i^{th} under-five children being stunted (Y_{1i}), underweight (Y_{2i}), and wasting (Y_{3i}) given other predictors X. Consistently, the logit (log odds) that marked linear association with independent variables can be stated as:

$$logit\left[P\left(Y_{ji} = {}^{1}/_{X}\right)\right] = \beta_{j0} + \beta_{j1}X_1 + \beta_{j2}X_2 + \cdots + \beta_{jp}X_p = X\beta_j, j = 1,2,3 \quad (2)$$

Odds ratio is the best method that is used to measure the relationship between categorical variables in the logistic regression model. It is the proportion of odds defined as:

$$OR_j = \frac{{}^{\pi_j(X_1)}/_{1-\pi_j(X_1)}}{{}^{\pi_j(X_2)}/_{1-\pi_j(X_2)}} \quad (3)$$

To the best of researchers' knowledge, there's no research done on undernutrition indicators within the Gambia, so we will perform a separate analysis of stunting, underweight, and wasting of children under-five years as previously done by studies of [10, 21, 35, 39], using ordinal or binary logistic regression is enough. But, using binary or ordinal logistic regression ignore the association between stunting, underweight, and wasting. To do this, we consider the correlation between the undernutrition indicators and hence evaluate the special effects of other predictors. Therefore, multivariate logistic regression may be a more possible alternative. This statistical model serves to model two or more binary outcomes variables at a time and measure their relationship conditional to other predictors [47, 48]. It qualifies to model the marginal likelihoods as a function of explanatory variables. At a time, the model measures association among stunting, underweight, and wasting of under-five children. The data was firstly imported and managed using

SPSS version 26 software. Lastly, the analysis was executed by R software version 4.0.5 using VGAM package [49]. VGAM was habituated deliver functions designed for fitting vector generalized linear and additive models.

The goodness of fit test

Before fitting the model, an examination of the adequacy or goodness of fit of the model is mandatory. This might be perceived via the predictive power of the assessed model. In multivariate logistic regression model, predictive power is usually measured or detected using the concordance proportion. Concordance value estimates the likelihood that the predictions and the outcomes are concordant, which is whether the expected response matched with the observed response [46]. Accordingly, in this study, the concordance proportion was computed to check exactly how well the predicted model approximates the data well.

Result

Of a weighted total of 2,399 under-five children considered in this study 13.5%, 18.7%, and 5.9% of children agonized from stunting, underweight, and wasting respectively (Table *6*). The majority of children under-five years (40.1%) were obtained from the Brikama local government area of Gambia, while 63.3% households were accessed improved drinking water. 24.0% of the children were aged between 12 months and 23 months, more than half of the children (52.9%) were male, and 63.3% of children were lived in urban areas. Most of the households (62.9%) have 10 and more family members, and more than 50 % (55.5%) of the households have three and more under-five children. The highest proportion of children (19.0%) was from Fula/Tukulur/Lorobo Ethnicity, while the lowest (0.5%) was obtained from Manjago ethnicity. More than 23 % (23.7%) of households have poorest wealth index. Two weeks' prior the survey, 19.7, 17.6, and 15.6% of children had diarrhea, cough, fever respectively. Almost half (46.3%) of children under-five years were anemic.

The result in Table *1* and Table *2* showed that children were infected by more than one of the three children undernourishment indicators, therefore attention is required in understanding the total undernourished children. For example, 86 children had both wasting and underweight see the results in Table *1* and Table *2* for more detail.

Table 1. Simultaneous frequency distribution of stunting, underweight and wasting

				Underweight		Total
				No	Yes	
Wasting	No	**Stunting**	No	1,810	157	1,967
			Yes	119	171	290
	Yes	**Stunting**	No	22	86	108
			Yes	0	34	34
Total				1,952	448	2,399

Table 2.. Cross classification of undernutrition indicators and resultant frequency distribution

Undernourished indicators	**Frequency (%)**
Non- undernourished	1,810 (75.45)
Stunting only	119 (4.96)
Underweight only	157 (6.54)
Wasting only	22 (0.92)
Stunting and underweight	171 (7.13)
Stunting and wasting	0 (0.0)
Underweight and wasting	86 (3.58)
Stunting, underweight and wasting	34 (1.42)

The composite index of anthropometric failure (CIAF) was examined to quantity the whole occurrence of undernourishment for children [50]. Based on the classification of CIAF, children can be separated into No failure; Stunted only; Underweight only; Wasted only; Stunted and underweight; underweight and wasted and stunted, underweight and wasted. So, the groups of CIAF are presented in Table *2* and it demonstrates groups of the Composite Indicator of Anthropometric Failure along with its frequency calculated from Table *1*. According to the composite index of Failure, about 24.55% = [(4.6+6.54+0.92+7.13+3.58+1.42) %] of children were diagnosed with undernutrition while 75.45% were not diagnosed with undernutrition from the sampled children in The Gambia. Indicating that 24.55% of children were stunted, underweight, or wasted. This implies that the prevalence of total undernutrition in children is about 24.55% in the Gambia.

Table *3* represents all probable pairwise dependencies between three undernourishment indicators using odds ratio (OR). The odds ratio for the dependency between wasting and stunting; wasting and underweight; and underweight and stunting were 0.353 (95% CI = 0.22 – 0.55), 46.54

(95% CI = 28.98 – 77.85), and 16.74 (95% CI = 12.63 – 22.30) respectively. One is not included on the 95 % Confidence interval of the dependency, this indicates a dependency between undernutrition indicators, and hence fitting a multivariate binary logistic model for the three indicators is suitable to include their dependency and measured the effects of the predictors. So, a multivariate binary logistic regression analysis of stunting, underweight, and wasting given that of other predictors was indicated in Table *7*.

Table *4* showed bivariable analysis on the association between predictors and each undernutrition indicators. Mothers' anemia level, number of under-five children in the household, birth type of children, size of children, age of children, body mass index of mother, and wealth index were predictors independently associated with stunted, underweight, and wasted (p-value < 0.05).

Table 3. Pairwise dependency between undernutrition indicators using odds ratio (OR)

	Stunting	**Underweight**
	OR (95% CI))	OR (95% CI))
Wasting	0.353 (0.22, 0.55)	46.54 (28.98, 77.85)
Underweight	16.74 (12.63, 22.30))	

The predictors included in this study; birth type of children, anemia level of children, and age of children were common determinants that were significantly associated with stunting, underweight. The size of children at birth was significantly associated with stunting, underweight and wasting. Moreover, body mass index of the mother was predictor that were significantly associated with stunting only. The estimated odds of a child who has multiple births to be stunted, and underweight was 1.153, and 1.159 times the estimated odds of a child who has single birth, respectively. This indicates that a child who has single birth is less likely to be stunted, and underweight compared to a child who has multiple births. The estimated odds of the anemic child to be stunted, and underweight, were 1.022, and 1.033 times the estimated odds of a non-anemic child, respectively. This refers to the estimated odds of the anemic child to be stunted, and underweight was lower by 2.2%, and 3.3% of the estimated odds of a non-anemic child. On the other hand, an anemic child was more likely to be stunted, and underweight compared to a non-anemic child. The estimated odds of children whose age was 12 to 23 months to be stunted, and underweight was 1.041 and 1.071 times the estimated odds of children whose age was 0 to 11 months respectively. This indicates that children whose age was 12 to 23 months were more likely to be stunted and underweight as compared to children whose age is between 0 and 11 months. The risk of children being stunted, underweight, and wasted was higher for small birth size children as compared to normal birth size. This suggests that a child who has a small birth size is more likely to be stunted, underweight, and wasted than a child who has an average birth size. The estimated odds of children from normal and overweight mother to be stunted was 0.916 and 0.890 times the estimated odds of children from thin mother respectively. This indicates that children from normal and overweight mother were less likely stunted as compared children from thin mother (see Table *7*).

Concordant and dis-concordant proportion was computed based on multivariate binary logistic regression model estimation of undernutrition indicators. The result in Table *5* indicated that 81.6% of children with undernutrition indictors such as stunting, underweight, and wasted would have good chance in forecasting the level of stunting, underweight, and wasted. In this respect, the concordant proportion was very high. This indicates that the model capability in explaining the relationship between the indices were very decent and fit the data well.

Table 4. Bivariate Analysis of stunting, underweight, and wasting with the predictors

Predictors	Stunting		Underweight		Wasting	
	Chi-square	P-value	Chi-square	P-value	Chi-square	P-value
Region	43.089	<0.001	13.252	0.066	8.615	0.281
Residence	16.551	<0.001	2.873	0.090	1.026	0.311
Mother education level	7.392	0.025	0.319	0.852	2.065	0.356
Source of drinking water	0.448	0.503	0.378	0.539	2.095	0.088
Religion	1.448	0.229	4.709	0.030	1.149	0.284
Ethnicity	13.815	0.182	7.315	0.695	5.364	0.066
Number of household members	9.799	0.007	4.633	0.099	1.847	0.397
Sex of household head	2.222	0.136	0.061	0.806	0.001	0.999
Husband education level	11.576	0.003	8.577	0.014	2.583	0.275
Breastfeeding	0.725	0.395	0.010	0.921	0.556	0.456
Wealth index	38.104	<0.001	11.431	0.022	6.545	0.162
Body mass index of mother	20.604	<0.001	40.860	<0.001	12.497	0.002
Sex of children	1.050	0.305	0.076	0.782	3.988	0.046
Age of children	31.866	<0.001	30.670	<0.001	11.746	0.019
Diarrhea	8.225	0.004	7.467	0.006	1.445	0.229
Fever	0.433	0.511	4.028	0.045	2.534	0.111
Cough	0.255	0.614	0.046	0.830	0.117	0.732
Size of children at birth	31.878	<0.001	114.296	<0.001	41.716	<0.001
Birth type of children	35.401	<0.001	22.566	<0.001	0.674	0.412
Birth order of children	17.314	0.003	1.740	0.628	1.009	0.799
Number of under-five children in the household	11.943	0.003	10.336	0.006	2.577	0.276
Mother anemia level	4.600	0.032	9.354	0.002	5.556	0.018
Children anemia level	41.316	<0.001	27.283	<0.001	0.096	0.757

Table 5. Concordant and Dis-concordant proportion for model goodness of fit test.

	Dis-concordant	Concordant
Proportion	18.4	81.6

Discussion

The relationship among undernutrition indicators such as stunting, underweight, and wasting for under-five children given other predictors was concisely discussed and the effects of predictors were assessed in this study in Gambia using Gambian Demographic Health Survey (GDHS). The indicators were recoded into binary outcomes of stunting, underweight, and wasting. To determine the effect of predictors on wasting, underweight, and stunting multivariate binary logistic regression model was employed. In this model the pairwise dependency between undernutrition indicator were verified given other predictors. This study reported that underweight significantly associated with both stunting and wasting, and also revealed that underweight is a composite measure of stunting and wasting. Yet, in these studies, when the relationship between the three indicators was evaluated, the consequence of other predictors was not assuming into considered. This result is in line with the studies in Ethiopia, India, and Malawi [41, 43]respectively.

The occurrence of stunting and wasting for under-five children in current study were lower than the world cases of 22 and 6.7% respectively, but the prevalence of wasting is higher according to GDHS report [37]. This indicated that stunting and wasting prevalence are decreased in Gambia. This study is coincides with the study [51-53] in Ethiopia, Pakistan and Gahanna respectively.

In this finding anemia level of children, age of children and birth type of children were statistical significant determinants of both stunting and underweight. The current study is consistent the study in [51-53] Ethiopia, Pakistan and Gahanna respectively. Anemic children were more likely stunted and underweight as compared to non-anemic children. Children whose age is between 12 and 23 months were more likely stunted and underweight as compared to 0 to 11 months. Children who has multiple type of birth were more likely stunted and underweight as compared to single birth type.

In this study size of children at birth were important determinant of stunting, underweight, and wasting. The risk of children being stunted, underweight, and wasted was higher for small birth size children as compared to normal birth size. This finding is in line with the study in [20, 21] Ethiopia, in Gahanna [32]. Body mass index of mother were most important determinants of stunting only. Children from normal and overweight mother were less likely stunted as compared children from thin mother. This study coincides with the study [30] in Ethiopia, and [27]in Bangladesh.

Conclusion

In end, in this finding we found that birth type of children, anemia level of children, age of children were important predictors that correlates with both stunting and underweight. Birth size of children was most important determinant of stunting, wasting and underweight. Whereas body mass index of mother is the only determinant factors that correlate with stunting.

Abbreviations

DHS: Demographic health survey; EAs: Enumeration areas, GDHS: Gambian demographic and health survey, Ref.: Reference Category, HAZ: Height for age standardized score; WAZ: Weight for age standardized score; WHZ: Weight for height standardized score; OR: Odds ratio

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Authors' contributions

AA wrote the proposal, analyzed the data and manuscript writing. YA accredited the proposal with revisions, analysis the data and manuscript writing. Both YA and AA read and approved the very last manuscript.

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Availability of data and materials

The data used in this article were available http://dhsprogram.com.

Declaration

Ethics approval and consent to participate

This study was built on the analysis of openly accessible secondary data with all identifier information were removed. The Institutional Review Board (IRB) of ICF Macro at Fairfax, Virginia in the USA reviewed and approved the MEASURE DHS Project Phase three. The 2010–2018 DHS's are considered under that approval. The IRB of ICF Macro complied with the United States Department of Health and Human Services requirements for the "Protection of Human Subjects" (45 CFR 46). Most importantly, the informed consent statement emphasizes that participation is voluntary; that the respondent may refuse to answer any question, decline any biomarker test, or terminate participation at any time; and that the respondent's identity and information will be kept strictly confidential. In addition, written informed consent was obtained from a parent or guardian for participants under 16 years old. ICF Macro permitted the authors to use the data. The full details of the ethical approvals can be found at http://dhsprogram.com and the data can be founded on https://dhsprogram.com/Data/terms-of-use.cfm.

Consent for publication

Not applicable

Competing interests

The authors declare that they have no competing interests.

Author details

AAA: Department of Statistics, Mekdela Amba University, P.O. Box: 32, Tuluawlyia, Ethiopia.

YAA: Department of Rural Development and Agricultural Extension, Mekdela Amba University, P.O. Box: 32, Tuluawlyia, Ethiopia

Table 6. Variable description and frequency distribution, GDHS 2019/20

Variables	Categories (code)	Weighted frequency (%)
Region	Banjul(0)	26 (1.1)
	Kanifing(1)	386 (16.1)
	Brikama(2)	961 (40.1)
	Mansakanko(3)	121 (5.0)
	Kerewan(4)	277 (11.6)
	Kuntaur (5)	145 (6.0)
	Janjanbureh(6)	176 (7.3)
	Basse (7)	308 (12.8)
Type of place of residence	Urban (0)	1518 (63.3)
	Rural (1)	881 (36.7)
Highest educational level of mother	No education (0)	1139 (47.5)
	Primary education(1)	424 (17.7)
	Secondary and above(2)	836 (34.8)
Source of drinking water	Unimproved(0)	175 (7.3)
	Improved (1)	2225 (92.7)
Religion	Islam (0)	2375 (99.0)
	Christianity(1)	24 (1.0)
Number of household member (listed)	Small (1-4)	145 (6.0)
	Medium (5-9)	745 (31.1)
	Large (10 and more)	1509 (62.9)
sex of household head	Male(0)	2037 (84.9
	Female (1)	362 (15.1)
Ethnicity	Mandinka /Jahanka(0)	820 (34.2)
	Wollof (1)	326 (13.6)
	Jola/karoninka (2)	214 (8.9)
	Fula/Tukulur/Lorobo (3)	455 (19.0)
	Serere (4)	61 (2.5)
	Serahuleh (5)	201 (8.4)
	Creole/Aku Marabout (6)	4 (0.1)
	Manjago (7)	12 (0.5)
	Bambara (8)	25 (1.0)
	Other (9)	12 (0.5)
	Non-Gambian (10)	269 (11.2)
Age of respondent at1st birth	Less than 20	1266 (52.8)
	20 to 34	1133 (47.2)
	35 and more	1 (0.0)

Table 1. Variable description and frequency distribution, GDHS 2019/20 (continued)

Variables	Categories (code)	Weighted frequency (%)
Husbands educational level	No education (0)	1311 (54.6)
	Primary education (1)	517(21.6)
	Secondary and above (2)	571 (23.8)
Breastfeeding	No (0)	1069 (44.5)
	Yes (1)	1331 (55.5)
Wealth index of the household	Poorest (0)	569 (23.7)
	Poorer (1)	505 (21.0)
	Middle (2)	508 (21.2)
	Richer (3)	406 (16.9)
	Richest (4)	412 (17.2)
Body mass index	Thin (0)	206 (8.6)
	Normal (1)	1241 (51.7)
	Overweight (2)	952 (39.7)
Stunting	No (0)	2075 (86.5)
	Yes (1)	324 (13.5)
Underweight	No (0)	1950 (81.3)
	Yes (1)	449 (18.7)
Wasting	No (0)	2257 (94.1)
	Yes (1)	142 (5.9)
Sex of child	Male (0)	1269 (52.9)
	Female (1)	1130 (47.1)
Child age in month	0-11 months (0)	285 (11.9)
	12-23 months (1)	575 (24.0)
	24-35 months(2)	530 (22.1)
	36-47 months (3)	553 (23.1)
	48-59 months (4)	457 (19.0)
Diarrhea	No (0)	1927 (80.3)
	Yes (1)	472 (19.7)
Fever	No (0)	2025 (84.4)
	Yes (1)	374 (15.6)
Cough	No (0)	1976 (82.4)
	Yes (0)	423(17.6)

Table 1. Variable description and frequency distribution, GDHS 2019/20 (continued)

Variables	**Categories (code)**	**Weighted frequency (%)**
Size of child at birth	Small (0)	349 (14.6)
	Average(1)	1030 (42.9)
	Large (2)	1020 (42.5)
Child is twin	Single birth (0)	2297 (98.7)
	Multiple birth (1)	102 (4.3)
Birth order child	First (0)	367 (15.3)
	Two to three (1)	858 (35.8)
	Four to five (2)	603 (25.1)
	6 and more (3)	571 (23.8)
Number of under-five children in the household	Only one (0)	385 (16.1)
	2 children (1)	683 (28.5)
	3 and more (2)	1331 (55.5)
Mother anemia level	Not anemic (0)	1264 (52.7)
	Anemic (1)	1135 (47.3)
Child anemia level	Not anemic (0)	1289 (53.7)
	Anemic (1)	1111 (46.3)

Table 7. Parameter estimation of undernutrition indicators using Multivariate logistic regression

Predictors	**Stunting**		**Underweight**		**Wasting**	
	AOR (95% CI)	P-value	AOR (95%CI)	P-value	AOR (95%CI)	P-value
Intercept	2.888 (2.604, 3.203)	<0.001	0.150 (0.146, 0.155)	<0.001	3.376 (2.958, 3.852)	<0.001
Region						
Banjul	Ref.		Ref.		Ref.	
Kanifing	0.999 (0.945, 1.055)	0.966	1.012 (0.944, 1.085)	0.741	1.002 (0.981, 1.022)	0.882
Brikama	1.009 (0.957, 1.063)	0.745	1.000 (0.935, 1.069)	0.990	1.002 (0.982, 1.022)	0.843
Mansakanko	0.997 (0.939, 1.060)	0.932	0.995 (0.921, 1.075)	0.987	1.002 (0.979, 1.025)	0.867
Kerewan	1.006 (0.950, 1.066)	0.832	1.002 (0.931, 1.079)	0.959	1.005 (0.983, 1.027)	0.649
Kuntaur	1.022 (0.961, 1.086)	0.500	0.983 (0.909, 1.062)	0.659	1.000 (0.977, 1.023)	0.983
Janjanbureh	1.020 (0.961, 1.082)	0.522	1.008 (0.934, 1.087)	0.844	1.004 (0.982, 1.027)	0.711
Basse	1.039 (0.980, 1.102)	0.196	1.024 (0.951, 1.103)	0.527	1.002 (0.980, 1.024)	0.874
Residence						
Urban	Ref.		Ref.		Ref.	
Rural	0.987 (0.953, 1.022)	0.463	0.981 (0.939, 1.026)	0.404	1.000 (0.987, 1.013)	0.989
Mother education level						
No education	0.999 (0.971, 1.027)	0.918	1.009 (0.974, 1.045)	0.626	1.002 (0.992, 1.013)	0.706
Primary	1.008 (0.980, 1.037)	0.571	1.033 (0.997, 1.070)	0.074	1.001 (0.991, 1.012)	0.833
Secondary +	Ref.		Ref.		Ref.	
Source of drinking water						
Unimproved	1.006 (0.965, 1.049)	0.777	1.026 (0.973, 1.082)	0.351	1.004 (0.988, 1.019)	0.662
Improved	Ref.		Ref.		Ref.	
Religion						
Islam	Ref.		Ref.		Ref.	
Christianity	0.986 (0.854, 1.138)	0.849	0.929 (0.774, 1.116)	0.432	0.998 (0.945, 1.053)	0.933
Ethnicity						
Mandinka	Ref.		Ref.		Ref.	
Wollof	1.007 (0.974, 1.042)	0.667	1.012 (0.969, 1.056)	0.599	1.002 (0.989, 1.015)	0.798
Jola/Karoninka	1.041 (0.989, 1.096)	0.121	1.027 (0.962, 1.097)	0.417	1.001 (0.982, 1.021)	0.895
Fula/Tukulur	1.011 (0.982, 1.041)	0.445	1.022 (0.985, 1.061)	0.249	1.001 (0.990, 1.012)	0.917
Serere	1.005 (0.938, 1.077)	0.887	1.062 (0.972, 1.159)	0.183	1.000 (0.975, 1.027)	0.988
Serahuleh	0.981 (0.941, 1.022)	0.350	0.982 (0.931, 1.034)	0.487	0.998 (0.983, 1.014)	0.830
Creole/Aku	1.086 (0.877, 1.345)	0.448	1.095 (0.834, 1.437)	0.515	0.991 (0.915, 1.074)	0.833
Manjago	1.013 (0.825, 1.244)	0.903	1.023 (0.787, 1.328)	0.866	0.992 (0.919, 1.072)	0.846
Bambara	1.014 (0.920, 1.117)	0.756	1.026 (0.907, 1.161)	0.679	0.998 (0.962, 1.035)	0.921
Other	0.969 (0.815, 1.153)	0.726	1.027 (0.823, 1.280)	0.817	1.009 (0.945, 1.077)	0.784
Non-Gambian	0.999 (0.963, 1.036)	0.945	1.006 (0.960, 1.054)	0.806	1.000 (0.986, 1.014)	0.986
Number of households						
Small	Ref.		Ref.		Ref.	
Medium	1.010 (0.962, 1.060)	0.699	1.014 (0.952, 1.079)	0.671	0.999 (0.980, 1.017)	0.885
Large	1.014 (0.962, 1.068)	0.613	1.012 (0.946, 1.082)	0.726	0.998 (0.978, 1.018)	0.840
Sex of household head						
Male	Ref.		Ref.		Ref.	
Female	1.003 (0.973, 1.034)	0.830	1.008 (0.969, 1.048)	0.698	0.999 (0.988, 1.011)	0.906

Table 6. (continued)

Predictors	Stunting		Underweight		Wasting	
	AOR (95% CI)	P-value	AOR (95%CI)	P-value	AOR (95%CI)	P-value
Husband education						
No education	Ref.		Ref.		Ref.	
Primary	0.999 (0.971, 1.028)	0.940	0.977 (0.943, 1.013)	0.215	0.998 (0.987, 1.009)	0.715
Secondary +	0.993 (0.964, 1.023)	0.629	0.981 (0.944, 1.019)	0.312	1.001 (0.989, 1.012)	0.915
Breastfeeding						
No	Ref.		Ref.		Ref.	
Yes	0.991 (0.968, 1.015)	0.475	0.980 (0.951, 1.009)	0.1778	0.997 (0.989, 1.006)	0.562
Poorest	Ref.		Ref.		Ref.	
Poorer	0.988 (0.960, 1.018)	0.441	0.998 (0.961, 1.036)	0.923	1.002 (0.991, 1.013)	0.728
Middle	0.981 (0.944, 1.019)	0.318	0.992 (0.945, 1.041)	0.740	1.003 (0.989, 1.018)	0.654
Richer	0.956 (0.911, 1.003)	0.063	0.952 (0.896, 1.012)	0.1112	1.005 (0.988, 1.024)	0.554
Richest	0.972 (0.921, 1.026)	0.297	0.973 (0.908, 1.042)	0.434	1.001 (0.981, 1.022)	0.892
Body mass index of mother						
Thin	Ref.		Ref.		Ref.	
Normal	0.979 (0.946, 1.014)	0.234	0.916 (0.877, 0.959)	<0.001	0.994 (0.981, 1.007)	0.386
Overweight	0.964 (0.929, 1.001)	0.058	0.890 (0.849, 0.934)	<0.001	0.994 (0.980, 1.008)	0.393
Sex of children						
Male	Ref.		Ref.		Ref.	
Female	0.994 (0.974, 1.013)	0.521	0.999 (0.974, 1.024)	0.925	0.997 (0.989, 1.004)	0.421
Age of children in the month						
0 to 11	Ref.		Ref.		Ref.	
12 to 23	1.041 (1.004, 1.079)	0.029	1.071 (1.023, 1.122)	0.003	1.003 (0.989, 1.017)	0.684
24 to 35	1.001 (0.962, 1.042)	0.959	1.023 (0.973, 1.077)	0.373	0.999 (0.984, 1.014)	0.850
36 to 47	1.008 (0.970, 1.048)	0.675	1.014 (0.965, 1.064)	0.588	0.997 (0.983, 1.011)	0.686
48 to 59	0.995 (0.956, 1.036)	0.818	1.008 (0.958, 1.060)	0.768	0.999 (0.984, 1.014)	0.895
Diarrhea prevalence in the last two weeks prior to the survey						
No	Ref.		Ref.		Ref.	
Yes	1.015 (0.989, 1.043)	0.253	1.018 (0.985, 1.053)	0.285	1.000 (0.990, 1.010)	0.959
Fever prevalence in the last two weeks prior to the survey						
No	Ref.		Ref.		Ref.	
Yes	0.999 (0.971, 1.028)	0.941	1.031 (0.994, 1.069)	0.103	1.003 (0.992, 1.014)	0.619
Cough prevalence in the last two weeks prior to the survey						
No	Ref.		Ref.		Ref.	
Yes	1.004 (0.977, 1.032)	0.770	1.001 (0.979, 1.013)	0.228	1.002 (0.988, 1.005)	0.670
Size of children at birth						
Small	Ref.		Ref.		Ref.	
Average	0.965 (0.947, 0.988)	0.002	0.885 (0.852, 0.919)	<0.001	0.989 (0.978, 0.998)	0.046
Large	0.956 (0.982, 0.985)	0.003	0.838 (0.807, 0.871)	<0.001	0.992 (0.981, 1.003)	0.158
Birth type of children						
Single	Ref.		Ref.		Ref.	
Multiple	1.153 (1.090, 1.220)	<0.001	1.159 (1.078, 1.245)	<0.001	1.000 (0.978, 1.021)	0.931

Table 6. (continued)

Predictors	Stunting		Underweight		Wasting	
	AOR (95% CI)	P-value	AOR (95%CI)	P-value	AOR (95%CI)	P-value
Birth order of children						
First	1.000 (0.971, 1.031)	0.986	1.081 (0.979, 1.057)	0.375	1.001 (0.990, 1.012)	0.871
Two to three	1.021 (0.988, 1.055)	0.212	1.027 (0.985, 1.070)	0.218	1.000 (0.988, 1.055)	0.998
Four to five	1.024 (0.989, 1.060)	0.175	1.036 (0.992, 1.083)	0.113	1.001 (0.988, 1.014)	0.906
Six and more	Ref.		Ref.		Ref.	
Number of under-five children in the household						
Only one	Ref.		Ref.		Ref.	
two children	1.000 (0.966, 1.043)	0.968	1.014 (0.972, 1.056)	0.518	1.001 (0.989, 1.014)	0.851
3 and more	1.009 (0.972, 1.047)	0.643	1.034 (0.986, 1.084)	0.173	1.004 (0.990, 1.018)	0.598
Children anemia level						
Not anemic	Ref.		Ref.		Ref.	
Anemic	1.022 (1.001, 1.045)	0.044	1.033 (1.005, 1.062)	0.020	1.001 (0.991, 1.007)	0.759
Dependency		**Odds ratio (OR)**		**P-value**		
Stunting/Underweight		15.87		<0.001		
Stunting/Wasting		0.31		<0.001		
Underweight/Wasting		46.34		<0.001		

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