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Analyzing childhood (0-59 months) malnutrition determinants in five West African Countries of Gabon, Gambia, Liberia, Mauritania, and Nigeria using survey logistic regression-insights from DHS data

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Abstract

Background Malnutrition is one of the most critical health challenges confronting public health agencies in developing nations. This study aimed to determine the scope and underlying factors contributing to malnutrition in West African countries, specifically Gabon, Gambia, Liberia, Mauritania, and Nigeria.

Method For this secondary data analysis, this study drew upon the demographic and health surveys (DHS) conducted within these West African nations. These surveys employed a complex sampling design involving a combination of stratification and cluster sampling in two stages, with varying probabilities of selection leading to weighted samples that effectively represented different components of the population. Given the intricacies of this sampling design, it is paramount to account for them when analyzing the survey data. To address this concern, this study applied a survey logistic regression model, which accommodates factors such as stratification, clustering, and sampling weights and departs from the assumption of independence inherent in the ordinary logistic regression model.

Results The outcomes of this model revealed several variables that emerged as statistically significant ($p < 0.05$) determinants of malnutrition. These influential factors encompass the region of the respondent, the current age of the mother, the highest level of education attained by the mother, the source of drinking water, the type of toilet facility, the household's wealth status, the age and gender of the child, and whether the child experienced a fever in the preceding two weeks.

Conclusion These findings demonstrate with poignant clarity the importance of primary health care interventions in the recognition and management of malnutrition. The countries of interest should invest in public health care interventions including community workshops and outreach programs. Workshops may occur at primary health care facilities during queue waits, or health workers may work with community leaders to perform workshops in areas of high foot traffic, such as places of worship, shopping hubs and collection points for financial aid or grants.

Keywords West African countries, Public health, Malnutrition, Survey logistic regression

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Text box 1. Contributions to literature

- This study significantly broadens the scope of existing literature by incorporating unique dietary factors (including the child's consumption of milk, formula feeds, tubers, eggs, and meat) and sanitation variables (access to water sources and toilet facilities), as well as clinical variables such as anemia level, the presence of fever, and cough, to comprehensively assess the correlation between malnutrition and poor health outcomes.
- The methodology applied to the data as well as the variables selected provide unique insight into the determinants of malnutrition in the selected West African countries.
- Recommendations based on the research findings are needed for informing public health policies.

Introduction

The World Health Organization (WHO) defines malnutrition as "deficiencies or excesses in nutrient intake, imbalance of essential nutrients or impaired nutrient utilization" [1]. Malnutrition can be described as undernutrition or overnutrition (obesity) and may further manifest as a dietary-associated non-communicable disorders. According to the WHO, in 2016, approximately 155 million children aged 5 years and younger were found to be stunted, with an estimated 45% of deaths among children under 5 years of age attributed to undernutrition, which occurs predominantly in low- and middle-income nations [2]. These findings are mirrored in the West African countries, which demonstrate an elevated burden of malnutrition driven by multifaceted, context-specific factors and intersecting across individual, social, economic, political, and environmental thresholds [3].

By measuring the anthropometrical parameters of mid-upper arm circumference (MUAC), weight and height in conjunction with a subject's age, undernutrition may be categorized as stunting, wasting, underweight or micronutrient deficiencies [4]:

- Wasting may be defined as a low weight-for-height z score and is often indicative of acute, severe weight loss, usually associated with poor food security and acute illness.
- Stunting was indicated by a low height-for-age z score. It is a marker of chronic or recurring undernutrition, often because of poverty, poor maternal health, frequent or chronic disease, low birth weight and neonatal factors.
- Underweight was defined as a low weight-for-age z score. A child who is underweight may be classified as stunted, wasted or both.
- Micronutrient deficiencies refer to the shortage of elemental vitamins and minerals, which are necessary in small amounts, to ensure optimum growth and development. Common micronutrient deficiencies affect approximately 2 billion people worldwide; common micronutrient deficiencies include, but are not isolated from vitamin A, folate, iron, iodine, or zinc; however, these deficiencies usually occur in tandem[4]. Micronutrient deficiencies may represent a vicious cycle of inheritance from mother to child following undernutrition during pregnancy and lactation or may indicate socioeconomic challenges because of poverty and food insecurity.

The severity of undernutrition may be classified as moderate acute malnutrition (MAM) or severe acute malnutrition (SAM). A MUAC between 115 mm and < 125 mm is indicative of MAM, while SAM may be diagnosed if a child (1) has a MUAC of < 115 mm or (2) has nutritional edema [5]. The diagnosis of SAM is associated with a tenfold greater mortality rate than a z score ≥ − 1 [6].

Oyekale [7] investigated factors contributing to acute malnutrition in children under five, in Sub-Saharan Africa. A probit regression approach was utilized to analyze anthropometry, gender, urbanization, age of child, maternal education level, Vitamin A supplementation, history of breastfeeding, presence of diarrhoea, cough, fever, vaccination history, parental mortality, caregiver, sanitation, household amenities and media accessibility in 6 countries (Gambia, Niger, Comoros, Central African Republic, Lesotho, and Swaziland). Probit analysis concluded that maternal attainment of secondary education, vaccination, sanitation, and access to media were protective factors, whereas infection with diarrhoea and the presence of fever were associated with adverse nutritive outcomes.

Igbokwe et al. [8] conducted a cross-sectional study in Enugu, Nigeria, for the time March 2013 to July 2013, to further establish the socio-economic determinants of malnutrition primary school-going children. Sex, age, parental literacy, illness, socioeconomic status, poor sanitation, and hygienic practices were analysed by the implementation of a logistic regression model, to conclude that children of lower socioeconomic class were more stunted, underweight, and wasted, while overweight and obesity were more prevalent among children from the upper socioeconomic class.

Uthman and Aremu [9] utilized a logistic regression model to highlight the nutritional disparities existing between urban and rural women, in twenty-six Sub-Saharan countries. Anthropometry, BMI, and place of residence was considered to conclude that rural women are 68% more likely to develop malnutrition, than their urban counterparts, thus emphasizing the need for improved rural health care interventions.

A bi-variate analysis utilizing a chi-square, was undertaken in Nigeria, by [10], to examine the prevalence and socio-economic determinants of malnutrition amongst children aged under five, in the Omu State. Age, gender, class, position among siblings, mother's education, caregiver, mother's occupation, father's occupation, weight for age, height for age, weight for height and mid-upper arm circumference (MUAC) were reviewed to conclude that whilst there was a high prevalence of malnutrition amongst the rural community, most of the contributing factors were avertible, thus necessitating the installation of relevant community intervention programmes.

Sawadogo et al. [11] conducted a systematic search for scientific articles published between January 1, 2000, and October 15, 2020, focusing on chronic malnutrition in children in West and Central Africa. Databases queried included CAIRN, PubMed, CINAHL, MEDLINE, Scopus, and Google Scholar. The authors identified sixty articles from twenty countries, predominantly Ghana and Nigeria, for final analysis. The studies sourced were mainly cross-sectional, utilizing data from demographic and health surveys. The authors findings indicate that chronic malnutrition in children is influenced by sociocultural, economic, and healthcare factors associated with the characteristics of children, mothers, households, and communities.

Salm et al. [3] also performed a systematic review of 358 studies on the drivers of malnutrition in West Africa, which revealed distinct patterns in public health and social science literature. The public health studies, predominantly found in the MEDLINE database, often highlight immediate drivers (43%), particularly health status (38%), and to a lesser extent basic (34%) and underlying (23%) factors. Conversely, social science studies, primarily from the IBSS database, focus more on underlying drivers (46%) such as living environment and gender, and basic drivers (43%) like economic and social contexts, with immediate drivers being the least reported (11%).

As the African continent gauges the aftermath of the SARS-CoV-2 pandemic and battles to contain the consequences of climate change, disrupted supply chains, inflated food costs and surges of communicable diseases continue to embattle already fragile healthcare systems. This article investigates the extent and underlying causes of the high prevalence of malnutrition in the West African countries of Gabon, Gambia, Liberia, Mauritania, and Nigeria by employing a survey logistic regression model in a novel approach to analyzing data obtained from the DHS, the most recently available data at the time of the study. These countries were selected due to the limited existing literature on them and the availability of recent data, allowing for a timely and relevant analysis of malnutrition in these specific contexts. Furthermore, while [8] and [10] evaluated only sociodemographic factors, the scope of this study has been broadened to include unique dietary factors (including the child's consumption of milk, formula feeds, tubers, eggs, and meat) and sanitation (access to water sources and toilet facilities). Therefore, this study included clinical variables, namely, anemia level, the presence of fever and cough, to assess the correlation between malnutrition and poor health outcomes, which further underscores the novelty of the paper.

Methodology

The methodology section of this study is divided into several key subsections. Firstly, the Model Outline specifies the statistical model used in the analysis, including the rationale for selecting the survey logistic regression model. Secondly, the Data subsection describes the dataset employed in the study which details the variables included in the analysis. The Ethics Approval subsection addresses the ethical considerations of the study. The Funding subsection discloses the sources of financial support for the study, ensuring transparency regarding potential conflicts of interest. Finally, the Data Source subsection provides comprehensive information about the origin of the data, including the organizations responsible for data collection and any permissions required for data access.

Model outline

The surveys in question utilized a multistage sampling approach, employing both stratified and cluster sampling methods with varying probabilities of selection for elements within the survey. This approach involves a complex survey design. When analyzing the data collected from these surveys, it is crucial to consider the intricacies of the sampling design. To accomplish this goal, the present study employed a survey logistic regression model (95% confidence interval), which considers stratification, clustering, and sampling weights and relaxes the assumption of independence found in the ordinary logistic regression model. Neglecting factors in clustering and sampling weights can result in an underestimation of variability and consequently lead to incorrect conclusions. In essence, the underlying theories of ordinary logistic regression and survey logistic regression are the same; the key distinction lies in how variance estimation is handled. Both models fall under the category of generalized linear models, with parameter estimation conducted using maximum likelihood methods [12]. The model formulation utilized in this study is described in the following manner:

Let y_{ijk} represent the malnutrition status of child i within stratum j and cluster k, where i ranges from 1 to 65 994, j from 1 to 165, and k from 1 to 1400. The outcome variable is defined as a dichotomous measure such that y_{ijk} equals 1 if child i is malnourished and 0 otherwise.

In this study, an assumption is made such that the outcome variable y_{ijk} follows a Bernoulli distribution, denoted as $y_{ijk} \sim$ Bernoulli (μ_{ijk}), where μ_{ijk} is referred to as the mean and can be expressed as $E\left(y_{ijk}\right) = \mu_{ijk}$. The relationships between μ_{ijk} and the covariates are defined as follows:

$$g\left(u_i jk\right) = x'_{ijk}\beta$$

The fitted survey logistic regression model can be mathematically expressed by the following equation:

$$\begin{aligned} Y = b_0 &+ b_1 * \textit{region of the respondent} \\ &+ b_2 * \textit{current age of the mother} \\ &+ b_3 * \textit{type of residence} \\ &+ b_4 * \textit{highest level of education obtained by the mother} \\ &+ b_5 * \textit{source of drinking water} \\ &+ b_6 * \textit{type of toilet facility} \\ &+ b_7 * \textit{whether the household has electricity or not} \\ &+ b_8 * \textit{gender of the head of the household} \\ &+ b_9 * \textit{age of the head of the household} \\ &+ b_{10} * \textit{type of cooking fuel used by the household} \\ &+ b_{11} * \textit{wealth of the household} \\ &+ b_{12} * \textit{whether the respondent slept under a mosquito net lastnight} \\ &+ b_{13} * \textit{whether the respondent visited a health facility in the last twelve months} \\ &+ b_{14} * \textit{whether the child was given milk or not} \\ &+ b_{15} * \textit{whether the child was given formula or not} \\ &+ b_{16} * \textit{whether the child was given fortified food or not} \\ &+ b_{17} * \textit{whether the child was given potatoes, cassava, or other tubers or not} \\ &+ b_{18} * \textit{whether the child was given eggs or not} \\ &+ b_{19} * \textit{whether the child was given meat or not} \\ &+ b_{20} * \textit{anemia level} \\ &+ b_{21} * \textit{whether the household has mosquito bed net for sleeping or not} \\ &+ b_{22} * \textit{age of the child} \\ &+ b_{23} * \textit{gender of the child} \\ &+ b_{24} * \textit{whether the child had a fever in the last two weeks or not} \\ &+ b_{25} * \textit{whether the child had a cough in the last two weeks or not} \\ &+ \varepsilon \end{aligned}$$

where

Y *denotes whether a child is malnourished or not*

b_0 *denotes a constant*

$b_1 \ldots b_{25}$ *denotes the coefficients per an independent variable*

ε *denotes an error term*

For the analysis in this study, the SAS Proc Surveylogistic from SAS Enterprise Guide version 8.1 was used. The Taylor series method was utilized for variance estimation [12]. Model fit statistics were assessed using the Akaike information criterion (AIC) and the -2 log-likelihood (-2LogL) principle. Model tests were conducted based on the likelihood ratio, score, and Wald test principles [12, 13].

The AUC-ROC curve was used to assess the fit of the model. The AUC-ROC curve is a performance assessment for the classification of problems at numerous threshold settings. ROC is a probability curve and AUC represents the degree or measure of separability. A model that has an AUC close to 1 implies that the model has a good level of differentiation, therefore the model is regarded as a strong predictive model. However, if a model has an AUC close to 0 this implies that the model has a poor level of separability and therefore is deemed to have low predictive strength. When a model has an AUC of 0.5, it means that the model has no class separation power [14].

The odds ratio (OR) denotes the constant effect of a predictor X on the probability that one outcome will ensue [15]. For categorical predictors, the OR compares the odds of the event occurring at various levels of the predictor variable, using one of the levels as a reference point. The confidence intervals are arrays of values that are expected to contain the true values of the ORs with 95% certainty [16].

The adjusted odds ratio (AOR) is an OR that has been adjusted to account for other explanatory variables within the model. The AOR is a useful measure for assisting in understanding how an explanatory variable impacts the likelihood of an outcome occurring after the effects of other explanatory variables within the model are altered. The AOR was calculated as the exponentiate of the coefficient estimates from a logistic regression model [17]. The AOR was calculated within this study.

Data

Demographic and Health Surveys (DHS) conducted within West African countries was the data source for this secondary data analysis paper. The survey followed a complex sampling design (i.e., combined stratification and clustering in two stages, with unequal probabilities of selection that resulted in a weighted sample to separate the sample components) and was designed to obtain representative estimates at the national level. The data were obtained by submitting a written application to DHS Micro for consent.

Under the guidance of the DHS manual, the data used were extracted from the Kids Recode table, which has a unit of analysis of a child under the age of 5 born to a woman interviewed. This table contains all the variables of interest in this study; therefore, no additional tables were created. A dataset was created by stacking the various Kids Recode tables from the surveys conducted within the following countries: Gabon (2019–2021), Gambia (2019–2020), Liberia (2019–2020), Mauritania (2019–2021), and Nigeria (2021). Population sampling adjustment weights were applied to the clusters to account for differences due to the unequal proportions selected per cluster.

The outcome variable in this study is stunting, which is a measure of chronic undernutrition. Specifically, the dependent variable was defined as whether a child (less than 59 months old) was stunted or not. A child was considered malnourished when the height-for-age (HAZ) z score was less than -2.0 standard deviations (SD) and was considered nourished when the HAZ z score was greater than -2.0 SD [18]. In this case, the outcome variable was coded as 1 for stunted (HAZ < -2.0 SD) and 0 for not stunted (HAZ ≥ -2.0 SD). The threshold of a HAZ score less than -2.0 SD is a well-established clinical benchmark for identifying malnutrition in children (World Health Organization, 2023). Using this cut-off point allows for a clear and standardized definition of malnutrition that is widely recognized in both clinical practice and public health research [19].

Logistic regression models with dichotomous outcomes are straightforward to interpret, making the findings more accessible to a broader audience, including those without advanced statistical training. This enhances the usability of the research findings in practical applications [20]. Using a dichotomous variable aligns the study with a large body of existing literature on child malnutrition, which often employs the same cut-off. This consistency allows for easier comparison and synthesis of our results with those of other studies [21].

The HAZ z-score is a standardized score that indicates how a child's height compares to what is expected for their age and sex. It is used to assess stunting in children, which reflects chronic malnutrition. The following steps are required to calculate the HAZ z-score [22]:

1. *Measure the Child's Height and Age*: Accurately measure the child's height (in centimeters) and record their age (in months).
2. *Refer to Standard Growth Charts*: Use the WHO child growth standards, which provide the median height and standard deviation for children of various ages and sexes.
3. *Calculate the Z-Score*: The HAZ is calculated using the following formula:

$$HAZ = \frac{Observed\ height - Median\ height\ for\ age}{Standard\ Deviation\ of\ height\ for\ age}$$

Figures 1 and 2 display the distribution of the target binary variable for the pooled data sample as well as the country level data sample.

This study examined demographic, socioeconomic, and environmental independent factors related to child malnutrition that have been explored in numerous prior studies. These factors served as the foundation for the present study, which led to the following potential independent variables being identified: region of the respondent, current age of the mother, type of residence, highest level of education obtained by the mother, source of drinking water, type of toilet facility, whether the household has electricity or not, gender of the head of the household, age of the head of the household, type of cooking fuel used by the household, wealth of the household, whether the respondent slept under a mosquito net last night, whether the respondent visited a health facility in the last twelve months, whether the child was given milk or not, whether the child was given formula or not, whether the child was given fortified food or not, whether the child was given potatoes, cassava, or other tubers or not, whether the child was given eggs or not, whether the child was given meat or not, anemia level, whether the

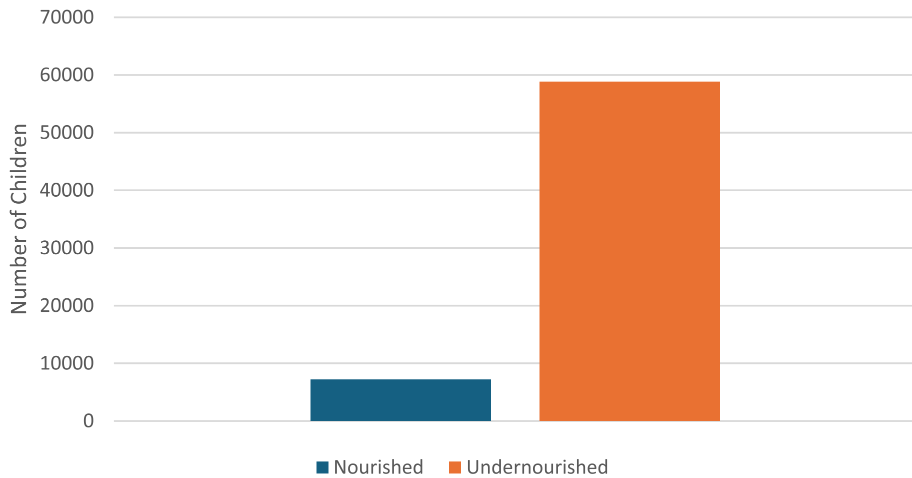

Fig. 1 Overall assessment of the nutritional status of children (0-59m) in Gabon (2019–2021), Gambia (2019–2020), Liberia (2019–2020), Mauritania (2019–2021), and Nigeria (2021)

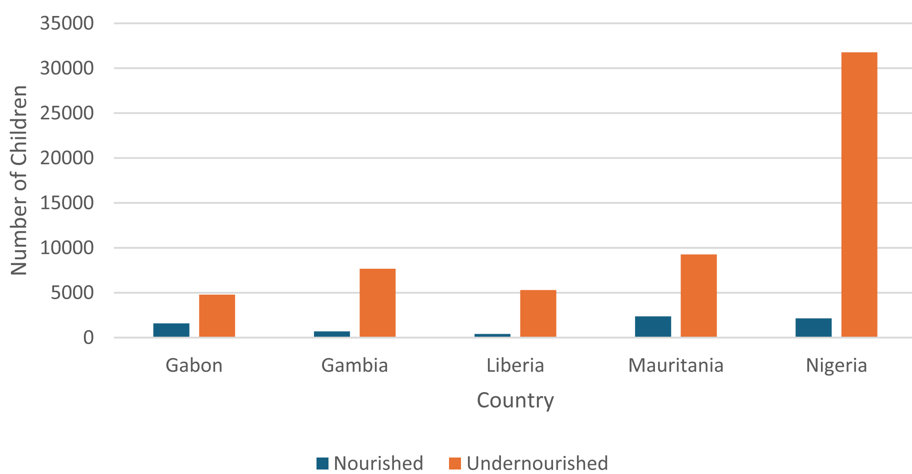

Fig. 2 Country level assessment of the nutritional status of children (0-59m) in Gabon (2019–2021), Gambia (2019–2020), Liberia (2019–2020), Mauritania (2019–2021), and Nigeria (2021)

household has a mosquito bed net for sleeping or not, age of the child, gender of the child, whether the child had a fever in the last two weeks or not and whether the child had a cough in the last two weeks. The factors noted are all categorical variables except for the current age of the mother which is a continuous variable.

The theoretical framework employed was grounded in existing literature [7, 8, 10, 11]. The framework employed draws on established theories and concepts to guide the selection of variables that are hypothesized to influence malnutrition.

Ethical approval
This study does not involve any experimental or interaction with human or animal subjects. The study uses secondary data from DHS.

Funding
The authors declare that there was no funding associated with this study.

Availability of data and materials
The present study utilized existing dataset and is available from: https://dhsprogram.com/data/available-datasets.cfm with the permission from the DHS program.

Results
Figure 3 depicts the goodness of fit test performed for the model fitted on the variables of interest. The fit shows that the model has a strong predictive power.

The results of the model identified several significant ($p < 0.05$) determinants of malnutrition: respondent's region,

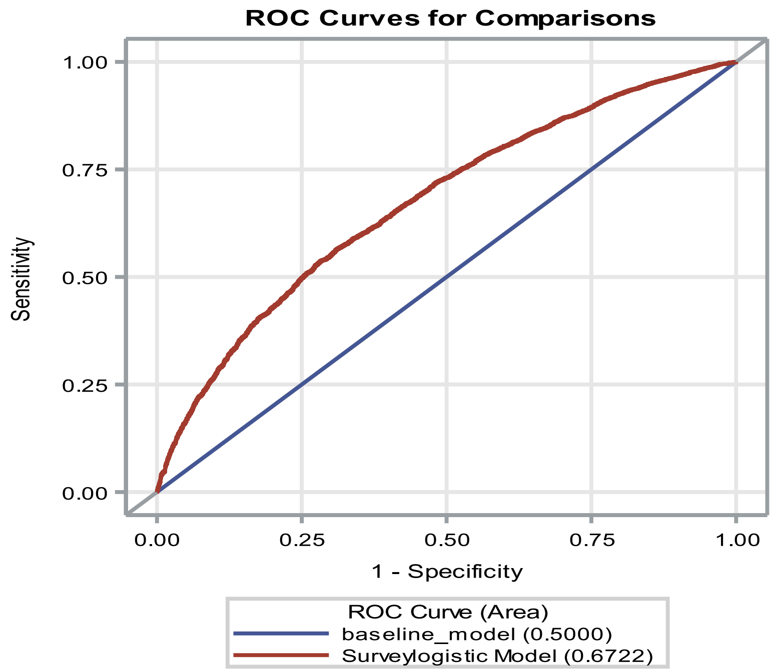

Fig. 3 AUC-ROC Curve

mother's current age, mother's highest education level, source of drinking water, type of toilet facility, household wealth, child's age, child's gender, and whether the child had a fever in the last two weeks. The analysis of interaction terms revealed no significant interactions.

As shown in Table 1, maternal education was significantly associated with malnutrition. Children of mothers with only primary education (OR = 1.243; $p < 0.0001$; 95% CI: 0.996-1.345) were 1.243 times more likely to be malnourished compared to children of mothers with tertiary education (OR = 0.769; $p = 0.0009$; 95% CI: 0.569-0.902), when compared to children of mothers with no education. Household drinking water source also significantly affected malnutrition risk. Children from households using tanker water (OR = 1.406; $p = 0.022$; 95% CI: 0.879-1.736) or well water (OR = 1.251; $p = 0.0029$; 95% CI: 0.943-1.281) were more likely to be malnourished compared to those with piped water, with risks increased by 1.41 and 1.25 times, respectively. Sanitation facilities were another determinant. Children from households using pit latrine toilets (OR = 1.144; $p = 0.0026$; 95% CI: 1.026-1.415) were significantly more likely to be malnourished compared to those using flush toilets.

Household wealth categories significantly influenced malnutrition risk. Children from the "Poorest" (OR = 1.294; $p = 0.0007$; 95% CI: 1.284-2.354) and "Poorer" (OR = 1.15; $p = 0.0197$; 95% CI: 1.182-2.017) households were more likely to be malnourished, while those from "Richer" households (OR = 0.82; $p = 0.0021$; 95% CI: 0.888-1.366) were less likely, compared to children from the "Richest" households. Child age also showed significant associations. Children aged 12-24 months (OR = 1.514; $p < 0.0001$; 95% CI: 2.159-2.81) and 48-60 months (OR = 1.165; $p = 0.0151$; 95% CI: 1.609-2.232) were more likely to be malnourished than those aged 0-12 months, with increased risks of 1.51 and 1.17 times, respectively. Gender was a significant factor, with female children (OR = 0.893; $p < 0.0001$; 95% CI: 0.719-0.885) being 0.89 times less likely to be malnourished than male children. Finally, having a fever two weeks prior to the interview was significantly associated with malnutrition (OR = 1.114; $p = 0.0045$; 95% CI: 1.069-1.442). Children who had a fever were 1.11 times more likely to be malnourished than those who did not.

Discussion

Malnutrition remains highly prevalent in the Western African countries of Gabon, Gambia, Liberia, Mauritania, and Niger and is a leading contributor to pediatric morbidity and mortality rates. Western African governments, nonprofit organizations and humanitarian aid projects have aimed to alleviate the effects of malnutrition through the implementation of various healthcare policies and improved access to care; however, a more reactive approach is required to alleviate this health crisis.

Table 1 Parameter estimates of factors associated with malnutrition among children (0-59months) in Gabon (2019–2021), Gambia (2019–2020), Liberia (2019–2020), Mauritania (2019–2021), and Nigeria (2021)

Variable name	Estimate	OR	95% CI		*p* value
Residence_type (Ref = Urban)					
Rural	-0.0198	0.98	0.831	1.112	0.5943
Mother highest education level (Ref = No Education)					
Primary	0.2175	1.243	0.996	1.345	< .0001
Secondary	-0.0265	0.974	0.769	1.069	0.6145
Tertiary	-0.2622	0.769	0.569	0.902	0.0009
Source of drinking water (Ref = Piped)					
Bottle/Sachet	-0.4538	0.635	0.306	1.019	0.0766
Natural Sources	-0.0525	0.949	0.679	1.023	0.5733
Tanker	0.3411	1.406	0.879	1.736	0.022
Well	0.224	1.251	0.943	1.281	0.0029
Other	-0.1884	0.828	0.534	0.991	0.1617
Type of toilet facility (Ref = Flush)					
Pit	0.1346	1.144	1.026	1.415	0.0026
Other	-0.0828	0.921	0.814	1.155	0.0916
Household has electricity (Ref = Yes)					
No	-0.053	0.948	0.775	1.044	0.1636
Gender of the head of the household (Ref = Male)					
Female	0.016	1.016	0.897	1.189	0.6563
Age of the head of household (Ref = < 18)					
< 25	-0.0845	0.919	0.309	2.188	0.5066
< 35	0.0225	1.023	0.356	2.356	0.7835
< 45	-0.0172	0.983	0.332	2.335	0.856
< 55	-0.0159	0.984	0.337	2.306	0.8661
< 65	0.061	1.063	0.362	2.504	0.5414
> 65	-0.0765	0.926	0.313	2.194	0.4922
Type of cooking fuel (Ref=Wood)					
Electricity	-0.2643	0.768	0.549	1.281	0.3724
Gas	-0.206	0.814	0.746	1.058	0.4311
No Food cooked	0.5583	1.748	0.266	13.668	0.46
Wealth Index (Ref = Richest)					
Poorest	0.258	1.294	1.284	2.354	0.0007
Poorer	0.1397	1.15	1.182	2.017	0.0197
Middle	0.096	1.101	1.154	1.894	0.0928
Richer	-0.1988	0.82	0.888	1.366	0.0021
Slept under a net last night (Ref = only untreated nets)					
No net	0.4891	1.631	0.84	1.557	0.0641
Only treated nets	0.4934	1.638	0.852	1.547	0.0595
Both treated and untreated	-1.3376	0.262	0.025	1.375	0.0806
Visted a health facility in the last 12 months (Ref = Yes)					
No	-0.011	0.989	0.868	1.102	0.7167
Gave the child milk (Ref = No)					
Yes	0.0349	1.036	0.94	1.224	0.3002
Gave the child formula (Ref = No)					
Yes	-0.00651	0.994	0.822	1.185	0.8892
Gave the child fortified food (Ref = No)					
Yes	-0.05	0.951	0.728	1.124	0.3666
Gave the child tubers (Ref = No)					
Yes	0.0449	1.046	0.944	1.268	0.2315
Gave the child eggs (Ref = No)					
Yes	-0.0293	0.971	0.793	1.121	0.507
Gave the child meat (Ref = No)					
Yes	-0.0733	0.929	0.734	1.017	0.078
Anemia Level (Ref = Not Anemic)					
Anemic	0.0366	1.037	0.966	1.198	0.1839
Has a mosquito net (Ref = Yes)					
No	-0.038	0.963	0.793	1.083	0.3379
Age of the child (Ref = 0 to 12 months)					
12 to 24 months	0.415	1.514	2.159	2.81	< .0001
24 to 36 months	-0.0737	0.929	1.247	1.831	0.3325
36 to 48 months	-0.00785	0.992	1.381	1.886	0.8942
48 to 60 months	0.1529	1.165	1.609	2.232	0.0151
Gender of the child (Ref = Male)					
Female	-0.1129	0.893	0.719	0.885	< .0001
Fever in the last 2 weeks (Ref = No)					
Yes	0.1082	1.114	1.069	1.442	0.0045
Cough in the last 2 weeks (Ref = No)					
Yes	-0.0805	0.923	0.824	1.127	0.8122
Don't know	0.124	1.132	0.164	8.519	0.8535

This study identified several key determinants of malnutrition, including region of the respondent, current age of the mother, highest level of education obtained by the mother, source of drinking water, type of toilet facility, wealth of the household, age of the child, gender of the child and whether the child had a fever in the last two weeks.

Although there is a deficit of data investigating the determinants of malnutrition in Gabon, Gambia, Liberia, Mauritania, and Nigeria, particularly in recent years, these results are comparable [10]; these authors utilized a bivariate analysis using the chi-square test in 2013 to concur that age, sex, maternal education and maternal occupation are significant contributors to malnutrition in Nigeria. A logistic regression model was employed by [8] in 2017, who further stressed that age, sex, and parental education are predictors of malnutrition in Nigeria, supporting the findings illustrated in this paper. In 2012, [7] studied the factors contributing to acute malnutrition in Gambia, Niger, Comoros, the Central African Republic, Lesotho and Swaziland and concluded that the sex of the child, the age of the child, maternal education, access to piped water and access to toilet facilities were considerable determinants of malnutrition using a probit regression model. These findings were further supported by the work of [23] and [24], who utilized a multivariate generalized linear mixed model and spatial joint model, respectively. However, it should be noted that [25] and [26] discount the impact of adequate toilet facilities, deeming it to be insignificant in the prevalence of malnutrition, which contradicts the findings illustrated in this paper.

The findings of the paper demonstrate with poignant clarity the importance of primary health care interventions in the recognition and management of malnutrition. Regions that demonstrate a high prevalence of malnutrition should have regular workshops and community outreach. Workshops may occur at primary health care facilities during queue waits, or health workers may work with community leaders to perform workshops in areas of high foot traffic, such as places of worship, shopping hubs and collection points for financial aid or grants.

At the prenatal level, high-risk pregnancies, such as teenage pregnancies and pregnancies in low-income households, should be flagged as high risk. Young women should be afforded access to safe, confidential, and reliable contraception methods to prevent unplanned pregnancy. Patients with socioeconomically high-risk pregnancies could be enrolled in prenatal classes at local clinics, which focus on perinatal and postnatal care, hygiene, diet, milestone achievement, importance of deworming, vaccinations, and signs of malnutrition. Pregnancies that red flag for other significant risk factors should be assigned to community caregiver case workers, who monitor and counsel the mothers and, eventually, their children. Weight, height, MUAC, z scores and/or BMI were duly calculated at every postnatal visit. Children identified as MAMs should be timeously referred to multidisciplinary teams and managed as outpatients by a medical doctor and dietician, while children identified as SAMs should be referred for inpatient management. Primary health care clinics should also employ community-based caregivers to guide and supervise mothers of at-risk children while negating the cost and effort of mothers attending ongoing clinic appointments. Local governments should liaise with nonprofit organizations to ensure that food parcels, fortified foods and high protein supplements are readily available to families of malnourished children.

The role of technology should also not be underestimated when addressing significant risk factors. Mothers deemed high risk can be enrolled in webinars, which detail antenatal care. Alternatively, a primary health cellphone application system can be downloaded for offline usage. The application can highlight basic prenatal and antenatal care, including reminders for clinic attendance, prenatal supplement prompts and danger signs, thus aiming to correct the disparity of poor literacy levels. The app can also include guidelines for safe water usage and hygiene measures that should be employed if piped water and sanitation information are unavailable.

Conclusion

This study utilized a survey logistic regression model to identify the major contributors to malnutrition in Gabon, Gambia, Liberia, Mauritania, and Nigeria from 2019 to 2021. Significant determinants included the region of residence, the current age and education level of the mother, the source of drinking water, the type of toilet facility, household wealth, the age and gender of the child, and whether the child had a fever in the last two weeks.

The findings underscore the critical importance of primary health care interventions. Regular workshops and community outreach programs should be implemented in collaboration with community leaders at primary health care facilities and high-traffic community areas. High-risk pregnancies, particularly among teenagers and low-income households, need early identification and support through prenatal classes, community caregiver monitoring, and access to contraception. Malnourished children should be referred to appropriate care, with MAM cases managed as outpatients and SAM cases as inpatient care. Community-based caregivers can support at-risk children, reducing clinic visits. Partnerships with nonprofits can ensure the availability of essential food and supplements. Technology, such as antenatal webinars and health apps, can enhance care by providing essential prenatal and postnatal information and reminders, addressing literacy gaps, and improving health outcomes.

Due to unique challenges in Sub-Saharan Africa, administrators aim to become less dependent on Western data to guide their policies. However, the paucity of recent data exploring malnutrition in this region highlights the need for ongoing exploration. Future studies should examine additional indicators of wealth, family health history, anemia severity, tuberculosis and HIV status, vaccination rates, vitamin A supplementation, deworming, and adherence to chronic medication. Social paradigms such as primary caregivers, chaperones to healthcare services, and qualifications for government economic grants should also be assessed. Furthermore, alternative methodologies, such as generalized additive models, could provide deeper insights. Conducting longitudinal analyses could reveal more significant trends and patterns, addressing the limitations of cross-sectional data.

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RB wrote the paper as well as performed the analysis. SR and FH provided guidance on the paper and reviewed it.

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Availability of data and materials
The present study utilized existing dataset and is available from: https://dhsprogram.com/data/available-datasets.cfm with the permission from the DHS program.

Declarations

Ethics approval and consent to participate
This study does not involve any experimental or interaction with human or animal subjects. The study uses secondary data from DHS.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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