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The determinants of child malnutrition in Sokoto state, Nigeria: A multi-sectoral analysis of socio-demographic and health-related factors

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Abstract
Malnutrition among under-five children is a persistent public health challenge in Northern Nigeria, yet the complex interplay of socio-demographic and health-related determinants at the household level remains inadequately characterized. This study aimed to identify the socio-demographic and health-related factors associated with malnutrition among children under five years in Sokoto State, Nigeria. A community-based cross-sectional study was conducted among 150 mother-child pairs attending Primary Health Centres across twelve Local Government Areas in Sokoto State. Data were collected using a semi-structured questionnaire capturing geographic, demographic, socioeconomic, WASH (Water, Sanitation, and Hygiene), and health-related characteristics. Anthropometric measurements (weight, height/length, MUAC) were collected, and malnutrition was defined as underweight (Weight-for-Age Z-score < -2SD). Bivariate and multivariate binary logistic regression analyses were performed to identify independent predictors of malnutrition. The study revealed a population facing profound multi-dimensional deprivation. The majority of respondents resided in rural areas (82%), depended on subsistence farming (55.3%), and lived in extreme poverty (45.3% with monthly income < ₦20,000). Dietary diversity was critically low, with 73.3% of households consuming ≤4 food groups daily. Incomplete immunization coverage (54.7%), poor sanitation (35.3% practicing open defecation), and suboptimal Infant and Young Child Feeding (IYCF) practices (76.7% mixed feeding) were highly prevalent. Multivariate logistic regression identified three independent predictors of underweight: low household dietary diversity (AOR = 4.2, 95% CI: 1.8–9.8, p = 0.001), low maternal education (none/Qur'anic only) (AOR = 3.1, 95% CI: 1.3–7.4, p = 0.011), and extreme household poverty (AOR = 2.8, 95% CI: 1.2–6.5, p = 0.018). The model explained 41% of the variance in malnutrition status (Nagelkerke R^2 = 0.41). Malnutrition in Sokoto State is driven by a synergistic interplay of dietary inadequacy, maternal educational deprivation, and extreme poverty. These findings underscore the need for integrated, multi-sectoral interventions that simultaneously address dietary diversity, women's empowerment, and economic resilience, rather than narrow, nutrition-specific approaches alone.

Keywords: Child Malnutrition, Socio-Demographic Factors, Dietary Diversity, Maternal Education, Poverty, Under-Five Children, Sokoto State

Introduction

Childhood malnutrition remains one of the most formidable barriers to human capital development in low- and middle-income countries (Black *et al*., 2013) [4]. In Nigeria, the burden is starkly concentrated in the northern regions, where chronic poverty, food insecurity, and weak health systems converge to create a perfect storm of nutritional deprivation (National Population Commission [NPC] & ICF, 2019). Sokoto State, located in the North-West zone, consistently reports some of the worst nutritional indicators in the country, with stunting, wasting, and underweight prevalence far exceeding national averages and international emergency thresholds (NPC & ICF, 2019).

While the anthropometric and biochemical dimensions of malnutrition have been increasingly documented, a comprehensive understanding of the underlying and basic determinants remains critical for effective intervention design. The UNICEF Conceptual Framework of Malnutrition posits that child undernutrition is not a direct consequence of dietary inadequacy alone, but the outcome of a complex cascade of factors operating at multiple levels (UNICEF, 2021) [21]. These include immediate causes (inadequate dietary intake and disease), underlying causes (household food insecurity, inadequate care practices, unhealthy household environment, and lack of health services), and basic causes (poverty, social inequity, and weak governance) (UNICEF, 2021) [12].

In the context of Sokoto State, these determinants operate within a specific socio-ecological context characterized by deep-rooted poverty, low female literacy, reliance on climate-sensitive agriculture, poor water and sanitation infrastructure, and limited access to quality health services (National Population Commission [NPC] & ICF, 2019; UNICEF, 2022). However, the relative contribution of each of these factors to child malnutrition in this setting, and their independent effects after controlling for confounding, remains inadequately quantified. Such evidence is essential for moving beyond descriptive epidemiology to targeted, evidence-based policy and programming (Bhutta *et al*., 2013; Ruel & Alderman, 2013) [3, 15].

This study is designed to address this critical evidence gap. The primary objective is to identify the socio-demographic

and health-related factors associated with malnutrition among under-five children in Sokoto State. By employing multivariate analysis, this study aims to disentangle the complex web of determinants (Victora *et al*., 1997) [23], identify the most powerful and independent predictors of malnutrition, and provide the empirical foundation for integrated, multi-sectoral interventions that address the root causes of one of Nigeria's most severe child nutrition crises (Black *et al*., 2013; Ruel & Alderman, 2013) [4, 15].

Methodology

1. Study Design and Setting

This study employed a community-based, cross-sectional design. It was conducted in selected Primary Health Centres (PHCs) across twelve Local Government Areas (LGAs) in Sokoto State, Northwest Nigeria, between September, 2024 [19] and September, 2025. The LGAs were purposively selected to capture the socio-ecological and economic heterogeneity of the state, including border LGAs (Illela, Gudu, Isa), agrarian heartland LGAs (Tambuwal, Dange Shuni, Kware, Bodinga, Silame), LGAs hosting internally displaced persons (Gwadabawa), and urban LGAs (Sokoto North, Sokoto South, Wamakko).

2. Study Population and Sampling

The study population comprised children aged 0 to 59 months and their mothers/caregivers who presented at the selected PHCs for routine child welfare services. A total of 150 mother-child pairs were enrolled using a multi-stage sampling technique. Children with physical deformities that could impede accurate anthropometric measurement, those who were critically ill and requiring immediate emergency care, or those with known chronic illnesses (e.g., sickle cell disease) were excluded from the study.

3. Data Collection

Data were collected through face-to-face interviews with mothers or caregivers using a semi-structured, pre-tested questionnaire adapted from validated instruments (FAO, 2011; WHO, 2010), which captured information across several domains: geographic and community characteristics such as LGA of residence and rural or urban location; socio-demographic details including age, sex, marital status of the caregiver, maternal education, and household size; household economic characteristics like primary income source and monthly income; household food security and dietary diversity, assessed by the frequency of missed balanced meals per week as a proxy for food insecurity and the Household Dietary Diversity Score (HDDS) based on a 7-day recall of food groups consumed (FAO, 2011) [8]; water, sanitation, and hygiene (WASH) conditions, including type of sanitation facility and primary water source; child health and nutrition practices, covering immunization status verified by vaccination cards where available, recent morbidity such as diarrhea, malaria, and acute respiratory infections in the past two weeks, and Infant and Young Child Feeding (IYCF) practices like exclusive breastfeeding versus mixed feeding; and access to health services, including distance to the nearest health facility, perceived adequacy of government or NGO interventions, and reported constraints in nutrition service delivery. Additionally, anthropometric measurements weight, height or length, and mid-upper arm circumference (MUAC) were collected using standardized techniques and calibrated equipment, and Weight-for-Age Z-scores (WAZ) were calculated using WHO Anthro software (version 3.2.2), with underweight defined as WAZ less than -2 standard deviations (WHO, 2006).

4. Data Analysis

Data were entered and analyzed using IBM SPSS Statistics version 26. Descriptive statistics (frequencies, percentages, means, standard deviations) were used to summarize all variables. Bivariate analysis was conducted to examine the association between each independent variable and the dependent variable (underweight status) using chi-square tests. Variables with a p-value < 0.25 in bivariate analysis, and those of known biological importance from the literature, were entered into a multivariable binary logistic regression model. A backward stepwise elimination procedure was used to derive the final parsimonious model. Model fit was assessed using the Hosmer-Lemeshow goodness-of-fit test ($p > 0.05$ indicating good calibration) and the Nagelkerke R^2 (indicating the proportion of variance explained). Adjusted Odds Ratios (AOR) with 95% Confidence Intervals (CI) were calculated, and statistical significance was set at $p < 0.05$.

5. Ethical Considerations

This study adhered to the ethical principles of the Declaration of Helsinki. Ethical approval was obtained from the Health Research Ethics Committee of the Sokoto State Ministry of Health (Ref: SKHREC/059/2022). Permission was also secured from the SSPHCDA and local government authorities.

Results and Discussions

1. Geographic and Community Characteristics

The geographic distribution of the study sample across twelve LGAs is presented in Table 1. The sample was predominantly rural, with approximately 82% of respondents residing in rural and peri-urban communities, accurately reflecting Sokoto State's largely agrarian population. Border and security-compromised LGAs (Illela, Gudu, Isa) accounted for 30.6% of the sample, while agrarian heartland LGAs (Tambuwal, Dange Shuni, Kware, Bodinga, Silame) contributed 41.4%.

Table 1: Distribution of Respondents by Local Government Area (LGA) (N=150)

LGA	Frequency	Percentage (%)	Key Contextual Characteristics
Illela	18	12.0	Border LGA, cross-border trade, security concerns
Tambuwal	16	10.7	Agrarian, potential SAM hotspot

Gudu	14	9.3	Border area, pastoralist communities, remote
Wamakko	12	8.0	Peri-urban, mix of agrarian and urban livelihoods
Sokoto North	10	6.7	Urban, high-density population
Sokoto South	10	6.7	Urban, central lab hub
Dange Shuni	10	6.7	Agrarian, riverine potential
Kware	12	8.0	Agrarian
Bodinga	10	6.7	Agrarian
Isa	14	9.3	Border LGA, known security challenges
Gwadabawa	12	8.0	Hosts IDP settlements, environmental stress
Silame	12	8.0	Agrarian
Total	150	100	

Characteristics inferred from Sokoto state Government (2020) and SPHCDA (2024) [18, 19] reports.

2. Socio-Demographic Characteristics of Caregivers
The socio-demographic profile of the caregivers is presented in Table 2. The majority were married (60.0%), but a substantial proportion (40.0%) were not in a marital union, including single (25.3%), divorced (8.0%), and widowed (6.7%) individuals. Educational attainment was low, with 75.3% of caregivers having secondary education or less, 10% with no formal schooling, and 9.3% with exclusively Qur'anic/religious education. Only 10% had attained tertiary education.

Table 2: Socio-Demographic Characteristics of Caregivers (N=150)

Characteristic	Category	Frequency (n)	Percentage (%)
Marital Status	Married	90	60.0
	Single	38	25.3
	Divorced	12	8.0
	Widowed	10	6.7
Educational Attainment	None	15	10.0
	Primary	45	30.0
	Secondary	53	35.3
	Tertiary	15	10.0
	Qur'anic/Religious	14	9.3
	Other	8	5.3

Source: SPSS

3. Household Economic Characteristics
The economic profile of households is presented in Table 3. The primary source of income for the majority was farming (55.3%), followed by trading (25.3%). Only 15.3% of households were engaged in more stable livelihoods such as artisan work (10.0%) or civil service (5.3%).

Monthly household income was critically low (Table 4). A staggering 80% of households survived on less than ₦50,000 per month, and nearly half (45.3%) lived in profound deprivation, earning less than ₦20,000 monthly. Only 5.3% of households had a monthly income exceeding ₦100,000.

Table 3: Major Sources of Household Income (n=150)

Source	Frequency (n)	Percentage (%)
Farming	83	55.3
Trading	38	25.3
Artisan	15	10.0
Civil Service	8	5.3
Others	6	4.0
Total	150	100

Source: SPSS

Table 4: Monthly Household Income (n=150)

Income Range (₦)	Frequency (n)	Percentage (%)	Poverty Context
< 20,000	68	45.3	Extreme Poverty
20,001–50,000	52	34.7	Moderate Poverty
50,001–100,000	22	14.7	Lower-Middle Income
>100,000	8	5.3	Middle Income & Above
Total	150	100	

Source: SPSS

4. Household Food Security and Dietary Diversity
Household food insecurity was pervasive (Table 5). Nearly two-thirds (64.7%) of households experienced an inability to access a balanced meal for three or more days each week, with 32.0% facing this situation for five to seven days weekly. Only 8.0% of households reported zero days without a balanced meal.

Dietary diversity was critically low (Table 6). The majority of households (73.3%) consumed a diet of low or moderate diversity (≤4 food groups), with 28.0% in the low diversity category (1-2 food groups). Only 4.7% of households achieved high dietary diversity (7+ food groups).

Table 5: Frequency of Experiencing Unbalanced Meals per Week (n=150)

Days Without Balanced Meals	Frequency (n)	Percentage (%)	Severity of Food Insecurity
0	12	8.0	Food Secure
1–2	41	27.3	Mild Food Insecurity
3–4	49	32.7	Moderate Food Insecurity
5–7	48	32.0	Severe Food Insecurity
Total	150	100	

Source: SPSS

Table 6: Household Dietary Diversity Score (DDS) (n=150)

Dietary Diversity Score	Frequency (n)	Percentage (%)	Nutritional Interpretation
1–2 (Low)	42	28.0	Severe Dietary Deprivation
3–4 (Moderate)	68	45.3	Inadequate Diversity
5–6 (Adequate)	33	22.0	Minimally Acceptable
7+ (High)	7	4.7	Good Diversity
Total	150	100	

Source: SPSS

5. Water, Sanitation, and Hygiene (WASH) Characteristics

Sanitation facilities were grossly inadequate (**Table 7**). Over one-third of households (35.3%) practiced open defecation. While the majority (55.3%) used pit latrines, these were often shared and poorly maintained. Only 4.7% of households had access to flush toilets.

Table 7: Types of Sanitation Facilities Used by Households (n=150)

Facility Type	Frequency (n)	Percentage (%)
Pit Latrine	83	55.3
Open Defecation	53	35.3
Flush Toilet	7	4.7
Other	7	4.7
Total	150	100

Source: SPSS

6. Child Health and Nutrition Practices

Immunization coverage was critically low (Table 8). Only 45.3% of children were fully immunized. An equal proportion (45.3%) were partially immunized, and 9.4% remained completely unvaccinated.

Recent morbidity was highly prevalent (Table 9). Over half of the children (59.4%) had experienced at least one episode of illness in the two weeks preceding the survey. Acute Respiratory Infections (ARIs) were the most common (32.0%), followed by diarrhea (22.7%). Malaria was reported in 4.7% of children.

Infant and Young Child Feeding (IYCF) practices were suboptimal (Table 10). Only 23.3% of infants were exclusively breastfed, while the overwhelming majority (76.7%) received mixed feeding, with early introduction of water, traditional gruels, or other liquids alongside breastmilk.

Table 8: Immunization Coverage (n=150)

Vaccination Status	Frequency (n)	Percentage (%)
Fully Immunized	68	45.3
Partially Immunized	68	45.3
Not Immunized	14	9.4
Total	150	100

Source: SPSS

Table 9: Prevalence of Common Childhood Illnesses (Past 2 Weeks) (N=150)

Type of Illness	Frequency (n)	Percentage (%)
Diarrhea	34	22.7
Malaria	7	4.7
Respiratory Infection	48	32.0
None	61	40.6
Total	150	100

Source: SPSS

Table 10: Breastfeeding and Feeding Pattern (n=150)

Feeding Practice	Frequency (n)	Percentage (%)
Exclusively Breastfed	35	23.3
Mixed Feeding	115	76.7
Total	150	100

Source: SPSS

7. Access to Health and Nutrition Services

Geographic access to health facilities was a major barrier (Table 11). Nearly two-thirds of households (65.3%) resided more than 5 kilometers from a health facility, with 22.7% facing journeys exceeding 10 kilometers.

Perceptions of government and NGO interventions were overwhelmingly negative (Table 12). The vast majority of respondents (84.7%) perceived nutrition and food security interventions as inadequate (70.0%) or entirely absent (14.7%). Only 5.3% rated support as adequate.

Reported constraints in nutrition service delivery (Table 13) were dominated by systemic failures. Commodity stock-outs, particularly of Ready-to-Use Therapeutic Food (RUTF) and supplements, were cited by over half of the caregivers (54.7%). Lack of awareness (25.3%), security issues (12.7%), and cultural beliefs (7.3%) were also identified as barriers.

Table 11: Distance to Nearest Health Facility (n=150)

Distance (km)	Frequency (n)	Percentage (%)
<5 km	52	34.7
5–10 km	64	42.6
>10 km	34	22.7
Total	150	100

Source: SPSS

Table 12: Perceived Adequacy of External Support (n=150)

Support Adequacy	Frequency (n)	Percentage (%)
Inadequate	105	70.0
None	22	14.7
Fairly Adequate	15	10.0
Adequate	8	5.3
Total	150	100

Source: SPSS

Table 13: Reported Constraints in Nutrition Programs (n=150)

Challenge	Frequency (n)	Percentage (%)
Commodity Stock-outs	82	54.7
Lack of Awareness	38	25.3
Security Issues	19	12.7
Cultural Beliefs and Practices	11	7.3
Total	150	100

Source: SPSS

8. Caregiver-Perceived Malnutrition

There was a stark discrepancy between caregiver perception and objective anthropometric evidence of malnutrition (Table 14). Only 22.7% of households reported that a member had been affected by malnutrition-related illness, despite objective data showing that 68.7% of children had acute malnutrition based on MUAC and 83.3% were underweight.

Table 14: Household Reporting of Malnutrition-Related Illness (n=150)

Malnutrition Cases Reported	Frequency (n)	Percentage (%)
Yes	34	22.7
No	116	77.3
Total	150	100

Source: SPSS

9. Multivariate Analysis: Predictors of Malnutrition (Underweight)

Multivariable binary logistic regression was conducted to identify independent predictors of underweight (WAZ < -2SD). The final parsimonious model, presented in **Table 15**, identified three statistically significant predictors, explaining 41% of the variance in malnutrition status (Nagelkerke R^2 = 0.41). The Hosmer-Lemeshow test indicated good model fit (p = 0.342).

Table 15: Multivariate Logistic Regression Analysis of Factors Associated with Malnutrition (Underweight) Among Under-Five Children in Sokoto State (n=150)

Variable	Category	Frequency n (%)	AOR	95% CI	p-value
Household Dietary Diversity Score	Low (≤4 food groups)	110 (73.3)	4.2	1.8 - 9.8	0.001
	Adequate/High (≥5 food groups)	40 (26.7)	1.00	Reference	
Maternal Education	None / Qur'anic only	29 (19.3)	3.1	1.3 - 7.4	0.011
	Primary	45 (30.0)	2.1	0.9 - 5.1	0.089
	Secondary and above	76 (50.7)	1.00	Reference	
Household Monthly Income	< ₦20,000 (Extreme Poverty)	68 (45.3)	2.8	1.2 - 6.5	0.018
	₦20,000 - ₦50,000	52 (34.7)	1.6	0.7 - 3.8	0.261
	> ₦50,000	30 (20.0)	1.00	Reference	
Child's Age Group	13 - 24 months	45 (30.0)	2.3	0.9 - 5.6	0.072
	0 - 12 months	22 (14.7)	1.5	0.5 - 4.3	0.456
	25 - 59 months	83 (55.3)	1.00	Reference	
Sex of Child	Male	70 (46.7)	1.3	0.6 - 2.9	0.507
	Female	80 (53.3)	1.00	Reference	
Sanitation Facility	Open Defecation	53 (35.3)	1.8	0.7 - 4.4	0.202
	Improved (Latrine/Flush)	97 (64.7)	1.00	Reference	
Immunization Status	Not/Partially Immunized	82 (54.7)	1.9	0.8 - 4.5	0.134
	Fully Immunized	68 (45.3)	1.00	Reference	
Recent Illness (Past 2 weeks)	Yes	89 (59.4)	1.7	0.7 - 3.9	0.215
	No	61 (40.6)	1.00	Reference	
Distance to Health Facility	> 5 km	98 (65.3)	1.4	0.6 - 3.3	0.426
	≤ 5 km	52 (34.7)	1.00	Reference	
Breastfeeding Practice	Mixed Feeding	115 (76.7)	1.6	0.6 - 4.4	0.345
	Exclusive Breastfeeding	35 (23.3)	1.00	Reference	
Constant			0.12		<0.001

Source: SPSS

Note: AOR = Adjusted Odds Ratio; CI = Confidence Interval. Dependent variable: Underweight (WAZ < -2SD) = 1, Normal (WAZ ≥ -2SD) = 0. Hosmer-Lemeshow goodness-of-fit test: χ^2=8.9, p =0.342. Nagelkerke R^2 = 0.41. The analysis revealed that low household dietary diversity was the strongest predictor of underweight in children, with those from households consuming four or fewer food groups daily having 4.2 times higher odds of being underweight (AOR = 4.2, 95% CI: 1.8–9.8, p = 0.001) compared to children in households with adequate dietary diversity, emphasizing the critical importance of diet quality over mere caloric intake. Similarly, low maternal education emerged as a significant independent predictor, as children whose mothers had no formal or only Qur'anic education were 3.1 times more likely to be underweight (AOR = 3.1, 95% CI: 1.3–7.4, p = 0.011) than those whose mothers had at least secondary education, underscoring the role of maternal literacy and knowledge in child nutrition. Extreme household poverty also independently increased risk, with children from households earning less than ₦20,000 per month having 2.8 times higher odds of being underweight (AOR = 2.8, 95% CI: 1.2–6.5, p = 0.018) compared to those from households earning over ₦50,000, confirming that economic deprivation remains a foundational driver of malnutrition. Although factors such as child's age (13–24 months), open defecation, incomplete immunization, and

recent illness showed elevated odds ratios (AOR > 1.5) suggesting increased risk, they did not reach statistical significance in the final multivariate model ($p > 0.05$), possibly due to sample size limitations or because their effects are mediated through the more powerful predictors like dietary diversity and poverty.

Discussion

This study provides a comprehensive analysis of the socio-demographic and health-related determinants of child malnutrition in Sokoto State, one of Nigeria's most nutritionally vulnerable regions. The findings reveal a population facing profound, multi-dimensional deprivation and identify three powerful, independent predictors of underweight: low household dietary diversity, low maternal education, and extreme household poverty. These results underscore that malnutrition in this context is not a simple matter of food scarcity, but a complex syndemic driven by the synergistic interaction of dietary inadequacy, educational deprivation, and economic marginalization.

Dietary Diversity: The Strongest Predictor of Nutritional Status

The finding that low household dietary diversity (≤4 food groups) was associated with 4.2-fold increased odds of underweight is the most powerful and programmatically significant result of this analysis. It confirms that the quality of the diet, not just its quantity, is the primary nutritional determinant. The vast majority of households (73.3%) subsist on monotonous, cereal-based diets dominated by millet, sorghum, and maize, with minimal consumption of animal-source foods, fruits, vegetables, and legumes. This pattern is a direct reflection of the economic constraints documented in this study, where 80% of households live below or near the poverty line, and the agricultural constraints of a rural, rain-fed farming system (Arimond & Ruel, 2004) [2].

This dietary monotony has direct physiological consequences. It explains the near-universal prevalence of micronutrient deficiencies documented biochemically in this population 91.3% vitamin A deficiency, 73.3% zinc deficiency, and 78.7% anemia (Muthayya *et al*., 2013) [13]. The absence of animal-source foods deprives children of highly bioavailable iron, zinc, and vitamin B12, while the lack of fruits and vegetables eliminates critical sources of provitamin A carotenoids and vitamin C, which enhances iron absorption (Gibson *et al*., 2018) [9]. The finding that dietary diversity remains a significant predictor even after controlling for income suggests that it is not just about purchasing power, but also about nutrition knowledge, food availability, and dietary habits all of which are amenable to intervention.

Maternal Education: The Key to Unlocking Better Nutrition

The finding that children of mothers with no formal or only Qur'anic education had 3.1 times higher odds of underweight underscores the critical role of maternal human capital in child nutrition. This result is consistent with a vast body of literature demonstrating that maternal education is one of the most consistent and powerful predictors of child survival and nutritional status (Smith *et al*., 2003; Black *et al*., 2013) [4, 17].

In the context of Sokoto State, where only 10% of caregivers have attained tertiary education, the pathways linking low maternal education to poor child nutrition are multiple and interconnected. First, education enhances health literacy the ability to understand and act upon health and nutrition information. Educated mothers are more likely to comprehend messages about exclusive breastfeeding, dietary diversity, hygiene, and the importance of immunization and timely care-seeking for childhood illnesses (Glewwe, 1999) [10]. Second, education is associated with greater autonomy and decision-making power within the household. Educated mothers may have more say in household resource allocation, including food purchases and healthcare spending, and may be less constrained by traditional norms that prioritize male household members (Smith *et al*., 2003) [17]. Third, education often leads to delayed marriage and childbearing, and lower fertility, allowing mothers to invest more time and resources in each child (Cleland & van Ginneken, 1988) [5].

The finding that even primary education showed a protective but non-significant trend (AOR = 2.1, $p = 0.089$) suggests that any formal schooling is better than none, but that secondary education provides the critical threshold for substantial nutritional benefit. This has profound implications for policy, arguing for investments not just in universal primary education, but in ensuring that girls transition to and complete secondary school (UNESCO, 2014) [20].

Extreme Poverty: The Foundational Constraint

The finding that extreme household poverty (< ₦20,000/month) was associated with 2.8-fold increased odds of underweight confirms that economic deprivation is a fundamental, non-negotiable driver of malnutrition. This income level, which characterizes nearly half the sample (45.3%), is insufficient to meet even the most basic food needs for an average household of six, l*et al*one afford a diverse, nutrient-rich diet (NPC & ICF, 2019).

Poverty operates through multiple pathways to undermine child nutrition. It directly constrains the household's ability to purchase food, forcing reliance on cheap, energy-dense staples and driving the poor dietary diversity documented in this study (Hoddinott & Yohannes, 2002) [11]. It limits access to non-food inputs essential for nutrition, including healthcare, clean water, sanitation facilities, and adequate housing. It perpetuates a cycle of vulnerability to shocks, where a single bad harvest, illness, or price spike can push households over the edge into crisis, forcing detrimental coping strategies like selling assets or reducing meal frequency (Devereux, 2006) [7]. The 64.7% of households reporting missed balanced meals for three or more days per week is the lived experience of this economic vulnerability.

The Interplay of Determinants and the "Syndemic" of Malnutrition

The multivariate model demonstrates that these three factors dietary diversity, maternal education, and poverty are not independent silos but are deeply interconnected. Poverty constrains both dietary diversity and the ability to keep girls in school. Low education limits women's economic opportunities and their ability to maximize the nutritional value of limited resources. Together, they create a "syndemic" a synergistic interaction of biological and social

factors that amplifies the burden of disease and malnutrition (Singer & Clair, 2003) [16]. This is evidenced by the biochemical profile of the children, which shows a population simultaneously suffering from protein-energy malnutrition, multiple micronutrient deficiencies, and systemic inflammation (elevated CRP).

The Normalization of Malnutrition and the "Perception Gap"

The stark discrepancy between the 22.7% of households reporting malnutrition and the objective anthropometric evidence (68.7% malnourished by MUAC) is a critical finding. This "perception gap" reveals that malnutrition has become normalized in these communities. Chronic stunting is so common that small children are perceived as "normal," and the early signs of wasting or micronutrient deficiency are misattributed to teething, common infections, or spiritual causes (Abubakar *et al*., 2012) [1]. This has profound implications for care-seeking behavior. If caregivers do not recognize their child as malnourished, they will not seek timely care, and cases will only present when they are severe and life-threatening. This finding underscores the urgent need for social and behavior change communication (SBCC) interventions that help communities recognize malnutrition as a preventable and treatable condition, and not an inevitable fact of life.

Systemic Failures: The Broken Promise of Health and Nutrition Services

The study also exposes profound weaknesses in the health and nutrition service delivery system. The low immunization coverage (45.3% fully immunized) leaves children vulnerable to vaccine-preventable diseases like measles, which are known to precipitate and exacerbate acute malnutrition (Maternal and Child Epidemiology Estimation Group, 2021) [12]. The geographic inaccessibility of health facilities (65.3% living >5 km away) creates a structural barrier to both preventive and curative care, undermining the Community-Based Management of Acute Malnutrition (CMAM) model, which relies on regular follow-up (Collins *et al*., 2006) [6]. The overwhelming perception of inadequate external support (84.7%) and the high frequency of commodity stock-outs (54.7%) reveal a broken supply chain and a fundamental lack of trust between the community and the institutions meant to serve them. When caregivers travel long distances only to be turned away from a facility with no RUTF, it not only endangers the life of that child but erodes confidence in the entire health system, discouraging future care-seeking.

The principal strength of this study lies in its comprehensive, multi-sectoral analytical framework, which integrated geographic, demographic, socioeconomic, WASH, and health-related variables to identify independent predictors of child malnutrition. This approach enables a nuanced understanding of the complex, interconnected drivers of malnutrition in a highly vulnerable population. Nevertheless, the findings must be interpreted in light of several methodological limitations. First, the cross-sectional design precludes the establishment of causal relationships, capturing only associations at a single point in time. Second, the sampling frame, consisting of Primary Health Centre attendees, may introduce selection bias. This could either overestimate the burden of malnutrition if sicker children are more likely to be brought for care, or underestimate it if the most marginalized and vulnerable children never access the health system. Third, while the sample size was sufficient to detect the large effect sizes for the primary predictors, it limited statistical power to confirm the significance of other clinically plausible risk factors (e.g., immunization status, sanitation) that exhibited elevated odds ratios. Finally, the reliance on self-reported data for variables such as income, dietary recall, and perceptions of support is subject to recall and social desirability biases, which may affect the accuracy of these measures.

Conclusion and Recommendations

This study provides irrefutable evidence that malnutrition in Sokoto State is driven by a powerful and synergistic interplay of dietary inadequacy, maternal educational deprivation, and extreme poverty. These determinants operate within a context of systemic health system failures, poor sanitation, and normalized malnutrition, creating a syndemic that traps children in a cycle of ill health and blunted potential. Addressing this crisis requires a fundamental shift from narrow, nutrition-specific interventions to comprehensive, multi-sectoral strategies that tackle the root causes.

Based on these findings, the following recommendations are made:

Prioritize Dietary Diversity as the Central Programmatic Goal:

Given that low dietary diversity was the strongest predictor of malnutrition, interventions must move beyond a calorie-centric approach to a "nutrition-sensitive" approach focused on diet quality through a multifaceted strategy addressing both availability and affordability of nutrient-dense foods. First, promoting homestead food production is essential by scaling up programs that support households to establish home gardens rich in vitamin A fruits and vegetables, raise small-scale livestock for eggs, milk, and meat, and engage in fish farming, thereby improving both access to and affordability of diverse nutritious foods at the household level. Second, nutrition education must be integrated into agriculture by reorienting agricultural extension services to include strong nutrition components that teach households not merely how to increase yields, but how to cultivate a diverse range of nutritious foods and prepare them optimally for young children's complementary feeding. Third, supporting biofortification through promoting the cultivation and consumption of enhanced staple crops such as orange-fleshed sweet potato for vitamin A and high-iron beans can significantly improve micronutrient intake without requiring major shifts in established dietary habits. Finally, addressing affordability through social protection requires that for the poorest households, production support be complemented by predictable social safety nets, including cash transfers or food vouchers specifically designed to enable the purchase of diverse, nutrient-rich foods that might otherwise remain financially out of reach.

Invest in Girls' Education as a Foundational Nutrition Intervention:

The strong link between maternal education and child nutrition argues for education to be viewed as a core nutrition-sensitive intervention, requiring a comprehensive strategy that targets both current and future generations of mothers. First, policies must prioritize keeping girls in

school through the secondary level by implementing cash transfer programs conditional on school attendance, eliminating financial barriers such as school fees, and providing safe transportation and adequate sanitary facilities to address the structural factors that drive dropout rates. Second, it is essential to integrate comprehensive, age-appropriate nutrition and health education into the basic education curriculum, thereby equipping future mothers and fathers with essential life skills and nutritional knowledge before they begin raising families. Finally, for the current generation of mothers with low literacy, there is an urgent need for intensive, community-based adult education programs that integrate functional literacy training with practical nutrition and child care messaging, ensuring that women who have already left the formal education system can still access the knowledge needed to protect their children's nutritional status.

Implement Multi-Sectoral Poverty Alleviation Strategies

The finding that extreme poverty is an independent predictor of underweight confirms that nutrition interventions cannot succeed in isolation from broader economic development, necessitating a multi-pronged approach to address its root causes. First, social protection must be strengthened by establishing and scaling up predictable, reliable programs, including unconditional and conditional cash transfers, particularly targeted to support households during the pre-harvest "lean season" when food insecurity peaks and vulnerability is greatest. Second, promoting livelihood diversification is essential to reduce dependence on climate-sensitive subsistence agriculture, requiring support for households to develop alternative income sources through skills training, access to micro-credit, and assistance for small-scale enterprises. Third, improving market access through strategic investment in rural infrastructure including roads, storage facilities, and market information systems can help reduce post-harvest losses, strengthen farmers' bargaining power, and ultimately lower the cost of nutritious foods in rural markets, making them more accessible to vulnerable populations.

Rebuild the Health and Nutrition Service Delivery System

The systemic failures identified in this study demand urgent and fundamental health system strengthening, beginning with an end to commodity stock-outs by re-engineering the supply chain for life-saving commodities such as RUTF, vitamin A capsules, and vaccines to ensure resilience through robust logistics management information systems, decentralized warehousing, and contingency planning for hard-to-reach areas. Concurrently, Community-Based Management of Acute Malnutrition (CMAM) must be strengthened by further decentralizing services and empowering Community Health Workers to conduct active MUAC screening, manage uncomplicated severe acute malnutrition, and provide follow-up care, thereby reducing the burden of travel on caregivers. Service delivery should be streamlined by creating efficient "one-stop" points that integrate nutritional screening and counseling with immunization, vitamin A supplementation, deworming, and malaria chemoprevention. Finally, addressing the WASH-nutrition nexus requires scaling up community-led total sanitation (CLTS) programs to eliminate open defecation, while actively promoting point-of-use water treatment and handwashing with soap, ensuring these critical messages are integrated into all nutrition and health contacts.

Address the "Perception Gap" through Social and Behavior Change Communication (SBCC):

The normalization of malnutrition must be actively countered through sustained, community-engaged Social and Behavior Change Communication (SBCC) by first working to redefine what is considered "normal" developing culturally appropriate communication campaigns that help communities recognize the signs of malnutrition, such as using MUAC as a "nutrition thermometer," and understand its long-term consequences for their children's future. This effort requires actively engaging community leaders by working through traditional and religious figures, who hold immense influence in Sokoto State, to champion positive nutrition and care-seeking behaviors within their spheres of influence. Furthermore, consistent messaging must be delivered using multiple platforms, including health facilities, community meetings, religious gatherings, radio, and mobile phone technologies, to ensure that life-saving information reaches every segment of the population through trusted and accessible channels.

Strengthen Governance, Accountability, and Community Participation:

The pervasive perception of inadequate support and the lack of trust in external interventions must be addressed through fundamental changes in governance, beginning with a shift from mere provision to genuine partnership by moving away from top-down program design and actively engaging communities in the assessment, design, implementation, and monitoring of nutrition programs. This must be coupled with robust efforts to ensure transparency and accountability, including establishing clear eligibility criteria for all programs, publicly disseminating information about program implementation, and creating accessible feedback and grievance mechanisms. Additionally, investment in monitoring and evaluation is crucial, requiring strengthened routine data collection that is actively used for program improvement, alongside the integration of sentinel site biochemical monitoring to track the "hidden hunger" that anthropometry alone misses. In conclusion, addressing the malnutrition crisis in Sokoto State demands a paradigm shift that moves beyond a narrow focus on treating severely malnourished children to a comprehensive, multi-sectoral approach tackling the interconnected determinants of poor diet quality, low maternal education, and extreme poverty, while simultaneously rebuilding a trusted and functional health system; the children of Sokoto cannot afford anything less.

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