

BMJ Open Dietary diversity and child malnutrition in Ghana: a nationally representative analysis of socioeconomic gradients and effect modification

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ABSTRACT

Background Inadequate dietary diversity during complementary feeding contributes to high childhood malnutrition rates in sub-Saharan Africa. Understanding relationships between dietary quality and nutritional outcomes across socioeconomic subgroups is essential for designing effective, equitable interventions.

Objective We examined associations between dietary diversity and nutritional status among children aged 0–23 months in Ghana, with attention to effect modification by socioeconomic factors.

Methods We analysed data from 2031 children Ghana Demographic and Health Survey 2022 Dietary diversity was assessed using the WHO minimum dietary diversity indicator (≥ 5 of 7 food groups consumed in 24 hours). Nutritional status was evaluated through WHO z-scores; stunting, wasting and underweight were defined as z-scores below -2 SD. Survey-weighted multivariable logistic regression examined associations adjusting for child, maternal, household and geographic factors. Sensitivity analyses included prevalence ratios from modified Poisson regression, an 8-food-group minimum dietary diversity definition and models with region and additional covariates. Stratified analyses tested effect modification.

Results Only 28.3% of children aged 6–23 months achieved minimum dietary diversity, with disparities by wealth (20.8% poorest vs 47.6% richest) and maternal education (16.6% no education vs 57.1% higher education). Stunting affected 14.8% of children overall, increasing with age. In fully adjusted models, minimum dietary diversity was associated with a 42% reduction in underweight odds (OR=0.58, 95% CI 0.37 to 0.91, $p=0.018$). Wasting showed a consistent protective direction (OR=0.63, 95% CI 0.36 to 1.11, $p=0.110$), reaching significance with the 8-food-group definition (OR=0.51, $p=0.012$) and in dose–response analysis (OR=0.86 per food group, $p=0.018$). No association was observed for stunting (OR=1.09, 95% CI 0.73 to 1.63, $p=0.678$). Dose–response patterns were evident for underweight (OR=0.88 per food group, $p=0.021$) and wasting (OR=0.86, $p=0.018$). Exploratory stratified analyses suggested stronger protective associations among children of mothers with lower education, though formal interaction tests were non-significant.

Conclusions Dietary diversity is associated with reduced acute malnutrition among Ghanaian children,

STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ This study uses nationally representative data from the 2022 Ghana Demographic and Health Survey with survey-weighted analyses accounting for complex multistage sampling design.
- ⇒ Dietary diversity was assessed using the WHO minimum dietary diversity indicator based on a standardised list-based 24-hour recall instrument administered by trained interviewers.
- ⇒ Sequential multivariable models with progressive covariate adjustment, dose–response analyses and multiple sensitivity analyses (prevalence ratios, 8-food-group definition, region adjustment and expanded covariates) strengthen the analytical framework.
- ⇒ The cross-sectional design precludes causal inference and reverse causation whereby poorly nourished children consume less diverse diets cannot be excluded.
- ⇒ Dietary assessment relied on a single 24-hour recall, which may not capture habitual intake and is subject to recall and social desirability bias.

particularly underweight, with suggestive evidence for wasting. The null finding for stunting is consistent with the multifactorial, cumulative aetiology of chronic malnutrition. Findings support incorporating dietary diversity improvement into equity-focused nutrition strategies while recognising that addressing stunting requires broader multi-sectoral approaches.

INTRODUCTION

Adequate nutrition during the first 1000 days of life represents a critical foundation for child survival, growth and long-term development. Global estimates indicate that approximately 149 million children under 5 years were stunted and 45 million were wasted in 2020, with the vast majority concentrated in low- and middle-income countries. Sub-Saharan Africa bears a disproportionate share of childhood malnutrition, with regional stunting prevalence of approximately 30% substantially exceeding the global average.¹

The consequences of early childhood malnutrition extend far beyond immediate health impacts, encompassing increased mortality risk, impaired cognitive development, reduced educational achievement, diminished adult productivity and intergenerational transmission of poverty.²

Ghana is a lower-middle-income country in West Africa with a population of approximately 33 million, currently experiencing rapid economic growth and demographic transition. The 2022 Ghana Demographic and Health Survey (DHS) documented a total fertility rate of 3.9 births per woman, with a median age at first birth of 21.0 years.³ Exclusive breastfeeding for the first 6 months is practised by 68.3% of mothers, and 96.6% of infants under 6 months are currently breastfeeding.³ Women's educational attainment has improved considerably, with 52.4% of mothers of young children having completed secondary education and 12.7% attaining higher education; however, 19.2% remain without any formal education, with substantial regional variation concentrated in the northern savannah zone.³ Approximately 61.3% of mothers report engagement in income-generating work.³ Despite progress in poverty reduction, significant socioeconomic disparities persist between Ghana's urbanised southern regions and the predominantly rural northern regions, with implications for food access, dietary quality and child health outcomes.

The period from 6 to 23 months represents a particularly vulnerable window during which growth faltering, micronutrient deficiencies and infectious diseases converge to undermine nutritional status. During this complementary feeding period, infants transition from exclusive breastfeeding to increasing reliance on family foods that may be insufficient in quantity or quality. Dietary diversity, defined as the number of different food groups consumed over a reference period, has emerged as a practical indicator of diet quality in resource-constrained settings.⁴ The WHO minimum dietary diversity indicator defines adequate diversity as consumption of foods from at least five of seven food groups in the preceding 24 hours.⁵ The theoretical basis rests on the principle that essential nutrients are distributed across different food categories, such that consuming greater variety increases the probability of meeting requirements for multiple nutrients simultaneously.⁶

Despite the conceptual appeal of dietary diversity indicators, several questions remain inadequately addressed. While cross-sectional associations between dietary diversity and child anthropometric status have been documented in numerous settings,^{7–10} the magnitude and consistency vary considerably across studies. Randomised controlled trials of interventions to improve dietary diversity have shown mixed results, with some demonstrating improvements in child growth and others finding effects on dietary intake but not anthropometric outcomes.^{11–13} This heterogeneity suggests that contextual factors may modify the relationship, yet few studies have systematically examined effect modification across population

subgroups. Most existing research has focused on rural populations or specific regions, with limited nationally representative analyses capturing the full spectrum of urban–rural and socioeconomic diversity.

Ghana presents a particularly relevant context given its status as a lower-middle-income country experiencing rapid economic growth and demographic transition. National stunting prevalence declined from approximately 32.7% in 1993 to 17.3% in 2022, indicating progress but highlighting that nearly one in five young children continue experiencing chronic malnutrition.¹⁴ This study examined the relationship between dietary diversity and nutritional status among infants and young children in Ghana using nationally representative data, with specific attention to whether associations vary across wealth quintiles, urban–rural settings and maternal education levels.

METHODS

The STrengthening the Reporting of OBservational studies in Epidemiology reporting guideline was used to prepare this manuscript, with the completed checklist included in supplementary materials.¹⁵

Study design and data source

This study employed a cross-sectional analytical design using data from the Ghana DHS conducted in 2022. The Ghana 2022 survey employed a two-stage stratified cluster sampling design, with enumeration areas serving as primary sampling units and households as secondary sampling units. The sampling frame was stratified by region and urban–rural residence, with probability proportional to size selection of clusters within each stratum and systematic random selection of households within clusters. All women aged 15–49 years in selected households were eligible for interview, and anthropometric measurements and feeding practice assessments were conducted for all children under 5 years. Fieldwork was conducted between October 2022 and January 2023 by trained interviewers and anthropometry teams.

Study population

The analytical sample comprised children aged 0–23 months living with their mothers at the time of the survey with complete anthropometric and feeding practice data. Of 2047 children identified, children with biologically implausible anthropometric values were excluded on an outcome-specific basis (see below), yielding a final analytical sample of 2031 children with at least one valid anthropometric outcome. For complementary feeding analyses, the sample was restricted to children aged 6–23 months (n=1516) because dietary diversity indicators are not applicable to infants under 6 months who should be exclusively breastfed. Missing data were minimal: anthropometric outcomes had less than 1% missing (13–15 children per outcome with biologically implausible values); all covariates had 0% missing. Complete-case analysis was employed for regression models.

Dietary diversity assessment

Dietary diversity was assessed using the WHO minimum dietary diversity indicator for children aged 6–23 months, following the original 7-food-group definition (WHO 2008/2010).⁵ Trained DHS interviewers administered a structured, list-based 24-hour dietary recall to mothers or primary caregivers, reading a standardised list of food items and recording whether each was consumed by the child in the preceding 24 hours. This is a food-group screening tool rather than an open-ended quantitative dietary recall; a single interview was conducted per child, consistent with the DHS cross-sectional design. The DHS-8 Woman's Questionnaire (Infant and Young Child Feeding section) served as the instrument and is publicly available from the DHS Programme (dhsprogram.com).^{16 17}

Reported foods were classified into seven standard food groups using the following variable mapping from the Ghana DHS 2022 Kids Recode (GHR8C): (1) grains, roots and tubers (v414e: bread/noodles/grains; v414f: plantains/potatoes/cassava/tubers); (2) legumes and nuts (v414o: beans/peas/lentils; v414c: nuts/seeds); (3) dairy products (v411: tinned/powdered/fresh milk; v411a: baby formula; v414p: cheese; v414v: yoghurt); (4) flesh foods (v414h: meat; v414n: fish/shellfish; v414m: organ meat; v414b: processed meat; v414d: insects); (5) eggs (v414g); (6) vitamin A-rich fruits and vegetables (v414i: pumpkin/carrots/squash; v414j: dark green leafy vegetables; v414k: mangoes/papayas/vitamin A fruits; v414u: red palm oil); and (7) other fruits and vegetables (v414a: other vegetables; v414l: other fruits).

A binary indicator for each food group denoted whether the child consumed any food from that group. The dietary diversity score was calculated as the sum of food groups consumed, ranging from zero to seven. Minimum dietary diversity was defined as consumption of foods from at least five of seven food groups, coded as a binary indicator. As a sensitivity analysis, we also computed an 8-food-group indicator incorporating breast milk as a separate group¹⁸ update, with minimum dietary diversity defined as consumption from at least five of eight groups.¹⁸

Anthropometric assessment

Child weight and recumbent length were collected by trained teams using standardised equipment and techniques. Weight was measured to the nearest 100 g using electronic SECA scales calibrated daily. Recumbent length was measured to the nearest millimetre using portable length boards. All measurements were taken in duplicate, with a third measurement obtained if the difference between the first two exceeded prespecified tolerance limits. Anthropometric indices were calculated using the WHO 2006 Child Growth Standards. Weight-for-length z-scores (WLZ), length-for-age z-scores (LAZ) and weight-for-age z-scores (WAZ) were computed using WHO Anthro software. Biologically implausible values were flagged and excluded on an outcome-specific basis

following WHO recommendations: LAZ below −6 or above +6, WLZ below −5 or above +5 and WAZ below −6 or above +5. Wasting was defined as WLZ below −2 SD, stunting as LAZ below −2 SD and underweight as WAZ below −2 SD.

Covariates

Child characteristics assessed included age in months, sex, current breastfeeding status and recent diarrhoeal disease defined as caregiver report of diarrhoea during the 2 weeks preceding the interview. Acute respiratory infection (ARI) was defined as concurrent cough and short, rapid breathing in the preceding 2 weeks. Vitamin A supplementation was defined as receipt of a high-dose vitamin A supplement within 6 months preceding the survey (DHS variable h34, binary). Maternal characteristics included age, educational attainment categorised as no education, primary, secondary or higher education. Household characteristics included household size, number of children under five (v137), access to improved water sources and improved sanitation facilities classified per Joint Monitoring Programme (JMP) definitions and wealth index constructed by the DHS Programme using principal components analysis with households divided into quintiles. Geographic variables included region of residence (16 administrative regions) and urban–rural classification.

The covariate set was informed by a conceptual directed acyclic graph based on the UNICEF framework for child malnutrition (supplementary material), selecting variables along the causal pathway from dietary diversity to nutritional status while avoiding adjustment for colliders or mediators. Region was excluded from the primary model due to collinearity with wealth and urban–rural classification across 16 regions with small within-stratum sample sizes but was included in a sensitivity model.

Statistical analysis

All analyses incorporated survey sampling weights, stratification and clustering to account for the complex survey design and produce nationally representative estimates with appropriate SEs. The survey design was specified using primary sampling units (v021), sample strata (v022) and individual sampling weights (v005/1 000 000) with nesting of PSUs within strata. Variance estimation employed Taylor series linearisation. Survey-weighted proportions with 95% CIs were calculated for dietary diversity indicators and malnutrition outcomes overall and stratified by subgroups. Design-adjusted Rao–Scott χ^2 tests assessed subgroup differences.

Multivariable logistic regression models examined associations between minimum dietary diversity and binary malnutrition outcomes, estimating ORs and 95% CIs using the quasibinomial family. Three sequential models were fitted: model 1 controlled for child age and sex; model 2 additionally adjusted for current breastfeeding status and recent diarrhoeal disease; model 3 additionally

controlled for maternal education, household wealth quintile, vitamin A supplementation and urban–rural residence.

Sensitivity analyses included: (1) modified Poisson regression with quasipoisson family estimating prevalence ratios, addressing the recommendation to use prevalence ratios for cross-sectional studies; (2) the 8-food-group MDD definition with breast milk as a separate group; (3) models additionally adjusting for region; (4) models with expanded covariates including ARI symptoms and improved water/sanitation; (5) dietary diversity score as a continuous predictor assessing dose–response and (6) linear regression with anthropometric z-scores as continuous outcomes. Effect modification was examined through stratified analyses within strata defined by household wealth quintile, urban–rural residence, child age group, breastfeeding status and maternal education level. Multiplicative interaction was tested using design-adjusted Wald tests. Subgroup analyses are presented as hypothesis-generating given multiple comparisons and limited power. Statistical significance was assessed at the 0.05 alpha level. All analyses were performed using R V.4.3.1 with the survey package for complex survey analysis.

Patient and public involvement

Patients or the public were not involved in the design, conduct, reporting or dissemination plans of this research. This study involved secondary analysis of publicly available, deidentified survey data from reference.³

RESULTS

Sample characteristics

The analytical sample comprised 2031 children aged 0–23 months, with valid anthropometric data for 1999 (stunting), 1998 (wasting) and 2002 (underweight). Sex distribution was balanced, with 51.7% male and 48.3% female children. Mean age was 11.5 months (SD 7.0). Children aged 12–23 months constituted 50.3% of the sample, followed by infants 0–5 months at 25.4%, 6–8 months at 12.3% and 9–11 months at 12.0%. Current breastfeeding prevalence was 96.6% among 0–5 month infants, 97.6% among 6–8 month-olds, 96.8% among 9–11 month-olds and 70.6% among 12–23 month children. Maternal mean age was 29.6 years. Educational attainment varied substantially, with 19.2% having no formal education, 15.7% primary, 52.4% secondary and 12.7% higher education. Mean household size was 5.6 members. Access to improved water sources reached 83.6% of households, while 85.5% had improved sanitation. Mean number of children under five per household was 1.7. ARI prevalence in the preceding 2 weeks was 5.8%. Geographic distribution reflected national settlement patterns, with 58.2% in rural areas and 41.8% in urban areas. Complete sample characteristics are presented in [table 1](#).

Table 1 Characteristics of the study sample: children aged 0–23⁷ (n=2031)

Characteristic	Value
Total children	2031
Child characteristics	
Age (months), mean (SD)	11.5 (7.0)
Age category	
0–5 months	515 (25.4%)
6–8 months	250 (12.3%)
9–11 months	244 (12.0%)
12–23 months	1022 (50.3%)
Sex	
Male	1051 (51.7%)
Female	980 (48.3%)
Currently breastfeeding	
0–5 months	96.6%
6–8 months	97.6%
9–11 months	96.8%
12–23 months	70.6%
Overall (6–23 months)	79.3%
Recent diarrhoea (past 2 weeks)	18.6%
ARI symptoms (past 2 weeks)	5.8%
Vitamin A supplementation (past 6 months)	67.8%
Maternal characteristics	
Age (years), mean (SD)	29.6 (6.4)
Education level	
No education	19.2%
Primary	15.7%
Secondary	52.4%
Higher	12.7%
Currently married/in union	78.6%
Engaged in income-generating work	61.3%
Household characteristics	
Household size, mean (SD)	5.6 (2.9)
Children under five per household, mean (SD)	1.7 (0.9)
Improved water source	83.6%
Improved sanitation facility	85.5%
Wealth quintile	
Poorest	24.2%
Poorer	19.9%
Middle	18.8%
Richer	19.8%
Richest	17.3%
Geographic characteristics	
Residence	
Rural	58.2%
Urban	41.8%

Continued

Table 1 Continued

Characteristic	Value
Data are weighted to account for complex survey design unless otherwise noted. Percentages may not sum to 100% due to rounding.	
ARI, acute respiratory infection.	

Dietary diversity achievement and food group consumption

Among children aged 6–23 months, 28.3% achieved minimum dietary diversity (MDD-7), indicating that fewer than one in three young children consumed foods from at least five of seven food groups. Mean dietary diversity score was 3.28 food groups (SE 0.07). The distribution showed 12.6% of children consumed zero food groups, 11.0% one group, 11.6% two groups, 18.1% three groups, 21.6% four groups, 17.1% five groups, 6.3% six groups and 1.5% all seven groups. Dietary diversity achievement increased substantially with child age, rising from 6.1% among 6–8 month-olds to 26.3% among 9–11 month-olds and 34.2% among 12–23 month-olds. Wealth-related gradients were substantial, ranging from 20.8% in the poorest quintile to 18.1% poorer, 23.3% middle, 35.4% richer and 47.6% richest. Maternal education showed similar gradients, from 16.6% among mothers with no education to 19.5% primary, 30.9% secondary and 57.1% higher education. Urban children achieved MDD at 32.3% compared with 24.8% of rural children. [Table 2](#) presents dietary diversity achievement by all subgroups. [Figure 1](#) illustrates the socioeconomic gradients in MDD achievement and stunting prevalence across wealth quintiles.

Using the updated 8-food-group definition (with breast milk as a separate group), 45.2% of children achieved MDD-8 (≥ 5 of 8 groups), reflecting the high breastfeeding prevalence in this age group.

Examination of individual food group consumption revealed important patterns. Grains, roots and tubers were consumed by 84.5% of children. Other fruits and vegetables reached 64.2%, flesh foods 55.8%, vitamin A-rich fruits and vegetables 39.5%, dairy products 33.4%, legumes and nuts 28.0% and eggs 22.1%. Food group consumption patterns by age group are presented in [table 3](#).

Prevalence of malnutrition

Stunting affected 14.8% of children (SE 1.2), with prevalence increasing from 13.4% among 0–5 month-olds to 9.9% among 6–8 month-olds, 12.9% among 9–11 month-olds and 17.2% among 12–23 month-olds. Male children showed higher stunting at 17.8% compared with 11.7% among females. Stunting varied by wealth from 19.5% in the poorest quintile to 9.1% in the richest. Wasting affected 8.5% of children (SE 0.9). Male wasting prevalence was 10.1% versus 6.8% among females. Underweight affected 13.4% of children (SE 1.0). Complete malnutrition prevalence by subgroups is presented in [table 4](#).

Table 2 Dietary diversity achievement among children aged 6–23 months by population subgroups (n=1516)

Characteristic	N	Mean DDS $\pm$ SD	MDD achievement (%)	P value
Overall	1516	3.3 $\pm$ 1.8	28.3	–
Age group				<0.001
6–8 months	250	1.9 $\pm$ 1.6	6.1	
9–11 months	244	3.2 $\pm$ 1.8	26.3	
12–23 months	1022	3.6 $\pm$ 1.7	34.2	
Sex				0.41
Male	760	3.2 $\pm$ 1.8	27.1	
Female	756	3.3 $\pm$ 1.8	29.5	
Residence				0.031
Rural	891	3.1 $\pm$ 1.8	24.8	
Urban	625	3.4 $\pm$ 1.8	32.3	
Wealth quintile				<0.001
Poorest	498	3.0 $\pm$ 1.8	20.8	
Poorer	356	2.9 $\pm$ 1.7	18.1	
Middle	273	3.2 $\pm$ 1.7	23.3	
Richer	214	3.7 $\pm$ 1.8	35.4	
Richest	175	3.8 $\pm$ 1.9	47.6	
Maternal education				<0.001
No education	437	2.8 $\pm$ 1.7	16.6	
Primary	246	2.8 $\pm$ 1.8	19.5	
Secondary	717	3.4 $\pm$ 1.8	30.9	
Higher	116	4.2 $\pm$ 1.9	57.1	

Data are survey-weighted. P values from design-adjusted Rao–Scott χ^2 tests.
DDS, Dietary Diversity Score; MDD, minimum dietary diversity (≥ 5 of 7 food groups).

Bivariate associations between dietary diversity and nutritional status

Among children not achieving minimum dietary diversity, stunting prevalence was 15.8% compared with 14.1% among those achieving it. For wasting, prevalence was 11.0% among those not achieving MDD versus 6.4% among those achieving it. The strongest bivariate gradient was for underweight: 17.7% among those not achieving MDD versus 9.8% among those achieving it. Analysis across dietary diversity categories showed dose–response patterns for wasting (13.9% for 0–2 groups, 8.6% for 3–4 groups and 6.4% for 5–7 groups) and underweight, but not for stunting.

Multivariable regression analysis

For underweight, the minimally adjusted model yielded OR=0.50 (95% CI 0.32 to 0.77, $p=0.002$). The fully adjusted model yielded OR=0.58 (95% CI 0.37 to 0.91, $p=0.018$), representing a 42% reduction in underweight odds.

Socioeconomic Gradients in Dietary Diversity and Stunting

MDD among children 6–23 months; Stunting among children 0–23 months
Ghana Demographic and Health Survey 2022

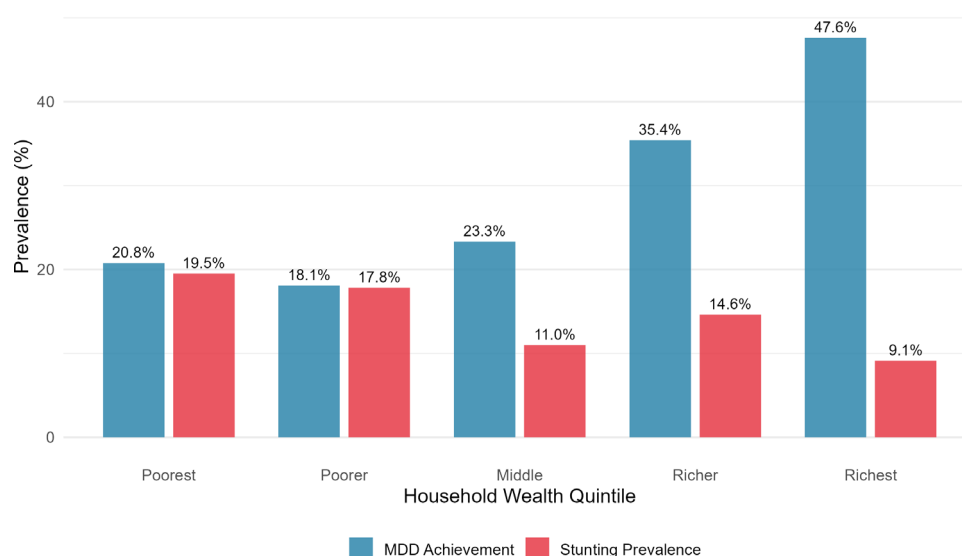


Figure 1 Socioeconomic gradients in minimum dietary diversity achievement and stunting prevalence by household wealth quintile, Ghana DHS 2022. MDD assessed among children aged 6–23 months (n=1516). Stunting assessed among children aged 0–23 months (n=2031). MDD defined as consumption of foods from at least five of seven food groups in the preceding 24 hours. Stunting defined as length-for-age z-score below minus two SD. Data weighted to account for complex survey design. DHS, Demographic and Health Survey; MDD, minimum dietary diversity.

Table 3 Food group consumption among children aged 6–23 months by age group (n=1516)

Food group	6–8 months (%)	9–11 months (%)	12–23 months (%)	Overall (%)
Grains, roots, tubers	66.0	79.6	90.2	84.5
Legumes and nuts	6.9	23.9	34.2	28.0
Dairy products	39.8	44.4	29.1	33.4
Flesh foods	19.3	49.8	66.1	55.8
Eggs	7.2	17.3	26.9	22.1
Vitamin A-rich F&V	17.7	37.9	45.3	39.5
Other fruits and vegetables	33.3	63.4	71.9	64.2
Breast milk*	97.6	96.8	70.6	79.3
Mean DDS±SD	1.9±1.6	3.2±1.8	3.6±1.7	3.3±1.8
MDD-7 achievement (%)	6.1	26.3	34.2	28.3

Breast milk (current breastfeeding status) included in 8-food-group sensitivity analysis only.

Bold values indicate summary statistics.

*Values represent weighted percentage of children who consumed at least one food from each group in the 24 hours preceding the survey. Food groups defined per WHO 2008 IYCF indicator framework using DHS v414 variable series.

DDS, Dietary Diversity Score; DHS, Demographic and Health Survey; F&V, fruits and vegetables; MDD, minimum dietary diversity (≥5 of 7 food groups).

Other significant predictors included male sex (OR=1.91, $p<0.001$), recent diarrhoea (OR=1.71, $p=0.023$), and urban residence (OR=1.58, $p=0.030$).

For wasting, the minimally adjusted model yielded OR=0.59 (95% CI 0.33 to 1.06, $p=0.077$). The fully adjusted model yielded OR=0.63 (95% CI 0.36 to 1.11, $p=0.110$), representing a 37% reduction that did not reach statistical significance. Male sex (OR=1.88, $p=0.014$) and recent diarrhoea (OR=2.05, $p=0.016$) were significant predictors.

For stunting, no association with MDD was observed. The fully adjusted model yielded OR=1.09 (95% CI 0.73 to 1.63, $p=0.678$). Significant predictors included child age (OR=1.05 per month, $p=0.010$), male sex (OR=2.10, $p<0.001$) and household wealth (OR=0.77 per quintile, $p=0.015$). Bivariate associations and complete multivariable regression results are presented in [table 5](#). [figure 2](#) presents the fully adjusted ORs for the association between MDD and all three malnutrition outcomes.

Sensitivity analyses

Modified Poisson regression yielded consistent results: underweight PR=0.63 (0.43–0.93, $p=0.020$), wasting PR=0.66 (0.39–1.10, $p=0.113$), stunting PR=1.07 (0.77–1.48, $p=0.685$). The 8-food-group MDD definition strengthened the wasting association (OR=0.51, 0.30–0.86, $p=0.012$) and showed a trend for underweight (OR=0.66, $p=0.062$). Adding region to the fully adjusted model strengthened the underweight finding (OR=0.54, 0.33–0.87, $p=0.011$). Expanded covariates including ARI, improved water and improved sanitation did not

Table 4 Prevalence of malnutrition among children aged 0–23 months by population subgroups (n=2031)

Characteristic	N	Stunting (%)	P value	Wasting (%)	P value	Underweight (%)	P value
Overall	2031	14.8	—	8.5	—	13.4	—
Age group			0.14		0.15		0.003
0–5 months	515	13.4		4.7		7.2	
6–8 months	250	9.9		10.8		12.5	
9–11 months	244	12.9		10.1		16.3	
12–23 months	1022	17.2		9.4		15.9	
Sex			0.002		0.053		0.009
Male	1051	17.8		10.1		15.8	
Female	980	11.7		6.8		10.9	
Residence			0.38		—		—
Rural	1214	15.8		8.5		13.5	
Urban	817	13.7		8.5		13.3	
Wealth quintile			0.015		0.80		0.070
Poorest	665	19.5		8.2		15.3	
Poorer	487	17.8		10.8		18.0	
Middle	359	11.0		8.2		10.6	
Richer	297	14.6		7.4		13.0	
Richest	223	9.1		7.8		8.9	
Maternal education			0.056		—		—
No education	592	19.5		9.4		16.5	
Primary	324	16.3		11.9		16.9	
Secondary	958	13.6		7.5		12.5	
Higher	157	8.9		6.3		5.7	

Biologically implausible values excluded per WHO thresholds (LAZ <−6 or >+6; WLZ <−5 or >+5; WAZ <−6 or >+5).

Data are survey-weighted. P values from design-adjusted Rao–Scott χ^2 tests. Dashes indicate p values not computed where differences were negligible.

LAZ, length-for-age z-score; Stunting, length-for-age z-score <−2 SD; Underweight, weight-for-age z-score <−2 SD; Wasting, weight-for-length z-score <−2 SD; WAZ, weight-for-age z-score; WLZ, weight-for-length z-score.

materially change MDD estimates; ARI was not significantly associated with any outcome (all $p>0.37$).

Dose–response analyses with continuous DDS showed significant associations for wasting (OR=0.86 per food group, 0.76–0.97, $p=0.018$) and underweight (OR=0.88, 0.80–0.98, $p=0.021$), but not stunting (OR=1.01, 0.90–1.13, $p=0.870$).

Effect modification analysis

Exploratory stratified analyses examined whether associations varied across population subgroups. All formal interaction tests were non-significant (all $p>0.30$). For wasting, a notable exploratory finding was the stronger protective association among children of mothers with lower education (OR=0.30, 95% CI 0.10 to 0.88, $p=0.030$) compared with higher education (OR=0.88, $p=0.716$) and among rural children (OR=0.44, 95% CI 0.18 to 1.08, $p=0.076$) compared with urban children (OR=0.78, $p=0.531$). Among currently breastfeeding children, MDD was associated with reduced wasting (OR=0.51, $p=0.047$). For stunting, no meaningful subgroup variation was

observed; point estimates were close to null across all strata. These subgroup findings should be interpreted as hypothesis-generating given the multiple comparisons and limited statistical power within individual strata. Sensitivity analyses and stratified results are presented in [table 6](#).

DISCUSSION

This nationally representative analysis of 2031 Ghanaian children provides evidence that dietary diversity is associated with reduced risk of acute malnutrition, particularly underweight, with suggestive evidence for wasting but not stunting. The findings are strengthened by dose–response relationships, robustness across multiple sensitivity specifications and biological plausibility.

Principal findings

Achievement of minimum dietary diversity was associated with 42% lower odds of underweight (OR=0.58, 95% CI 0.37 to 0.91), a finding robust across sensitivity analyses

Table 5 Bivariate and multivariable associations between dietary diversity and malnutrition among children aged 6–23 months (n=1516)

Variable	N	Stunting (%)		Wasting (%)		Underweight (%)	
Panel A: bivariate associations—malnutrition prevalence by dietary diversity							
By MDD achievement							
MDD not achieved	1137	15.8		11		17.7	
MDD achieved	379	14.1		6.4		9.8	
By DDS category							
0–2 food groups	534	15.2		13.9		19.4	
3–4 food groups	603	16.2		8.6		16.3	
5–7 food groups	379	14.1		6.4		9.8	
By egg consumption							
Did not consume eggs	1,268	15.8		10.1		16.2	
Consumed eggs	248	13.7		8.4		12.6	
Variable	Stunting		Wasting		Underweight		P value
	OR (95% CI)	P value	OR (95% CI)	P value	OR (95% CI)	P value	
Panel B: multivariable logistic regression—adjusted OR (95% CI)							
Model 1							
MDD achieved	0.82 (0.56–1.21)	0.316	0.59 (0.33–1.06)	0.076	0.50 (0.32–0.77)	0.002	
Age (per month)	1.04 (1.01–1.08)	0.024	0.98 (0.93–1.03)	0.429	1.01 (0.97–1.05)	0.569	
Male sex	2.06 (1.39–3.06)	<0.001	1.92 (1.18–3.13)	0.009	1.89 (1.33–2.69)	<0.001	
Model 2							
MDD achieved	0.87 (0.59–1.28)	0.486	0.60 (0.34–1.08)	0.088	0.52 (0.33–0.80)	0.003	
Age (per month)	1.06 (1.02–1.11)	0.002	0.98 (0.93–1.03)	0.497	1.02 (0.98–1.07)	0.33	
Male sex	2.08 (1.39–3.10)	<0.001	1.93 (1.18–3.14)	0.009	1.90 (1.33–2.70)	<0.001	
Currently breastfeeding	1.80 (1.00–3.24)	0.051	1.13 (0.56–2.29)	0.739	1.41 (0.76–2.61)	0.283	
Recent diarrhoea	1.18 (0.77–1.83)	0.448	2.00 (1.11–3.61)	0.021	1.70 (1.07–2.70)	0.026	
Model 3							
MDD achieved	1.09 (0.73–1.63)	0.678	0.63 (0.36–1.11)	0.11	0.58 (0.37–0.91)	0.018	
Age (per month)	1.05 (1.01–1.10)	0.01	0.99 (0.94–1.04)	0.589	1.02 (0.98–1.06)	0.372	
Male sex	2.10 (1.41–3.13)	<0.001	1.88 (1.14–3.09)	0.014	1.91 (1.34–2.71)	<0.001	
Currently breastfeeding	1.44 (0.80–2.59)	0.219	1.08 (0.52–2.24)	0.834	1.26 (0.67–2.35)	0.474	
Recent diarrhoea	1.17 (0.76–1.79)	0.487	2.05 (1.15–3.65)	0.016	1.71 (1.08–2.72)	0.023	
Education: primary	0.88 (0.55–1.41)	0.592	1.15 (0.59–2.26)	0.674	0.98 (0.57–1.67)	0.939	
Education: secondary	0.72 (0.45–1.17)	0.187	0.71 (0.37–1.36)	0.301	0.93 (0.57–1.51)	0.768	
Education: higher	0.48 (0.13–1.75)	0.265	0.94 (0.30–2.92)	0.918	0.54 (0.17–1.73)	0.301	
Wealth (per quintile)	0.77 (0.62–0.95)	0.015	0.97 (0.77–1.22)	0.769	0.86 (0.72–1.03)	0.093	
Vitamin A supplementation	0.75 (0.45–1.25)	0.27	0.68 (0.37–1.24)	0.211	0.70 (0.44–1.10)	0.119	
Urban residence	1.37 (0.79–2.38)	0.269	1.40 (0.85–2.30)	0.186	1.58 (1.05–2.38)	0.03	
Panel A: survey-weighted prevalences.							
Panel B: survey-weighted logistic regression using quasibinomial family. Model 1: adjusted for child age and sex. Model 2: additionally adjusted for current breastfeeding and recent diarrhoea. Model 3: additionally adjusted for maternal education (reference: no education), household wealth, vitamin A supplementation and urban–rural residence.							
DDS, Dietary Diversity Score; MDD, minimum dietary diversity (≥5 of 7 food groups).							

including prevalence ratios (PR=0.63, $p=0.020$), region-adjusted models (OR=0.54, $p=0.011$) and expanded covariate models. Dose–response relationships strengthened this finding, with each additional food group

associated with 12% lower odds of underweight (OR=0.88, $p=0.021$). The magnitude of these associations is comparable to effect sizes reported in meta-analyses of micro-nutrient supplementation and fortification interventions

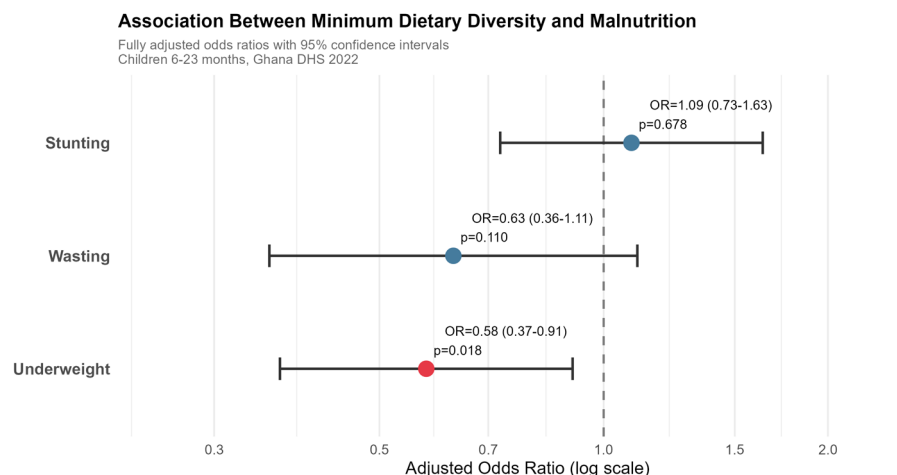


Figure 2 Association between minimum dietary diversity and malnutrition outcomes: fully adjusted ORs with 95% CIs. Children aged 6–23 months, Ghana DHS 2022 (n=1516). Models adjusted for child age, sex, current breastfeeding, recent diarrhoea, maternal education, household wealth, vitamin A supplementation and urban–rural residence. Red point indicates statistically significant association ($p<0.05$); blue points indicate non-significant associations. Dashed line represents null value (OR=1.0). DHS, Demographic and Health Survey.

in low- and middle-income countries.¹⁹ For wasting, the protective direction was consistent (OR=0.63, $p=0.110$), reaching significance with the 8-food-group definition (OR=0.51, $p=0.012$) and in dose–response analysis (OR=0.86, $p=0.018$). The convergence of multiple lines of evidence suggests a genuine protective association between dietary diversity and acute nutritional status. The finding that only 28.3% of Ghanaian children achieve MDD aligns with regional averages for West Africa but falls substantially short of global targets, consistent with multi-country analyses documenting similarly low dietary diversity across sub-Saharan Africa.^{20–22}

No association was observed between dietary diversity and stunting in any specification. This null finding contrasts with some previous cross-sectional studies but is consistent with the understanding that stunting reflects cumulative growth faltering driven by chronic nutritional deficiency, repeated infection, environmental enteropathy and intergenerational factors that a single-day dietary measure cannot adequately capture. The biological plausibility of dietary diversity affecting current weight status more than cumulative linear growth aligns with the temporal dynamics of these anthropometric indicators.

Multicausality and contextual factors

These findings must be interpreted within the UNICEF conceptual framework recognising that child malnutrition results from complex, multilevel interactions between immediate causes (dietary intake and disease), underlying causes (food security, care practices, health services, environment) and basic causes (socioeconomic conditions, governance). Dietary diversity, while an important proximal indicator of nutrient adequacy, operates alongside and is shaped by upstream structural factors. The steep socioeconomic gradients in MDD achievement; with more than twofold differences between poorest and richest quintiles, demonstrate that dietary quality is

strongly patterned by household economic resources and food access constraints. Research linking household food insecurity with dietary behaviours supports this interpretation.²³ Similarly, achieving dietary diversity requires not only food availability but also capabilities including food preparation skills and time,²⁴ factors not measured in the DHS.

Reverse causation and residual confounding

The cross-sectional design precludes definitive causal inference. Reverse causation is a plausible concern: children experiencing acute malnutrition may have reduced appetite, increased illness-related anorexia or altered feeding behaviours that reduce dietary diversity, potentially inflating observed protective associations. While adjustment for recent diarrhoea partially addresses illness-related confounding, the 2week recall period may not capture the full burden of infection. Residual confounding by unmeasured factors, including maternal mental health, household food insecurity, hygiene practices, mycotoxin exposure and environmental enteropathy, could bias estimates in either direction. The attenuation of the wasting association from minimally adjusted (OR=0.59) to fully adjusted (OR=0.63) models was modest, suggesting limited confounding by measured socioeconomic factors, though unmeasured confounding remains possible.

Effect modification and targeting implications

Exploratory stratified analyses suggested potentially stronger protective associations for wasting among children of mothers with lower education (OR=0.30, $p=0.030$) and among rural children (OR=0.44, $p=0.076$), compared with their better-off counterparts. However, formal interaction tests were consistently non-significant (all $p>0.30$), reflecting limited statistical power and the multiple comparisons involved. These findings should

Table 6 Sensitivity analyses and effect modification: dietary diversity and malnutrition among children aged 6–23 months

Analysis	Stunting		Wasting		Underweight	
Panel A: sensitivity analyses—alternative model specifications						
Primary model (OR)	1.09 (0.73–1.63), p=0.678		0.63 (0.36–1.11), p=0.110		0.58 (0.37–0.91), p=0.018	
Prevalence ratio (modified Poisson)	PR=1.07 (0.77–1.48), p=0.685		PR=0.66 (0.39–1.10), p=0.113		PR=0.63 (0.43–0.93), p=0.020	
8-food-group MDD	1.13 (0.72–1.76), p=0.594		0.51 (0.30–0.86), p=0.012		0.66 (0.43–1.02), p=0.062	
Fully adjusted + region	1.01 (0.65–1.56), p=0.962		0.58 (0.32–1.05), p=0.075		0.54 (0.33–0.87), p=0.011	
Expanded covariates (+ARI, WASH)	1.09 (0.72–1.64), p=0.685		0.63 (0.36–1.12), p=0.116		0.58 (0.37–0.91), p=0.019	
Dose–response (per food group)	1.01 (0.90–1.13), p=0.870		0.86 (0.76–0.97), p=0.018		0.88 (0.80–0.98), p=0.021	
Linear regression (z-score)	β=−0.326 (−0.849 to 0.196), p=0.222		β=−0.001 (−0.267 to 0.265), p=0.994		β=−0.125 (−0.628 to 0.378), p=0.627	
Stratifier	Stratum	n	Stunting OR (95% CI)	P value	Wasting OR (95% CI)	P value
Panel B: effect modification—stratified associations (wasting and stunting)						
Wealth quintile						
	Q1 Poorest	498	1.22 (0.63–2.37)	0.563	0.40 (0.11–1.42)	0.159
	Q2 Poorer	356	1.05 (0.50–2.19)	0.899	0.26 (0.06–1.14)	0.076
	Q3 Middle	273	0.71 (0.24–2.15)	0.548	2.07 (0.63–6.85)	0.235
	Q4 Richer	214	0.87 (0.34–2.23)	0.768	0.52 (0.12–2.23)	0.379
	Q5 Richest	175	3.60 (0.62–20.88)	0.157	0.69 (0.21–2.32)	0.553
	Interaction p value		0.669		0.776	
Residence						
	Rural	891	1.10 (0.67–1.82)	0.697	0.44 (0.18–1.08)	0.076
	Urban	625	1.12 (0.60–2.08)	0.729	0.78 (0.36–1.70)	0.531
	Interaction p value		0.949		0.317	
Maternal education						
	Low (none/primary)	683	0.91 (0.52–1.60)	0.74	0.30 (0.10–0.88)	0.03
	High (secondary/higher)	833	1.15 (0.64–2.06)	0.633	0.88 (0.45–1.72)	0.716
Panel A: all sensitivity models adjusted for child age, sex, current breastfeeding, recent diarrhoea, maternal education, household wealth, vitamin A supplementation and urban–rural residence unless otherwise specified. Primary model OR repeated for reference. Linear regression outcomes: LAZ (stunting column), WLZ (wasting column), WAZ (underweight column). Panel B: stratified logistic regression adjusted for relevant covariates excluding the stratification variable. Interaction p values from design-adjusted Wald tests. All subgroup findings are hypothesis-generating given multiple comparisons and limited power within strata. ARI, acute respiratory infection; LAZ, length-for-age z-scores; MDD-8, 8-food-group definition with breast milk; PR, prevalence ratio from modified Poisson regression; WASH, water/sanitation variables; WAZ, weight-for-age z-scores; WLZ, weight-for-length z-scores.						

be interpreted as hypothesis-generating. If genuine, the pattern would be consistent with conceptual models predicting larger effects where nutritional constraints are most binding. Adequately powered prospective studies with pre-specified interaction hypotheses are needed to confirm these exploratory observations.

Limitations

Several limitations merit acknowledgement. First, the cross-sectional design precludes causal inference; reverse

causation cannot be excluded. Prospective cohort studies would provide stronger evidence. Second, dietary diversity was assessed through a single list-based 24-hour recall, which may not capture habitual dietary patterns; day-to-day variation likely introduces non-differential measurement error attenuating associations toward the null. Social desirability bias in maternal reporting cannot be excluded. Third, the DHS does not collect a complete retrospective breastfeeding history; only current

breastfeeding status was available for adjustment. Fourth, the binary MDD indicator collapses substantial information about dietary quality. Fifth, residual confounding by unmeasured factors including household food insecurity, maternal depression, environmental enteropathy and detailed infant feeding history remains possible. Sixth, statistical power was limited in some strata, particularly within individual wealth quintiles and among non-breastfed children.

Implications for policy and programming

These findings support incorporating dietary diversity improvement into nutrition strategies targeting the 6–23 month complementary feeding period, while recognising that addressing stunting requires broader multisectoral approaches. The robust association with underweight and the suggestive evidence for wasting indicate that dietary quality matters for current nutritional status. The steep socioeconomic gradients in MDD achievement highlight that effective interventions must address structural barriers to food access and affordability, not only nutrition knowledge. Integrated approaches combining behaviour change communication with food access interventions, agricultural support and social protection are likely needed. The low egg consumption (22%) despite their exceptional nutrient density represents a concrete intervention opportunity.

CONCLUSIONS

This nationally representative analysis demonstrates that dietary diversity is associated with reduced risk of underweight among Ghanaian infants and young children, with suggestive evidence for wasting but not stunting. The differential findings across anthropometric indicators are consistent with the biological plausibility of dietary quality affecting current nutritional status more than cumulative linear growth. With only 28.3% of children achieving minimum dietary diversity and substantial socioeconomic gradients, improving dietary quality during the complementary feeding period represents an important priority. Prospective cohort studies and randomised trials are needed to confirm causal relationships and guide intervention design.

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Patient consent for publication Consent obtained directly from patient(s).

Ethics approval This study involves human participants. This study used data from the Ghana Demographic and Health Survey 2022, which received ethical approval from the Ghana Health Service Ethical Review Committee (GHS-ERC 005/09/22) and the ICF Institutional Review Board (ICF IRB FWA00000845). Written informed consent was obtained from all participants. Participants gave informed consent to participate in the study before taking part.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request. Data may be obtained from a third party and are not publicly available. The data analysed in this study are publicly available from the DHS Programme (<https://dhsprogram.com>) upon registration and approval of a data access request. The complete annotated R analysis script is available from the corresponding author upon reasonable request.

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