DOI: 10.51745/najfnr.9.19.129-136

ORIGINAL ARTICLE

Infant, Child, and Adolescent Nutrition

Association between dietary diversity and nutritional status of children aged 6-59 months in the Tamale Metropolis

Michael Akenteng Wiafe [1] **Emmanuel Afedzie** [2] **Prisca Ntim** [2] **Esther Owusu** [2] **Anthony Wemakor** [2]

1 University for Development Studies, School of Allied Health Sciences, Department of Dietetics, Tamale, Ghana mawiafe5@gmail.com
2 University for Development Studies, School of Allied Health Sciences, Department of Nutritional Sciences, Tamale, Ghana afedzieemma278@gmail.com / ntimpresca@gmail.com / ewurakuakesse@gmail.com / awemakor@uds.edu.gh

ABSTRACT

Background: Optimal growth and development in children requires adequate dietary intake from diverse food groups. A varied diet provides a comprehensive array of nutrients for achieving and maintaining optimal nutritional status in the pediatric population.

Aims: This study aimed to assess the association between dietary diversity and nutritional status of children aged 6 to 59 months in the Tamale Metropolis.

Methods: A cross-sectional study design was employed, utilizing systematic random sampling to select a cohort of 343 mothers and their children from four health facilities within the Tamale Metropolis. Data pertaining to sociodemographic characteristics, dietary intake, and anthropometric measurements, were collected. Dietary diversity score was assessed based on seven food groups, as recommended by the Food and Agriculture Organization of the United Nations. Z-scores for anthropometric indices were calculated using WHO Anthro software. Descriptive statistics, Chi-square tests, and partial correlation analyses were used for data analysis.

Results: The mean age (standard deviation) of the children was 11.9 ± 5.0 months. The prevalence of stunting, wasting, underweight, and overweight/obesity were recorded as 38.5%, 14.3%, 28.9%, and 18.1%, respectively. The proportions of children consuming from the various food groups in the preceding 24 hours were as follows: grains, roots and tubers (86.9%); legumes and nuts (24.8%); dairy products (46.1%); flesh foods (43.7%); eggs (17.8%); vitamin A rich fruits and vegetables (39.7%); and other fruits and vegetables (72.9%). The mean dietary diversity score was 3.3 ± 1.7, with 55.4% of children meeting the minimum dietary diversity criteria. Dietary diversity scores exhibited statistically significant correlations with z-scores for weight-for-age (r = 0.292), height-for-age (r = 0.382) and BMI-for-age (r = -0.165).

Conclusions: Despite a majority of the children in the Tamale Metropolis meeting the minimum dietary diversity, malnutrition remains a significant public health concern. Dietary diversity was found to exert a distinct influence on the nutritional status of the children in this study population.

Keywords: Dietary Diversity, Underweight, Wasting, Stunting, Nutritional Status, Children.

ARTICLE INFORMATION

Check for updates

Corresponding author: Michael Akenteng Wiafe
E-mail: michael.wiafe@uds.edu.gh
Tel. +233 200905456

Received: December 19, 2024
Revised: March 26, 2025
Accepted: April 04, 2025
Published: April 08, 2025

Article edited by:
Prof. Khaled Méghit Boumédiène
Article reviewed by:
Dr. Christiana Nsiah-Asamoah
Dr. Lesley Macheka

Cite this article as: Wiafe M. A., Afedzie E., Ntim P., Owusu E., Wemakor A. (2025). Association between dietary diversity and nutritional status of children aged 6-59 months in the Tamale Metropolis. *The North African Journal of Food and Nutrition Research,* 9 (19): 129 – 136. https://doi.org/10.51745/najfnr.9.19.129-136

1 INTRODUCTION

Dietary diversity, a qualitative measure of food intake, serves as an indicator of household's access to a wide ray of food categories and also serves as a stand-in for the nutrient adequacy of an individual's diet (Food and Agriculture Organization [FAO], 2018). Enhanced consumption of foods originating from disparate food groups has been shown to correlate positively with increased nutrient intake in pediatric populations (Zhao *et al.*, 2017).

The consumption of diverse range of foods has been associated with several determinants, including seasonality, geographical location, education level, age, high household income, maternal knowledge regarding dietary diversity, child feeding practices, and maternal access to media (Abizari *et al.*, 2017; Bandoh & Kenu, 2017; Dangura & Gebremedhin, 2017; Molla *et al.*, 2021; Paramashanti *et al.*, 2022; Sekartaji *et al.*, 2021; Solomon *et al.*, 2017; Zhao *et al.*, 2017).

Seasonal variations influence dietary patterns, with vitamin A-rich fruits and dark leafy green vegetables being consumed more frequently during the rainy season whereas deep yellow, red, and orange vegetables are favored in the dry season (Abizari *et al.*, 2017). While the consumption of flesh foods has been noted as predominant, the intake of fruits and vegetables, especially vitamin A-rich varieties, remains low in coastal regions (Bandoh & Kenu, 2017). A high intake of grains, roots, and tubers has been observed alongside high a low consumption of vitamin A-rich fruits and vegetables, as well as legumes and nuts (Anane *et al.*, 2021). Grains constitute the most frequently consumed food group among children (Modjadji *et al.*, 2020; Temesgen *et al.*,2018). Overall, the consumption of foods from diverse food groups has been reported as suboptimal among children (Amoah *et al.*, 2022; Anane *et al.*, 2021; Bandoh & Kenu, 2017; Modjadji *et al.*, 2020; Saaka *et al.*, 2015).

Studies conducted across various geographical jurisdictions have indicated a positive correlation between higher dietary diversity and improved anthropometric status, as evidenced by elevated weight-for-age, height- or length-for-age, and weight-for-height z-scores (Heidari‐Beni *et al.*, 2021; Modjadji *et al.*, 2020). A high level of dietary diversity has been specifically associated with the height-for-age of children (Darapheak *et al.*, 2013; Sié *et al.*, 2018). Furthermore, the consumption of vitamin A-rich foods, eggs, and other vegetables has shown a significant positive association with weight-for-age scores (Frempong & Annim, 2017). Conversely, a low intake of dairy products and meat and poultry has been associated with higher prevalence of stunting (Mahmudiono *et al.*, 2017; Ogechi & Chilezie, 2017).

While factors influencing dietary diversity among children have been identified in prior research, there remains a paucity of information regarding the association between the dietary diversity of children is associated and their nutritional status within the Tamale Metropolis of Ghana. Thus, this study aimed to assess the relationship between dietary diversity and the nutritional status of children aged 6 to 59 months in the Tamale Metropolis.

2 Material and Methods

2.1 Study design and population

A cross-sectional study was conducted within the urban areas of the Tamale Metropolis, the capital city of the Northern Region of Ghana. The primary occupation within the Metropolis is agriculture, with a significant portion of the population engaged in subsistence farming involving poultry (such as chickens and guinea fowl) and livestock (including sheep, goats, and cattle). Crop farming is also prevalent, with maize, millet, yam, sorghum, and beans being the principal cultivations. Employing Cochran's formula, a sample size of 343 mother-child was calculated, based on a 95% confidence interval, a 5% margin of error, and a malnutrition prevalence of 25% in Northern Ghana (University of Ghana, Ground Work, Wisconsin-Madison, U. of, Trust, K.-W., & UNICEF, 2017). This calculation incorporated a 15% anticipated attrition rate. A systematic random sampling technique was employed to select the 343 mother-child pairs from three randomly selected healthcare facilities within the Tamale Metropolis between June and August 2023. The proportional allocation of the sample across the selected healthcare facilities was determined using probability proportional to size sampling.

2.2 Data collection

Sociodemographic characteristics and dietary diversity data were collected through the administration of a semi-structured questionnaire. Anthropometric measurements were also carried out to determine the nutritional status of the children.

Dietary diversity score

The minimum dietary diversity for children was adapted from the Food and Agriculture Organization, utilizing eight food groups (FAO, 2018). For the purpose of this study, dietary diversity was assessed based on the consumption of seven food groups: grains, roots and tubers; other fruits and vegetables; dairy products; flesh foods; vitamin A rich fruits and vegetables; legumes and nuts; and eggs. Dietary intake data from the preceding day were used to calculate the dietary diversity score. Dichotomous responses of 'Yes' and 'No' were assigned numerical values of '1' and '0', respectively. The summation of consumed food groups yielded a score ranging from zero to seven. The total dietary diversity score of seven was subsequently categorized into "met" (4–7), indicating the consumption of four or more food groups, and "unmet" (1–3), signifying the consumption of three or fewer food groups].

Anthropometric indices

The weight of the children was measured to the nearest 0.1 kilogram (kg) using a calibrated Seca weighing scale. The recumbent length of the children under 24 months was measured with an infantometer, while the height of children aged 24 months and above was determined using a stadiometer. All length and height measurements were recorded to the nearest 0.1 centimeter (cm) .

Mid-upper arm circumference (MUAC) was measured using a standardized MUAC strip and categorized according to World Health Organization (WHO) criteria (2006) as follows: severely acute malnutrition (SAM) defined as < 11.5 cm, moderately acute malnutrition (MAM) defined as ≥ 11.5 cm to <12.5 cm, and normal nutritional status defined as ≥ 12.5cm).

2.3 Statistical analysis

The WHO Anthro software was used to calculate z-scores for weight-for-age, height-for-age, weight-for-height, and body mass index-for-age (BMI-for-age). These z-scores were subsequently classified based on WHO guidelines (2006): weight-for-age z-score: normal (≥ -2 SD) and underweight (<

-2 SD); height-for-age z-score: normal (≥ -2 SD) and stunted (< -2 SD); weight-for-height z-score: normal (≥ -2 SD) and wasted (< -2 SD); and BMI-for-age z-score: normal (≥ -2 SD and ≤ + 1 SD), overweight (> + 1 SD and ≤ + 2 SD), obese (> + 2 SD), and underweight (< -2 SD).

Further statistical analyses were performed using the Statistical Package for Social Sciences (SPSS) software. Data were presented using frequencies, percentages, means, and standard deviations. Descriptive statistics were used to present the sociodemographic characteristics, anthropometric measurements, and dietary diversity scores of the study population. The Chi-square test (χ^2) was conducted to assess the statistical association between dietary diversity and sociodemographic characteristics, as well as between dietary diversity and nutritional status indicators. Partial correlation analysis was performed to examine the relationship the between dietary diversity score and anthropometric z-scores. All statistical tests were considered significant at *p*-value < 0.05, unless otherwise specified.

2.4 Ethical Consideration

The study protocol underwent rigorous review and received ethical approval from the Institutional Review Board of University for Development Studies, Ghana (UDS/RB/043/23). Prior to data collection, the objectives and procedures of the study were thoroughly explained to all potential participants. Informed consent was obtained from all participating mothers or legal guardians through the signing of a written consent.

3 Results

3.1 Sociodemographic characteristics and dietary diversity

The sociodemographic characteristics of the study participants and their dietary diversity are presented in Table 1. The mean age of the children was 11.9 ± 5.0 months, with the majority (97.1%) falling within the 6–23 months age category. The sample comprised a slightly higher

Table 1. Sociodemographic characteristics and dietary diversity

Variables	M±SD	N (%)	Dietary diversity			
			Met	Unmet	X^2	*p*-value
Age						
Children (months)	11.9 ± 5.0					
Female	11.6 ± 4.3	185(53.9)				
Male	12.1 ± 5.7	158(46.1)				
			102(55.1)	83(44.9)	0.0	0.913
6-23 months		333(97.1)	88(55.7)	70(44.3)		
24-59 months		10(2.9)				
Mothers (years)	29.3 ± 5.3		184(55.3)	149(44.7)	0.1	1.000
			6(60)	4(40)		
Maternal educational status						
No-formal education		40(11.7)				
Basic education		211(61.5)				
Tertiary		92(26.8)	20(50)	20(50)	1.0	0.617
			121(57.3)	90(42.7)		
Marital status		335(97.7)	49(53.3)	43(46.7)		
Married		8(2.3)				
Single/widowed/divorced			188(56.1)	147(43.9)	3.1	0.146
Guardian income status			2(25)	6(75)		
Low		297(86.6)				
Moderate		46(13.4)				
			164(55.2)	133(44.8)	0.0	1.000
Dietary diversity	3.3 ± 1.7		26(56.5)	20(43.5)		
Met		187(55.4)				
Unmet		156(44.6)				

Chi-square= X^2, $p < 0.05$, Fisher's exact; low income (< Gh1,000 per month), moderate income (Gh1,000 - Gh2,000 per month)

Table 2. Age, sex and undernutrition status

Characteristics	Stunted N (%)	Wasted N (%)	Underweight N (%)	Acute Malnutrition N (%)
Age (months)				
6–23	123(93.2)	47(95.9)	89(89.9)	52(96.3)
24–59	9(6.8)	2(4.1)	10(10.1)	2(3.7)
Sex				
Male	79(59.8)	31(63.3)	60(60.6)	30(55.6)
Female	53(40.2)	18(38.7)	39(39.4)	24(44.4)

Frequency= N, percentage =%

proportion of females (53.9%) compared to males (46.1%). The predominant educational level among mothers was basic education (61.5%), and the majority were married (97.7%) and belonged to the low-income bracket (86.6%). The mean dietary diversity score was 3.3 ± 1.7, with over half of the children (55.4%) of the children meeting the minimum dietary diversity criteria. While a large proportion of males (55.7%), children aged 24–59 months (60%), and participants whose guardians had a moderate-income status (56.5%), basic education (57.3%), and were married (56.1%) met the minimum dietary diversity, none of these sociodemographic characteristics demonstrated a statistically significant association with dietary diversity.

3.2 Age, sex and undernutrition status

Regarding malnutrition prevalence, the rates of low height-for-age (stunting), low weight-for-age (underweight), low weight-for-height (wasting), and overweight/obesity were 38.5%, 28.9%, 14.3% and 18.1%, respectively. Stunting (93.2%), wasting (95.9%), and underweight (89.9%) were more pronounced in children aged 6-23 months and were more prevalent in males (60.6%, 63.3%, and 59.8%, respectively). The overall prevalence of acute malnutrition was 15.7% (Table 2).

3.3 Anthropometric indices and dietary diversity

The majority of participants who met the minimum dietary diversity criteria did not exhibit stunting (69.5%), underweight (74.7%), or wasting (85.3%), and also presented with a normal BMI-for-age (68.4%) and MUAC status (84.2%). A statistically significant association was observed between height-for-age and dietary diversity (χ^2 = 11.4, p = 0.001) (Table 3).

3.4 Proportion of children consuming from the diverse food groups

The proportions of children consuming from the different food groups in the 24 hours preceding data collection are illustrated in Figure 1. The primary food groups consumed were: grains, roots, and tubers (86.9%) and other fruits and vegetables (72.9%). Less than half of the children consumed dairy products (46.1%) and flesh foods (43.7%), approximately four in ten consumed vitamin A-rich fruits and vegetables (39.7%), less than three in ten consumed legumes and nuts (24.8%) and less than two in ten consumed eggs (17.8%).

3.5 Partial correlation of dietary diversity and anthropometric indices

The partial correlation coefficients between dietary diversity score and anthropometric z-scores, adjusted for age and sex, are represented in Table 4. The analysis revealed statistically significant (p < 0.01) and positive relationships between the dietary diversity score and the z-scores for weight-for-age (r = 0.292) and height-for-age (r = 0.382). Conversely, a statistically significant and inverse relationship was observed between the dietary diversity score and the BMI-for-age z-score (r = -0.165).

Table 3. Anthropometric indices and dietary diversity

Variables	M±SD	N (%)	Dietary diversity Met	Unmet	X^2	p-value
MUAC category						
Severe acute malnutrition		5(1.4)	4(2.1)	1(0.7)		
Moderate acute malnutrition		49(14.3)	26(13.7)	23(15.0)		
Normal		289(84.3)	160(84.2)	129(84.3)		
Height-for-age	-0.77±3.4					
Normal		211(61.5)	132(69.5)	79(51.6)	11.4	0.001
Stunted		132(38.5)	58(30.5)	74(48.4)		
Weight-for-age	-0.84±1.7					
Normal		244(71.1)	142(74.7)	102(66.7)	2.7	0.119
Underweight		99(28.9)	48(25.3)	51(33.3)		
Weight-for-height	-0.34±1.9					
Normal		294(85.7)	162(85.3)	132(86.3)	0.1	0.877
Wasted		49(14.3)	28(14.7)	21(13.7)		
BMI-for-age	-0.39±1.8					
Normal		227(66.2)	130(68.4)	97(63.4)	4.6	0.102
Overweight/obese		62(18.1)	27(14.2)	35(22.9)		
Underweight		54(15.7)	33(17.4)	21(13.7)		

Chi-square= X^2, p < 0.05, Fisher's exact

Table 4. Partial correlation of dietary diversity and anthropometric indices

Variables	DDS	WAZ	HAZ	BAZ	WHZ	MUAC
DDS	1.000	0.292**	0.382**	-0.165**	0.001	0.062
WAZ	0.292**	1.000	0.667**	0.281**	0.011	0.443**
HAZ	0.382**	0.667**	1.000	-0.519**	-0.006	0.231**
BAZ	-0.165**	0.281**	-0.519**	1.000	0.009	0.199**
WHZ	0.001	0.011	-0.006	0.009	1.000	-0.004
MUAC	0.062	0.443**	0.231**	0.199**	-0.004	1.000

*Adjusted for age and sex. **Correlation is significant at 0.01 level. DDS- dietary diversity score. WAZ- weight-for-age zscore. HAZ- height-for-age zscore. BAZ - BMI-for-age zscore. MUAC- mid-upper arm circumference*

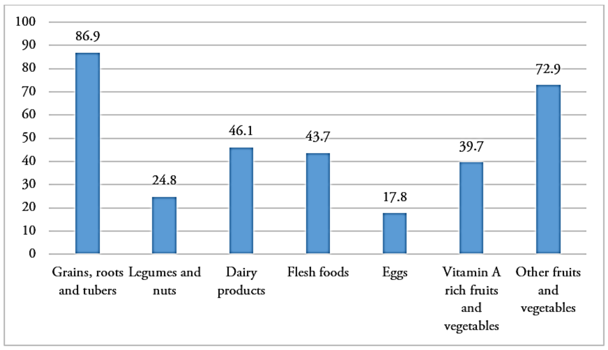

Figure 1. Proportion of children consuming from the diverse food groups

4 DISCUSSION

The consumption of a diverse range of food groups in adequate proportions holds the potential to improve the nutritional status of children. The present study aimed to assess the dietary diversity and nutritional status of children aged 6–59 months in the Tamale Metropolis.

The outcomes of the study revealed that a majority of the children met the minimum dietary diversity criteria. This observation contrasts with the findings reported by Amoah *et al.* (2022), Dangura & Gebremedhin (2017), Molla *et al.* (2021), and Saaka *et al.* (2015). This discrepancy may be attributed to the urban setting of the current study in the Tamale metropolis, as opposed to the rural context of the study by Saaka *et al.* (2015), conducted within the same region. Research has indicated that children in rural areas of China tend to exhibit poor dietary diversity (Zhao *et al.*, 2017). The majority of guardians in our study group, ranging from basic to tertiary levels, could have contributed to the observed differences in the outcomes, whereas the study by Amoah *et al.* (2022) reported a higher prevalence of low or no formal education. The present findings also diverge from those of another study involving children under five years of age in the Central Region of Ghana (Bandoh & Kenu, 2017). The high consumption of grains, roots, and tubers among our study participants aligns with the findings of Anane *et al.* (2021) and Temesgen *et al.* (2018), who also reported identical patterns. While grains, roots, and tubers were the most frequently consumed food groups in our study, Bandoh and Kenu (2017) reported a higher intake of flesh foods, a difference potentially attributable to variations in geographical location and the availability of specific food resources. However, our findings are consistent studies conducted among children in Ethiopia (Paramashanti *et al.*, 2022; Solomon *et al.*, 2017).

The current findings also indicated the high prevalence of stunting, wasting, and underweight. This may be associated with the low socioeconomic status of the guardians, potentially leading to reduced consumption of nutrient-dense foods such as eggs, legumes and nuts, dairy products, flesh foods, and vitamin A rich fruits and vegetables. Economic growth has been proposed as a panacea to promoting diversified diet intake to combat both chronic and hidden hunger (Gödecke *et al.*, 2018). These aforementioned food groups are rich sources of micronutrients essential for growth, and inadequate consumption of these nutrients has been implicated in the high prevalence of malnutrition and hidden hunger (Dewiasty *et al.*, 2022; Lowe, 2021; Vecchio *et al.*, 2014). A low mean dietary diversity score has been associated with micronutrient malnutrition (Ritchie & Roser, 2017), a finding consistent with another study demonstrating a relationship between a high prevalence of undernutrition and low dietary diversity (Mahmudiono *et al.*, 2017). A statistically significant association was identified between height-for-age score and dietary diversity, corroborating findings from other studies that have also reported an association between dietary diversity and nutritional status (Darapheak *et al.*, 2013; Frempong & Annim, 2017; Modjadji *et al.*, 2020; Ogechi & Chilezie, 2017; Sié *et al.*, 2018).

Furthermore, the results revealed high prevalence of overweight and obesity. This presence of overnutrition may be attributed to low levels of physical activity as studies have associated overweight and obesity with reduced physical activity among children in South Africa and urban Ghana (Armstrong *et al.*, 2017; Aryeetey *et al.*, 2017). The predominant food groups consumed in the present study were grains, roots, and tubers, with limited intake of other fruits and vegetables. This low consumption of micronutrient-rich foods may have contributed to the observed overnutrition within the study population. Deficiencies in micronutrients such as calcium, folate, vitamin D, magnesium, and potassium have been implicated as risk factors for overweight and obesity (Lapik *et al.*, 2020; McKay *et al.*, 2020).

The partial correlation analysis demonstrated a positive and significant relationship between the dietary diversity score and the z-scores for weight-for-age, height-for-age, and weight-for-height, indicating that as dietary diversity increased, these anthropometric indices also increased. This finding is consistent with other studies reporting identical outcomes among children (Heidari-Beni *et al.*, 2021), suggesting that the consumption of a variety of food groups provides a broader range of nutrients to support growth.

Limitations of the study

The current investigation provides valuable insight into the dietary diversity and malnutrition status of children in the Tamale Metropolis, and further indicates the association between dietary diversity and their anthropometric status. However, certain limitations should be acknowledged. There is a potential for social desirability bias, wherein some mothers may have provided responses to the dietary diversity questions that portray a more favorable caregiving image than their actual practices. Additionally, the cross-sectional design of the study prevents the establishment of causal relationships between dietary diversity and nutritional outcomes.

5 Conclusions

While a limited number of children in this study consumed from a majority of the assessed food groups, a greater proportion met the minimum dietary diversity criteria. The study population exhibited a double burden of malnutrition, characterized by the co-existence of both undernutrition and overnutrition. Dietary diversity demonstrated a significant impact on weight-for-age, height-for-age, and BMI-for-age. These findings underscore the necessity for public health officials to intensify nutrition education initiatives, emphasizing the critical role of dietary diversity in promoting child health. Such interventions have the potential to reduce the multifaceted challenge of the triple burden of malnutrition, encompassing undernutrition, overnutrition, and micronutrient deficiencies.

Data availability statement

The data generated and analyzed during this study are available upon reasonable request directed to the Chairman, Committee on Human Research Publication Ethics, Ethics Review Board of the University for Development Studies, P. O. Box TL 1350, Tamale, Ghana.

Acknowledgment: Guardians and participants are acknowledged.

Source of funding: No external funding from government or non-governmental organization was received for this research.

Previous submissions: Not applicable.

Authors' Contribution: **Michael Akenteng Wiafe** involved in conceptualization—lead, formal analysis—lead, investigation—lead, project administration—lead, supervision—lead, writing, review and editing—lead. **Emmanuel Afedzie** involved in conceptualization—supporting, formal analysis—supporting, investigation—equal, project administration—equal, writing original draft—equal. **Prisca Ntim** involved in conceptualization—supporting, formal analysis—supporting, investigation—equal, project administration—equal, writing original draft—equal. **Esther Owusu** involved in conceptualization—supporting, formal analysis—supporting, investigation—equal, project administration—equal, writing original draft—equal. **Anthony Wemakor** involved in conceptualization—lead, data curation- lead, formal analysis—lead, investigation—lead, project administration—lead, supervision—lead, writing, review and editing—lead.

Conflicts of Interest: None.

Preprint deposit: Authors did not share this manuscript as a preprint deposit.

References

Abizari, A. R., Azupogo, F., Nagasu, M., Creemers, N., & Brouwer, I. D. (2017). Seasonality affects dietary diversity of school-age children in northern Ghana. *PLoS One, 12*(8), e0183206. https://doi.org/10.1371/journal.pone.0183206 [Crossref] [PubMed] [Google Scholar] [Publisher]

Anane, I., Nie, F., & Huang, J. (2021). Socioeconomic and geographic pattern of food consumption and dietary diversity among children aged 6–23 months old in Ghana. *Nutrients, 13*(2), 603. https://doi.org/10.3390/nu13020603 [Crossref] [PubMed] [Google Scholar] [Publisher]

Amoah, A. N., Danquah, A. O., Stanislav, T. S., Drokow, E. K., Yacong, B., Wang, L., & Lyu, Q. (2022). Correlates of dietary diversity among children aged 6–23 months of head porters in Ghana. *Frontiers in Public Health, 10*, 1020265. https://doi.org/10.3389/fpubh.2022.1020265 [Crossref] [PubMed] [Google Scholar] [Publisher]

Armstrong, M. E., Lambert, M. I., & Lambert, E. V. (2017). Relationships between different nutritional anthropometric statuses and health-related fitness of South African primary school children. *Annals of Human Biology, 44*(3), 208–213.

https://doi.org/10.1080/03014460.2016.1229029 [Crossref] [PubMed] [Google Scholar] [Publisher]

Aryeetey, R., Lartey, A., Marquis, G. S., Nti, H., Colecraft, E., & Brown, P. (2017). Prevalence and predictors of overweight and obesity among school-aged children in urban Ghana. *BMC Obesity, 4*(1), 1–8. https://doi.org/10.1186/s40608-017-0152-6 [Crossref] [PubMed] [Google Scholar] [Publisher]

Bandoh, D. A., & Kenu, E. (2017). Dietary diversity and nutritional adequacy of under-fives in a fishing community in the central region of Ghana. *BMC Nutrition*, *3*(1). https://doi.org/10.1186/s40795-016-0120-4 [Crossref] [Google Scholar] [Publisher]

Darapheak, C., Takano, T., Kizuki, M., Nakamura, K., & Seino, K. (2013). Consumption of animal source foods and dietary diversity reduce stunting in children in Cambodia. *International Archives of Medicine, 6*(1), 1–11. https://doi.org/10.1186/1755-7682-6-29 [Crossref] [PubMed] [Google Scholar] [Publisher]

Dangura, D., & Gebremedhin, S. (2017). Dietary diversity and associated factors among children 6–23 months of age in Gorche district, Southern Ethiopia: Cross-sectional study. *BMC Pediatrics, 17*(1), 1–7. https://doi.org/10.1186/s12887-017-0914-9 [Crossref] [PubMed] [Google Scholar] [Publisher]

Dewiasty, E., Agustina, R., Saldi, S. R. F., Pramudita, A., Hinssen, F., Kumaheri, M., ... & Setiati, S. (2022). Malnutrition prevalence and nutrient intakes of Indonesian community-dwelling older adults: A systematic review of observational studies. *Frontiers in Nutrition, 9*, 780003. https://doi.org/10.3389/fnut.2022.780003 [Crossref] [PubMed] [Google Scholar] [Publisher]

FAO. (2018). *Dietary assessment: A resource guide to method selection and application in low resource settings*. Food and Agriculture Organization of the United Nations. https://www.fao.org/3/i9940en/I9940EN.pdf [Google Scholar] [Publisher]

Frempong, R. B., & Annim, S. K. (2017). Dietary diversity and child malnutrition in Ghana. *Heliyon, 3*(5), e00298. https://doi.org/10.1016/j.heliyon.2017.e00298 [Crossref] [PubMed] [Google Scholar] [Publisher]

Gödecke, T., Stein, A. J., & Qaim, M. (2018). The global burden of chronic and hidden hunger: Trends and determinants. *Global Food Security, 17*, 21–29. https://doi.org/10.1016/j.gfs.2018.03.004 [Crossref] [Google Scholar] [Publisher]

Heidari-Beni, M., Riahi, R., Massoudi, S., Qorbani, M., & Kelishadi, R. (2021). Association between dietary diversity score and anthropometric indices among children and adolescents: The weight disorders survey in the CASPIAN-IV study. *Journal of the Science of Food and Agriculture, 101*(12), 5075–5081. https://doi.org/10.1002/jsfa.11162 [Crossref] [PubMed] [Google Scholar] [Publisher]

Lapik, I. A., Galchenko, A. V., & Gapparova, K. M. (2020). Micronutrient status in obese patients: A narrative review. *Obesity Medicine, 18*, 100224. https://doi.org/10.1016/j.obmed.2020.100224 [Crossref] [Google Scholar] [Publisher]

Lowe, N. M. (2021). The global challenge of hidden hunger: Perspectives from the field. *Proceedings of the Nutrition Society,* *80*(3), 283–289. https://doi.org/10.1017/S0029665121000902 [Crossref] [PubMed] [Google Scholar] [Publisher]

Mahmudiono, T., Sumarmi, S., & Rosenkranz, R. R. (2017). Household dietary diversity and child stunting in East Java, Indonesia. *Asia Pacific Journal of Clinical Nutrition*, *26*(2), 317–325. https://doi.org/10.6133/apjcn.012016.01 [Crossref] [PubMed] [Google Scholar] [Publisher]

McKay, J., Ho, S., Jane, M., & Pal, S. (2020). Overweight & obese Australian adults and micronutrient deficiency. *BMC Nutrition*, *6*(1), 12. https://doi.org/10.1186/s40795-020-00336-9 [Crossref] [PubMed] [Google Scholar] [Publisher]

Modjadji, P., Molokwane, D., & Ukegbu, P. O. (2020). Dietary diversity and nutritional status of preschool children in North West Province, South Africa: A cross-sectional study. *Children, 7*(10), 174. https://doi.org/10.3390/children7100174 [Crossref] [PubMed] [Google Scholar] [Publisher]

Molla, W., Adem, D. A., Tilahun, R., Shumye, S., Kabthymer, R. H., Kebede, D., Mengistu, N., Ayele, G. M., & Assefa, D. G. (2021). Dietary diversity and associated factors among children (6-23 months) in Gedeo zone, Ethiopia: cross - sectional study. *Italian Journal of Pediatrics*, *47*(1), 233. https://doi.org/10.1186/s13052-021-01181-7 [Crossref] [PubMed] [Google Scholar] [Publisher]

Ogechi, U. P., & Chilezie, O. V. (2017). Assessment of dietary diversity score, nutritional status and socio-demographic characteristics of under-5 children in some rural areas of Imo State, Nigeria. *Malaysian Journal of Nutrition, 23*(3), 425–435. [Crossref] [Google Scholar] [Publisher]

Paramashanti, B. A., Huda, T. M., Alam, A., & Dibley, M. J. (2022). Trends and determinants of minimum dietary diversity among children aged 6–23 months: A pooled analysis of Indonesia Demographic and Health Surveys from 2007 to 2017. *Public Health Nutrition, 25*(7), 1956–1967. https://doi.org/10.1017/S1368980022000392 [Crossref] [PubMed] [Google Scholar] [Publisher]

Ritchie, H., & Roser, M. (2017). Micronutrient deficiency. *Our World in Data*. Retrieved from https://ourworldindata.org/micronutrient-deficiency [Google Scholar] [Publisher]

Saaka, M., Wemakor, A., Abizari, A.-R., & Aryee, P. (2015). How well do WHO complementary feeding indicators relate to nutritional status of children aged 6-23 months in rural Northern Ghana? *BMC Public Health*, *15*(1), 1157. https://doi.org/10.1186/s12889-015-2494-7 [Crossref] [PubMed] [Google Scholar] [Publisher]

Sekartaji, R., Suza, D. E., Fauziningtyas, R., Almutairi, W. M., Susanti, I. A., Astutik, E., & Efendi, F. (2021). Dietary diversity and associated factors among children aged 6–23 months in Indonesia. *Journal of Pediatric Nursing, 56*, 30–34. https://doi.org/10.1016/j.pedn.2020.10.006 [Crossref] [PubMed] [Google Scholar] [Publisher]

Sié, A., Tapsoba, C., Dah, C., Ouermi, L., Zabre, P., Bärnighausen, T., ... & Oldenburg, C. E. (2018). Dietary diversity and nutritional status among children in rural Burkina Faso. *International Health, 10*(3), 157–162. https://doi.org/10.1093/inthealth/ihy016 [Crossref] [PubMed] [Google Scholar] [Publisher]

Solomon, D., Aderaw, Z., & Tegegne, T. K. (2017). Minimum dietary diversity and associated factors among children aged 6–23 months in Addis Ababa, Ethiopia. *International Journal for Equity in Health, 16*(1), 1–9. https://doi.org/10.1186/s12939-017-0680-1 [Crossref] [PubMed] [Google Scholar] [Publisher]

Temesgen, H., Yeneabat, T., & Teshome, M. (2018). Dietary diversity and associated factors among children aged 6–23 months in Sinan Woreda, Northwest Ethiopia: A cross-sectional study. *BMC Nutrition, 4*(1), 1–8. https://doi.org/10.1186/s40795-018-0214-2 [Crossref] [PubMed] [Google Scholar] [Publisher]

University of Ghana, GroundWork, University of Wisconsin-Madison, Kyeema Foundation, & UNICEF. (2017). *Ghana micronutrient survey 2017*. [Publisher]

Vecchio, M. G., Paramesh, E. C., Paramesh, H., Loganes, C., Ballali, S., Gafare, C. E., ... & Gulati, A. (2014). Types of food and nutrient intake in India: A literature review. *The Indian Journal of Pediatrics, 81*(1), 17–22. https://doi.org/10.1007/s12098-014-1465-9 [Crossref] [PubMed] [Google Scholar] [Publisher]

World Health Organization. (2006). *WHO child growth standards: Length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age: Methods and development*. World Health Organization. [Google Scholar] [Publisher]

Zhao, W., Yu, K., Tan, S., Zheng, Y., Zhao, A., Wang, P., & Zhang, Y. (2017). Dietary diversity scores: An indicator of micronutrient inadequacy instead of obesity for Chinese children. *BMC Public Health, 17*(1), 1–11. https://doi.org/10.1186/s12889-017-4381-x [Crossref] [PubMed] [Google Scholar] [Publisher]