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ORIGINAL ARTICLE

Dietary diversity and nutritional status among children in rural Burkina Faso

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Background: Burkina Faso has a seasonal malnutrition pattern, with higher malnutrition prevalence during the rainy season when crop yields are low. We investigated the association between dietary diversity and nutritional status among children aged 6–59 mo during the low crop yield season in rural Burkina Faso to assess the role of dietary diversity during the lean season on childhood nutritional status.

Methods: Caregivers reported the dietary diversity of the past 7 d, consisting of 11 food groups, summed into a scale. Anthropometric measurements were taken from all children. Height-for-age (HAZ), weight-for-height (WHZ) and weight-for-age (WAZ) z-scores were calculated based on 2006 WHO standards. Stunting, wasting and underweight were defined as HAZ, WHZ and WAZ <−2 SD, respectively. Multivariable regression models adjusting for potential confounders including household food insecurity and animal ownership were used to assess the relationship between anthropometric indices and dietary diversity.

Results: Of 251 children enrolled in the study, 20.6% were stunted, 10.0% wasted and 13.9% underweight. Greater dietary diversity was associated with greater HAZ (SD 0.14, 95% CI 0.04 to 0.25) among all children. There was no association between dietary diversity and wasting or mid-upper arm circumference in this study.

Conclusions: Increasing dietary diversity may be an approach to reduce the burden of stunting and chronic malnutrition among young children in regions with seasonal food insecurity.

Keywords: Burkina Faso, child health, dietary diversity, malnutrition, nutritional status

Introduction

Childhood undernutrition contributes to 45% of mortality globally in children <5 y of age.[1] Dietary diversity, which refers to the number of different foods or food groups consumed in a given period, is a critical component of a high-quality diet.[2] Diets high in starch-based staples but low in animal products, fresh fruits or vegetables can result in micronutrient deficiencies, which can leave children vulnerable to undernutrition and its sequelae.[3,4] Previous studies have suggested an association between dietary diversity and height-for-age z-score (HAZ)[5] and stunting.[6] In turn, linear growth and malnutrition have been shown to be associated with cognitive and motor development.[7,8] Identification of potentially modifiable determinants of nutritional status in children is therefore a priority in regions with a high burden of undernutrition.

As in much of the Sahel and sub-Sahel regions, food security in Burkina Faso follows a seasonal pattern, with a lean season between harvests occurring from May to September. Nationally, the prevalence of stunting, wasting and underweight in 2010 among children <5 y of age were 34.8%, 15.7% and 25.8%, respectively.[9] Previous work in Burkina Faso has shown that dietary diversity is low, with mean dietary diversity scores of 2 out of 9 food groups and <25% meeting the minimum dietary diversity (at least 4 food groups).[10] Previous work in Burkina Faso has demonstrated that lower cereal crop harvest is associated with increased acute malnutrition and child mortality.[11,12] Dietary diversity may be altered during this period, as reduced cereal crop production may lead to reliance on alternate food sources.[13] The lean period is also the most critical for child survival, as it overlaps with the malaria season and has the highest incidence of child mortality.[14,15] Therefore, understanding dietary diversity and its influence on nutritional status during the lean season specifically may aid in the development of interventions to reduce malnutrition during this period. Here we assess dietary diversity patterns in children <5 y of age in northwestern rural Burkina Faso during the lean season (July) and assess the association between dietary diversity and nutritional status.

Materials and methods

Study setting

This study was conducted in the sub-Sahelian villages of Kamadena and Dara, which belong to the Nouna Health and Demographic Surveillance System (HDSS)[16] in rural northwest Burkina Faso. The HDSS comprises 58 contiguous villages over 1775 km^2; most inhabitants are subsistence farmers and cattle keepers. The rainy season lasts from July through October, which coincides with the malaria and malnutrition seasons. Kamadena and Dara are relatively larger villages within the HDSS and were selected to facilitate recruitment in the parent trial.

Participants and procedures

Participants were recruited and enrolled at the beginning of the rainy season in July 2017. Data arose from the baseline assessment from a randomized controlled trial of the effect of a short course of antibiotics on intestinal and nasopharyngeal microbiomes in children 6–59 mo of age (ClinicalTrials.gov, NCT03187834). For the parent trial, households were eligible if they had two or three children 6–59 mo of age at the time of the study, based on birth dates from the most recent census round in the HDSS. Households with two children were excluded if one or more of the children were unable to participate in the baseline assessment (e.g., due to illness or absence). Data were collected and managed in CommCare (Dimagi, Cambridge, MA, USA). The study was reviewed and approved by the Comité Institutionnel d'Ethique at the Centre de Recherche en Santé de Nouna (CRSN) in Nouna, Burkina Faso and the Institutional Review Board at the University of California, San Francisco. Written informed consent was obtained from the caregiver of each participant.

Dietary diversity

Dietary diversity was assessed by asking caregivers in their local dialect if the child had eaten a series of 11 food groups in the past 7 d, including grains (e.g., millet, rice or sorghum), vitamin A–rich vegetables (e.g., squash, sweet potato or other vegetables with orange flesh), sauce based on green leafy vegetables, mango/papaya, other fruits, vegetables (e.g., onion, cucumber, zucchini, okra or eggplant), meat or fish, eggs, legumes or nuts, milk and oil or fat.[17] A composite dietary diversity score was created by summing the number of food groups reported for each child by the caregiver (possible range 0, indicating the child ate none of the food groups, to 11, indicating the child ate all of the food groups).

Nutritional status

Height, weight and mid-upper arm circumference (MUAC) measurements were taken from all children. Recumbent length was measured in children <24 mo of age and standing height in children >24 mo (Shorrboard, Weight and Measure, Olney, MD, USA). Children were weighed standing if able or in the arms of a caregiver (Seca 874 flat floor scale, Seca, Hamburg, Germany). Heavy garments and jewellery were removed before weight measurements. Height and weight measurements were taken in triplicate and the median for each measure was used for analysis. Weight-for-height (WHZ), weight-for-age (WAZ) and height-for-age (HAZ) z-scores were calculated based on 2006 WHO standards.[18] Stunting, wasting and underweight were defined as HAZ, WHZ and WAZ<−2 SD, respectively.

Covariates

Each child's age and sex were extracted from the HDSS database. For each child, caregivers were asked if the child had drunk sugary beverages in the past 7 d and if the child was currently breastfeeding. For each household, caregivers reported on two elements of food insecurity (including if a member of the household had gone to bed hungry in the past 4 wk and if a member of the household had eaten a reduced diversity of food due to lack of resources in the previous 4 wk). Caregivers reported the number of poultry (chickens, guinea fowl, etc.), goats/sheep and cows owned by the household. The total number of animals owned by the household was summed. Finally, caregivers reported the type of sanitary facility used most frequently by the household, which was categorized as latrine (with or without slab) or none. These variables were chosen because they have been shown empirically or theoretically to be associated with nutritional status.[19–22]

Sample size calculation

The sample size calculation was based on the primary outcome for the trial, bacterial diversity in the intestinal microbiome. A sample size of 30 children per arm was estimated to provide at least 80% power to detect a 1.5-unit difference in Simpson's α diversity.[23] Two children from each household were enrolled and one was treated and one not treated after baseline assessments, for a total sample size target of 240 children.

Statistical methods

Descriptive characteristics were calculated overall and by study village with proportions for categorical variables and medians and IQRs for continuous variables. To assess the relationship between dietary diversity and anthropometric outcomes (including HAZ, WHZ, WAZ, MUAC, stunting, wasting and underweight), we first built a series of bivariate linear regression (for continuous outcomes) or logistic regression (for dichotomous outcomes) models. A separate model was created for each anthropometric outcome, with dietary diversity as the independent variable, and SEs were adjusted for clustering within the household. We then created a series of multivariable models for each outcome, adjusting for the child's sex, breastfeeding status (yes/no), household food insecurity, number of animals owned by the household, latrine use by the household, sugary beverage consumption by the child and village of residence. Due to differences in study communities, a fixed effect for study community was included in all models (bivariate and multivariable). Models were run for the overall sample and in the subgroup of children <36 mo of age to assess the effects in younger groups of children, who may have a higher risk of acute and chronic malnutrition.[24,25] All analyses were run in Stata 14.1 (StataCorp, College Station, TX, USA).

Results

A total of 251 children were enrolled in the study and included in the analysis, 130 in Kamadena and 121 in Dara. One child was exclusively breastfeeding and was excluded from this analysis. Table 1 lists descriptive characteristics of the study sample by village. Caregivers in Kamadena reported higher dietary diversity scores in Kamadena than in Dara (median 6 vs 5) and a larger number of animals owned by the household (median 20 vs 11). The study villages differed substantially for stunting and underweight prevalence (stunting 27.7% in Kamadena vs 13.1% in Dara; underweight 18.5% in Kamadena vs 9.0% in Dara). Caregivers of children in Kamadena were more likely to report sugary beverage consumption than caregivers in Dara (86.9% vs 68.9%). The median age was 37 mo (IQR 25–49) and approximately half (51.2%) were female. The median dietary diversity score was 6 food groups out of a maximum of 11 (IQR 4–7). Most children had eaten a form of grain (96.8%), sauce made of green leaves (93.7%), meat or fish (82.9%), legumes or nuts (80.6%), oil or fat (63.1%) and vegetables (50.8%). Less common was consumption of milk (26.2%), eggs (22.2%), mango/papaya (30.6%), vitamin A–rich foods (5.2%) and other fruits (1.2%). Overall, the prevalence of stunting was 20.6%, wasting 10.0% and underweight 13.9%.

Table 2 lists the results of bivariate and multivariable models of the association between dietary diversity and anthropometric indices. In an adjusted model, children with a higher dietary diversity score had a higher HAZ (mean increase 0.14 SD per one-count increase in dietary diversity [95% CI 0.04 to 0.25], p=0.009) and non-significantly higher WAZ (mean increase 0.08 SD per one-count increase in dietary diversity [95% CI −0.001 to 0.17], p=0.054). Although not statistically significant, children with higher dietary diversity had reduced odds of stunting (adjusted OR [aOR] 0.82 per one-unit increase in dietary diversity [95% CI 0.67 to 1.02], p=0.07) and underweight (aOR 0.82 [95% CI 0.65 to 1.04], p=0.10). There was no association between dietary diversity and WHZ, MUAC or wasting.

The association between dietary diversity and linear growth was stronger among children <36 mo of age (Table 3), with each one-count increase in dietary diversity score associated with a mean increase of 0.20 SD in HAZ (95% CI 0.04 to 0.35; p=0.02). Higher dietary diversity was also associated with less stunting (OR 0.73 [95% CI 0.53 to 0.99], p=0.04) and underweight (aOR 0.69 [95% CI 0.50 to 0.96], p=0.03) in this younger population.

Discussion

In this study, greater dietary diversity was significantly associated with increased HAZ among children in rural Burkina Faso. Among younger children, greater dietary diversity was also associated with reduced stunting. This is consistent with previous studies, which have generally found an association between dietary diversity and HAZ.[5] HAZ and stunting are reflective of longer-term nutritional status, and stunting is thought to begin early in a child's life.[26] In the present study, the association between both HAZ and stunting and dietary diversity was stronger in younger children. Despite this study taking place during the lean season, both nutritional status

Table 1. Descriptive characteristics of the study sample (N=251)

Characteristics	Kamadena (n=130)	Dara (n=121)	Overall (N=251)
Age, mo, median (IQR)	36 (23–48)	39 (26–52)	37 (25–49)
Female sex, n (%)	66 (50.8)	63 (51.6)	129 (51.2)
Dietary diversity, median (IQR)	6 (5–7)	5 (4–6)	6 (4–7)
Currently breastfeeding, n (%)	31 (23.9)	24 (19.7)	55 (21.8)
Caregiver or family member ate limited variety in past 30 d, n (%)	28 (21.5)	27 (22.1)	55 (21.8)
Caregiver or family member went to bed hungry in past 30 d, n (%)	12 (9.2)	19 (15.6)	31 (12.3)
Number of animals owned by household, median (IQR)	20 (9–40)	11 (5–21)	13 (6–28)
Latrine use, n (%)	90 (69.2)	77 (63.1)	167 (66.3)
Sugary beverage consumption, n (%)	113 (86.9)	84 (68.9)	197 (78.2)
HAZ, median (IQR)	−1.4 (−2.2 to −0.7)	−0.7 (−1.4 to −0.2)	−1.2 (−1.8 to −0.5)
WHZ, median (IQR)	−0.3 (−1.2–0.4)	−0.5 (−1.2–0.2)	−0.4 (−1.2–0.3)
WAZ, median (IQR)	−1.0 (−1.9 to −0.5)	−0.8 (−1.4 to −0.2)	−0.9 (−1.5 to −0.4)
MUAC, mm, median (IQR)	150 (143–160)	151 (145–160)	151 (144–160)
Stunted, n (%)	36 (27.7)	16 (13.1)	52 (20.6)
Wasted, n (%)	14 (10.8)	11 (9.1)	25 (10.0)
Underweight, n (%)	24 (18.5)	11 (9.0)	36 (13.9)

Table 2. Association between dietary diversity and nutritional status among all children (N=251)

	Bivariate[a]		Multivariable[b]	
	Mean/OR (95% CI)	p Value	Mean/aOR (95% CI)	p Value
HAZ	0.12 (0.03 to 0.21)	0.007	0.14 (0.04 to 0.25)	0.009
WHZ	−0.004 (−0.10 to 0.10)	0.94	0.006 (−0.09 to 0.10)	0.91
WAZ	0.06 (−0.02 to 0.14)	0.12	0.08 (−0.001 to 0.17)	0.054
MUAC	0.06 (−0.02 to 0.15)	0.15	0.06 (−0.04 to 0.16)	0.23
Stunting[c]	0.86 (0.72 to 1.03)	0.11	0.82 (0.67 to 1.02)	0.07
Wasting[d]	0.96 (0.80 to 1.17)	0.71	0.87 (0.68 to 1.11)	0.26
Underweight[e]	0.90 (0.74 to 1.09)	0.26	0.82 (0.65 to 1.04)	0.10

[a]Estimated with linear regression model for continuous variables or logistic regression model for categorical variables with SEs clustered by household.
[b]Adjusting for child's sex, health facility attendance in previous 30 d, food insecurity, number of animals owned by household, latrine use, sugary beverage consumption and study community.
[c]Defined as HAZ<−2 SD (2006 WHO guidelines).
[d]Defined as WHZ<−2 SD (2006 WHO guidelines).
[e]Defined as WAZ<−2 SD (2006 WHO guidelines).

Table 3. Association between dietary diversity and nutritional status among children <36 mo of age (N=113)

	Bivariate[a]		Multivariable[b]	
	Mean/OR (95% CI)	p Value	Mean/aOR (95% CI)	p Value
HAZ	0.17 (0.04 to 0.30)	0.01	0.20 (0.04 to 0.35)	0.02
WHZ	−0.005 (−0.14 to 0.13)	0.94	−0.01 (−0.16 to 0.13)	0.84
WAZ	0.08 (−0.02 to 0.19)	0.12	0.10 (−0.02 to 0.23)	0.11
MUAC	0.07 (−0.05 to 0.18)	0.25	0.07 (−0.06 to 0.20)	0.29
Stunting[c]	0.84 (0.66 to 1.07)	0.17	0.73 (0.53 to 0.99)	0.04
Wasting[d]	0.98 (0.77 to 1.27)	0.91	0.86 (0.61 to 1.22)	0.40
Underweight[e]	0.85 (0.67 to 1.07)	0.16	0.69 (0.50 to 0.96)	0.03

[a]Estimated with linear regression model for continuous variables or logistic regression model for categorical variables with SEs clustered by household.
[b]Adjusting for child's sex, health facility attendance in previous 30 d, food insecurity, number of animals owned by household, latrine use, sugary beverage consumption and study community.
[c]Defined as HAZ<−2 SD (2006 WHO guidelines).
[d]Defined as WHZ<−2 SD (2006 WHO guidelines).
[e]Defined as WAZ<−2 SD (2006 WHO guidelines).

and dietary diversity in this study population were higher than has been previously reported in Burkina Faso.[9,10] This may be indicative of secular trends or differences in socio-economic status in the study communities. However, these results indicate that dietary diversity is associated with chronic malnutrition, even in regions that have relatively higher dietary diversity and better nutritional status. For children who are not exclusively breastfeeding, increasing dietary diversity may be an important intervention to reduce stunting and underweight among children in the first 3 y of life.

Nutritional deficiency leads to growth retardation through a variety of mechanisms. Protein and micronutrient deficiencies affect insulin-like growth factor I (IGF-I) plasma concentration, which is thought to be involved in the control of bone growth.[27] Children with micronutrient deficiency may also be at increased risk of infection,[28] which may contribute to chronic undernutrition. Dietary diversity has been shown to be a good predictor of dietary quality and micronutrient density in young children.[4] Although in the present study overall intake of animal protein was high, children with lower dietary diversity may be at higher risk of micronutrient deficiencies that lead to chronic malnutrition and stunting.

There was no association between dietary diversity and wasting or MUAC in this study. In contrast to stunting, which refers to chronic malnutrition, wasting is generally the result of shorter-term episodes of acute malnutrition.[29] Previous studies have shown that food insecurity, rather than dietary diversity, is predictive of child wasting.[19,30] It is likely that dietary diversity scores are reflective of longer-term nutritional habits and that food insecurity reflects more immediate food shortages.

In children <36 mo of age, dietary diversity was associated with underweight. Weight-for-age is influenced by a child's height, as children who are short for their age also tend to weigh less. It is likely that this result is reflective of the effect of dietary diversity on height rather than acute changes in weight. However, low weight-for-age has been shown to contribute to both all-cause and infectious child mortality, including malaria mortality.[31] Child mortality incidence is highest during the rainy season in this region of Burkina Faso,[32] likely attributable to malaria. Interventions that impact weight-for-age and reduce chronic malnutrition during the overlapping malaria and lean seasons may be particularly impactful, such as unconditional seasonal cash transfers, which have been shown to increase intake of high-nutrition foods during the lean season in Burkina Faso.[33] However, there may also be utility in improving dietary diversity year-round to prevent chronic malnutrition.

The results of this study must be considered in the context of its limitations. The study relied on caregiver dietary recall, which is subject to misclassification and potential bias, and may not capture the full breadth of dietary information. This study may have been underpowered to detect small or modest differences in nutritional outcomes and was cross-sectional, thus was unable to determine the temporality of dietary patterns and nutritional outcomes. The study villages were generally larger than other communities in the HDSS and only households with two or more children <5 y of age were eligible for the underlying trial. Therefore the results of this study may not be generalizable to children from smaller households or villages, particularly those with different socio-economic status or prevalence of undernutrition.

In this setting in rural Burkina Faso during the lean season, dietary diversity appeared to be a modifiable risk factor for stunting and chronic malnutrition, particularly among younger children. Interventions that address dietary diversity, such as unconditional cash transfers, community-based caregiver nutritional education[34] or promotion of improved infant and young child feeding practices,[35] should be considered in rural sub-Sahelian regions with seasonal malnutrition, as well as efforts to reduce the burden of infectious disease, such as seasonal malaria chemoprevention[36,37] or integrated community case management.[38] Improving dietary diversity will likely have greater effects on longer-term chronic malnutrition than acute malnutrition.

Authors' contributions: AS, TB, EL, JDK and CEO designed the study protocol. AS, CT, CD, LO, PZ, AMA, EL, BMS, CM, JDK and CEO conducted all study assessments. PZ, TB, CM, JDK and CEO analyzed the data and all authors interpreted the data. AS and CEO drafted the manuscript. All authors critically revised the manuscript for intellectual content. All authors read and approved the final manuscript. AS, JDK and CEO are guarantors of the paper.

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Competing interests: None declared.

Ethical approval: The study was reviewed and approved by the Comité Institutionnel d'Ethique at the CRSN in Nouna, Burkina Faso and the Institutional Review Board at the University of California, San Francisco. Written informed consent was obtained from the guardian/caregiver of each participant.

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