Nutrition 65 (2019) 97–102

Contents lists available at ScienceDirect

Nutrition

journal homepage: www.nutritionjrnl.com

Applied nutritional investigation

Household food insecurity but not dietary diversity is associated with children's mean micronutrient density adequacy in rural communities across Ghana

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ARTICLE INFO

Article History:
Received 26 July 2018
Received in revised form 13 February 2019
Accepted 20 March 2019

Keywords:
Food insecurity
Dietary diversity
Nutrient intake
Farming household
Non-farming household

ABSTRACT

Objective: The aim of this study was to examine predictors of household food insecurity, dietary diversity, and children's mean micronutrient density adequacy and the relationship among these dietary measures.
Method: Baseline analysis of a quasi-experimental 16-mo intervention study conducted in 12 rural communities in the three main agroecological zones in Ghana. The study included 608 caregivers with their 2- to 5-y-old children. Nutrient density adequacy was estimated for a subsample of 120 children.
Results: Food insecurity was more severe among farming households than their non-farming counterparts ($P = 0.032$). Dietary diversity score was significantly higher among non-farming households than farming households ($P < 0.001$). Food insecurity was negatively correlated with both household dietary diversity ($r = -0.385$; $P < 0.001$) and child mean micronutrient adequacy ($r = -0.305$; $P < 0.001$). There was no significant correlation between dietary diversity and children's mean micronutrient density adequacy. Belonging to a household that is severely food insecure and household size were significant predictors of children's mean micronutrient density adequacy (ß = –0.124, $P = 0.006$; ß = 0.011, $P = 0.006$, respectively).
Conclusion: Household food insecurity continues to be a good indicator of lower nutrient intake in children.

Introduction

Micronutrient deficiencies are major public health challenges, particularly in sub-Saharan African developing countries [1,2]. In addition to improving household access to food, increasing the variety of foods is recommended for the provision of essential micronutrients, particularly among children. This notwithstanding, the relationship among diet-related measures such as food insecurity, dietary diversity, and adequate micronutrients intake is far from consistent across different age groups and cultural settings [3]. Some differences in findings may be attributed to location (urban versus rural), differences in sociodemographic characteristics, and within-food group variability [2]. Thus, there is a continued need for appropriate indexes to capture food access, food availability, and the adequacy of micronutrients intake [4,5].

Quantifying nutrients in food intake through direct weighing is expensive. This often has led to the use of low-cost tools such as dietary diversity indexes as proxies of micronutrient intake in antipoverty programs that address malnutrition [6]. Dietary diversity may serve as a practical indicator of nutrient adequacy; however, it requires evaluation in relation to agricultural interventions and different settings [7]. Conversely, household food insecurity expresses the degree to which nutritionally adequate foods are available and accessible thus may reflect in the households' ability to provide adequate micronutrients for thier children. Although current literature suggests a link between household food insecurity and dietary intakes, its relationship with micronutrient intakes and nutritional status outcomes, particularly in children, has been inconsistent [8,9]. It has been argued that although food insecurity is

This work was supported by the Global Livestock Collaborative Research Support Programme of the Office of Agriculture, Bureau for Economic Growth, Agriculture, and Trade, United States Agency for International Development (USAID) under terms of grant no. PCE-G-00-98-0003600. The opinions expressed here are those of the authors and do not necessarily reflect the views of the USAID. This study falls under a broader study—The Enhancing Child Nutrition through Animal Source Food Management (ENAM) project.
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https://doi.org/10.1016/j.nut.2019.03.006
0899-9007/

experienced by the entire household, the dietary consumption of individuals, especially children, is a managed process, thus household food insecurity measurements may not reflect children's dietary intake [10]. Adults may endure hunger so that children do not suffer [11]. These findings suggest that the association between different dietary intakes should be viewed within context.

Some studies conducted in sub-Saharan African countries have shown positive associations between dietary diversity, food security, and some key nutrients intake in children [2,3,12], albeit there are limited studies examining the relationship between household food insecurity and the mean micronutrient density adequacy (MMDA) of children and between dietary diversity and MMDA of children. Also, in addition to income and education being linked with the amount of nutrient intake [13], there are different predictors influencing nutrient intake among non-farming and farming households [14]. Thus, the aim of this study was to examine the determinants of household food insecurity, dietary diversity, and children's MMDA and the relationships among these three dietary indicators in rural Ghanaian households.

Materials and methods

This study draws on baseline data from the ENAM (Enhancing Child Nutrition through Animal Source Food Management) study. The ENAM study provided microcredit, nutrition education, and entrepreneurial training to caregivers with the objective of increasing the consumption of animal source foods (ASF) and improving diet quality and nutritional status of children 2 to 5 y of age [15]. Details of the ENAM study design and baseline data collection are described elsewhere [15–17]. The institutional review boards at the Noguchi Memorial Institute for Medical Research (University of Ghana, Legon), Iowa State University, and McGill University gave ethical clearance for the study. Written informed consent was obtained from all caregivers and permission was sought from community chiefs and other local leaders during community entry. The study procedure is described briefly.

Study sites and sample

The ENAM study was conducted in 12 communities (2 intervention and 2 control communities) within each of the three main agroecologic zones (Coastal Savannah, Savannah-Forest Transitional, and Guinea Savannah) in Ghana. In all, 608 caregivers with their 2- to 5-y-old children were enrolled in the baseline survey. Data were collected between April and July 2006. A caregiver was considered the person with whom the child lived and who had primary responsibility for childcare (particularly feeding) most of the time. For households with more than one child within the eligible age, the youngest child was selected along with the caregiver.

Survey

All survey questions were pretested and refined with neighboring communities of similar sociodemographic characteristics. Household questionnaires were administered one-on-one to the caregivers by a trained research enumerator in their preferred local language. For quality assurance, field supervisors duplicated a randomly selected number of questionnaires of each enumerator to validate answers.

Household characteristics

Households were grouped as either farming or non-farming according to the primary occupation reported by the household head or caregiver. For example, traders, skilled artisans, hunters, food sellers, or salaried workers occupation fell under "non-farming." Household information collected included caregiver age, education, occupation, relationship to household members, place of origin, ethnicity, marital status, and living arrangement. Local, sex-balanced key informants assigned participating households in the community to different wealth categories (low, medium, or high) based on community-agreed criteria [16]. Generally, a high wealth category household had a family member with a profession, earning a regular income, or being able to loan money to others. Medium wealth households were perceived as not being too rich but able to send their children to school, whereas low wealth households were those perceived as unable to send their children to school.

Dietary intake measures

Household food insecurity was measured using a pretested tool adapted from the United States Department of Agriculture (USDA) Household Food Security Core Module to emphasize ASF consumption as an indicator of diet quality [18]. This food security module is based on a set of 10 questions describing households' overall food insecurity experience. Children's dietary intake was assessed using data from 2-d, 12-h weighed food records, for a subsample of 120 households. A 12-h record that was used for previous research documented that 95% of toddlers' energy intake of family foods was consumed during the 12 daytime hours [19] and there were extreme challenges associated with data collection at night in rural communities. The 2 d selected were either one weekday and a weekend day or one market day and one non-market day. This was based on known differences in eating patterns between weekdays and weekends as well as between market and non-market days. In some rural communities, a market day is designated for marketing farm produce and engaging in other commercial activities.

Data management and statistical analyses

A categorical variable was generated for household food insecurity. Positive responses to eight dichotomous food security questions were summed to give a total household food insecurity score (HFIS). Households with no, one to three, four to six, and seven to eight positive responses were categorized as food secure, mildly food insecure, moderately food insecure, and severely food insecure, respectively [20]. The Food and Agriculture Organization's household dietary diversity score (HDDS) guidelines were used to calculate a dietary diversity score based on the number of food groups from which a household consumed over the previous 7 d [21,22]. The diet was classified according to 12 groups (roots and tubers, cereals, red meat, fish, birds, eggs, dairy, legumes, fats and oils, green leafy vegetables, other vegetables, and fruits). Each household was allocated a value of 1 for consuming any food item from a specific food group. A maximum score of 12 was achieved for households consuming from each group over the previous 1 wk preceding the interview. Children's dietary intakes collected from the 2-d, 12-h weighed food records were converted to energy and nutrients using a food database (RIING food composition database, Nutrition Department, University of Ghana) and ESHA-F-pro software [23].

Micronutrient density adequacy of the children's diet was calculated for eight micronutrients (vitamins A, B_6, B_{12}, and C, folate, calcium, iron, and zinc). Individual micronutrient density adequacy was calculated as the proportion of the nutrient consumed divided by the Estimated Average Requirement (EARs) on an age-specific requirement [24,25]. The EAR for a nutrient is the estimated intake of that nutrient to meet the requirement of half the healthy individuals in a particular life-stage and sex group [26]. The children's MMDA was calculated as the mean of all eight micronutrient density adequacies, with each capped at 1.

Caregivers and children's background characteristics were represented as percentages or means with SDs. Spearman's correlation was used to assess the extent of the linear relationship among HFIS, HDDS, and MMDA. Multiple linear regression analysis, adjusting for the household sociodemographic characteristics such as household wealth, educational status of head of household and caregiver, household size, and children's age were used to assess the association of HFIS with HDDS and MMDA. Given the HFIS, an ordinal logistic regression model was to examine independently the predictors of HFIS given that it was a rank-ordered variable. All analyses were performed using STATA version 14 (Stata Corp., College Station, TX, USA). Significance was considered at $P < 0.05$ unless otherwise noted.

Results

Household, caregiver, and child characteristics

Almost two-thirds (61%, n = 369) of the participating households were ranked as having low wealth status. More farming households were in the low wealth category than non-farming households (63% versus 37%; $P = 0.074$). About half (51%, n = 313) of household heads had some formal education. There tended to be a difference in household composition with fewer total members ($P = 0.054$) but more children under 5 y of age ($P = 0.055$) in non-farming households than farming households (Table 1). More caregivers in non-farming households had some formal education than their counterparts in farming households ($P < 0.05$); conversely fewer caregivers of non-farming households were married than caregivers of farming households ($P < 0.001$). Among the study participants, children in farming households were older than in non-farming households ($P < 0.001$). There were no differences in child nutritional status by household farming status. Overall, 28%, 14%, and 2% of children in the study sample were stunted, underweight, and wasted, respectively.

Table 1
Household, caregiver, and child characteristics in rural Ghana for farming and non-farming households*

	Non-farming (n = 147)	Farming (n = 461)	*P*-value†
Household			
Family size, n	6.4 ± 2.6	6.9 ± 2.8	0.054
Children <5 y, n	1.7 ± 1.2	1.5 ± 0.8	0.055
Dietary diversity‡	9.8 ± 1.9	9.1 ± 2	0.001
Food security status§			
Food secure	10.9 (16)	7.6 (35)	0.032
Mild food insecurity	25.8 (38)	16.7 (77)	
Moderate food insecurity	28.6 (42)	35.1 (162)	
Severe food insecurity	34.7 (147)	40.6 (187)	
Household head with any formal education	56.7 (83)	49.9 (230)	0.165
Caregiver			
Any formal education	55.8 (82)	45.3 (209)	0.027
Migrant	46.9 (69)	56.0 (258)	0.056
Married	70.8 (104)	92.4 (426)	<0.001
Age, y	34 ± 9.8	32.5 ± 8.6	0.091
Number of children <5 y supervised by caregiver	1.1 ± 0.8	1.2 ± 0.7	0.043
Child			
Sex, female	48.3 (71)	48.6 (224)	0.951
Age, mo	39.2 ± 11.1	43 ± 11.7	<0.001
Dietary diversity‡	10.0 ± 1.8	9.3 ± 1.9	<0.001
Nutritional status‖			
Stunted	27.9 (41)	28.2 (130)	0.942
Wasted	1.4 (2)	2.2 (10)	
Underweight	11.6 (17)	14.3 (66)	0.397

*Values are % (n), means ± SD.
†χ^2 tests or analysis of variance to examine group differences.
‡Summative score for 12 food groups consumed during the past 7 d (roots and tubers, cereal, red meat, fish, poultry, egg, milk, legume and seeds, fats, green vegetables, other vegetables, and fruits).
§Response scores of 0, 1–3, 4–6, and 7–8 were categorized as *food secure, mildly food insecure, moderately food insecure,* and *severely food insecure*, respectively.
‖Stunted: height-for-age < −2 *Z* scores; wasted: weight-for-age < −2 *Z* scores; underweight: weight-for-age <−2 *Z* scores.

Food insecurity and dietary diversity

Only 8% of all households reported being food secure. Food insecurity was more common among farming households than their non-farming counterparts; there was a 12 percentage point difference in being moderately or severely food insecure by farming status ($P = 0.032$; Table 1). The dietary diversity score was significantly higher among non-farming households than farming households ($P < 0.001$).

Nutrient intake, nutrient density adequacy, and prevalence of nutrient adequacy

Table 2 shows result for the percentage of children meeting the EAR for each nutrient and the median nutrient intakes by farming status. The EAR of iron and vitamin C was met by 99% and 83% of the children, respectively. Slightly more than half (52%) of the children met the EAR for vitamin A. The nutrient with the least percentage of children meeting the EAR was folate. The median intake of vitamin B_{12} of the children was 15 times higher among non-farming households than farming households ($P = 0.005$). There was no other group difference in the intake for the other micronutrients.

Associations among dietary intake measures

Almost all households (>98%) consumed cereals and fish (Table 3). Eight of the 10 remaining food groups were consumed more frequently in households that were food secure or mildly food insecure than those that were moderately or severely food insecure. There was no difference by food security status in the consumption of legumes/nuts or green leafy vegetables.

Predictors of food insecurity, dietary diversity, and MMDA

Multiple linear regression models adjusted for household, caregiver and child factors were applied to estimate the predictors of household food insecurity, dietary diversity, and children's MMDA (Table 4). Household food insecurity was negatively associated with having a medium/high wealth rank, caregivers with some education, and children's dietary diversity score. Household dietary diversity was positively associated with household size and the caregiver's education and negatively associated with food insecurity and being a farming household**.** Finally, the MMDA was negatively associated with severe food insecurity and tended to be positively associated with household size.

Discussion

This study investigated the factors that were related to household food insecurity, household dietary diversity, and children's micronutrient density adequacy in farming and non-farming rural households in Ghana. In addition, we examined whether these dietary measures were correlated with each other in this setting. Farming households were more food insecure and more likely to consume a less diverse diet than non-farming households. Two major strengths of this empirical work are the use of an adapted, validated version of the United States Department of Agriculture Household Food Security Core Module for measuring food insecurity across all three major agroecological zones in Ghana and assessing micronutrient intake by direct weighing of foods eaten by children within a 2-d, 12-h observation period. This is an improvement on the use of recalls methods for dietary intake even when food models are used to increase the accuracy of portion sizes.

Our findings showed that an increase in household dietary diversity is associated with a reduction in the severity of household food insecurity, even after controlling for household sociodemographic characteristics such as wealth and the formal education of household head and caregiver. Household food insecurity but not dietary diversity was a predictor (negative) of children's MMDA. In other words, children in food-secure households were more likely to be consuming adequate amounts of micronutrients. Despite differences in the methods used for the estimation of household food insecurity and dietary diversity in different studies, this finding was consistent with that of others showing that the degree of household food insecurity was always higher among households that consumed less diverse diets [27–29]. Na et al. (2016) also showed a reduction in dietary diversity with an increase in the severity of household food insecurity in rural Bangladesh [30]. In the present study, the decline in household dietary diversity with increasing severity of food insecurity was primarily due to lower consumption of ASF, fruits, fats, and roots among moderately to severely food-insecure households. Similarly, in rural Bangladesh, the severity of household food insecurity was associated with a reduction in dietary diversity namely from lack of ASF consumption such as meat and fish [30].

Belonging to a household that reported severe food insecurity was associated with a lower children's MMDA. Consistent with other studies, the diet quality of children was worse as household food insecurity was more severe [31]. Findings of this study were, however, contrary to that of Oh and Hong (2003) who showed that nutrient intakes were highest among children from households that were mildly food insecure compared with those in food-secure households, in Seoul and South Korea [32].

Table 2
Prevalence of nutrient adequacy and median nutrient intakes for children belonging to non-farming and farming households*

	EAR (1–3 y)	EAR (4–8 y)	Adequacy[†] (%)	Total (N = 120)	Non-farming (n=37)	Farming (n=83)	P -value[‡]
Micronutrient intake							
Vitamin A, μg RAE	210	275	51.7	277.1[‡] (85.5–756.8)	289.5 (73.3–750.2)	219.2 (88.7–787.4)	0.492
Vitamin C, mg	13	22	83.3	42.9 (23–63.7)	37.9 (24.5–54)	45.4 (22.5–67.2)	0.117
Vitamin B_6, μg	0.4	0.5	7.5	0.07 (0.02–0.19)	0.10 (0.02–0.20)	0.06 (0.02–0.20)	0.550
Vitamin B_{12}, μg	0.7	1	15.8	0.08 (0–0.45)	0.30 (0.001–0.719)	0.02 (0.00–0.24)	0.005
Calcium, mg	500	800	34.1	450.5 (320.6–851.3)	512.6 (320.6–851.3)	436.3 (286.5–724.4)	0.402
Iron, mg	3	4.1	99.2	14.8 (10.7–20.1)	14 (11.1–17.1)	15.1 (10.2–21.1)	0.287
Zinc, mg	2.5	4	90.8	7.1 (4.8–9.4)	7.7 (5.6–9.5)	6.3 (4.5–8.9)	0.221
Folate, μg	120	160	0.8	11.8 (2.3–35.4)	18.3 (3–45.2)	10.7 (2.3–33.3)	0.542
MMDA[§]				0.5 ± 0.15	0.51 ± 0.18	0.46 ± 0.13	0.097

EAR, Estimated Average Requirement; MMDA, mean micronutrient density adequacy; RAE, retinol activity equivalents.
Values represent median (interquartile range).
*Data from the mean of 2 d of 12-h weighed food intake of the child.
[†]Percent of children meeting the EAR.
[‡]*P*-value for comparison between farming and non-farming households.
[§]For the following nutrients: vitamins A, B_6, B_{12}, and C; folate, calcium, iron, and zinc.

Table 3
Household consumption of 12 food groups by food security status*

	Food secure and mildly food insecure (n = 166)	Moderately and severely food insecure (n = 442)	P -value[†]
Food groups			
Roots	98.2 (163)	73.8 (326)	<0.001
Cereal	99.4 (165)	99.8 (441)	0.470
Poultry	60.8 (101)	43.0 (190)	<0.001
Eggs	72.9 (121)	60.9 (269)	0.006
Dairy	51.2 (85)	31.9 (141)	<0.001
Legumes/Nuts	95.2 (158)	92.8 (410)	0.283
Fat	99.4 (165)	95.5 (422)	0.018
Green leafy vegetables	90.3 (149)	88.8 (382)	0.605
Other vegetables	100.0 (165)	94.4 (405)	0.002
Fruits	93.9 (155)	60.2 (257)	<0.001
Fish	98.8 (164)	98.2 (434)	0.601
Red meat	80.1 (133)	55.7 (246)	<0.001

MMDA, mean micronutrient density adequacy.
Overall household food insecurity was negatively correlated with both household dietary diversity ($r = -0.381$; $P < 0.001$) and MMDA ($r = -0.305$; $P = <0.001$). Dietary diversity was not correlated with MMDA ($r = 0.137$; $P = 0.135$).
*Values are % (n).
[†]χ^2 test examined group differences.

There was no significant association between household dietary diversity and children's MMDA in this study. In other studies, the dietary diversity score was shown to correlate positively with nutrient intake among 6- to 23-mo-old children in Madagascar [33] and also among 1- to 8-y-old children in South Africa [3]. Several reasons could explain the differences in these findings including a difference in the food groups considered in calculating the dietary diversity score as well as the difference in the methods used for estimating micronutrient intakes. More importantly, micronutrient intakes of children in this study were derived from the average of 2 d of 12-h weighed food intake compared with the 24-h dietary recalls employed by several studies to explore the relationship between dietary diversity and children's MMDA. Given previously documented dietary patterns showing almost exclusive (95%) daytime intake of family foods, the use of 12 h of data collection probably closely estimates total 24 h intake [19] . The 24-h dietary recall method often is used to assess children's micronutrients intake, but the lack of precision in estimating portion sizes could lead to either underestimating or overestimating individual nutrient intakes [34]. As household dietary diversity considers only the number of different food groups consumed within a given time and does not consider the quantity of food intakes and variability of foods within groups, it may not always be a strong indicator for MMDA. Additionally, different child age groups have been used in exploring this relationship. Although the current study encompasses 24- to 60-mo-old children, the participants in the study by Moursi et al. [33] were 6- to 23-mo-old. Thus, the relationship between dietary diversity and MMDA may be influenced not only by methods used in accessing dietary intake but also by the age group of the children being considered.

Whereas the majority of children surveyed in the United Kingdom were seen to have adequate or more than adequate intakes of energy, protein, and micronutrients (except for iron and vitamin D) [35], no nutrient was adequately consumed by all the children in our sample, with vitamin B_6 and folate being the nutrients with the least proportion of children meeting adequacy. More nutrients (except energy, calcium, and folate) were adequately consumed in a similar study conducted in Cape Town [36], where analysis was based on food frequency data which could easily be overreported.

Comparing the relationship between dietary measures across countries based on food insecurity, dietary diversity and micronutrient density adequacy can be complex given the varying methodologies used. Although some authors advocate the use of the Healthy Eating Index and the Dietary Quality Index [24–27] as improved dietary indicators, their use is complex and time consuming [3]. Thus, less complex and faster indicators are being explored.

This study had some limitations. First, this current analysis was based on cross-sectional data and offered only a snapshot of the examined relationships. It did not account for possible seasonal effects on all the dietary measures. Although we weighed foods prepared and consumed by children during a 12-h daytime period, a small portion of their daily intake may have been eaten after the 12-h daytime period. How this portion varied by age is unknown but the negative association between child age and MMDA may, in part, reflect an increasing portion of the total diet consumed in the evening hours as the child ages.

This study demonstrated the relationship between household food insecurity and children's MMDA to be consistent with other studies compared with that of household dietary diversity. The present results buttress others demonstrating that improved household food security has a positive effect on children's feeding practices and nutrition outcome, including nutrient intake. However, given that no micronutrient was adequately met by all the children in our study, even within food-secure households, it suggests the need for continuous education of caregivers on the importance of ASF in children's diet. This was the overall aim of the ENAM study: to improve the consumption of ASF in the diets of children under 5 y of age by enhancing household income in combination with nutrition education and entrepreneurial skills development [15].

Table 4
Predictors of household food insecurity, household dietary diversity, and children's mean micronutrient density adequacy

	Household food insecurity			Household dietary diversity			Children's mean micronutrient density adequacy*		
	β	SE	P-value	β	SE	P-value	β	SE	P-value
Household									
Wealth (reference = low)†									
Medium/High	−0.495	0.160	0.002	0.196	0.147	0.183	−0.004	0.024	0.853
Food security (reference = food secure)‡									
Mild				−0.087	0.253	0.731	−0.058	0.048	0.233
Moderate				−0.885	0.253	<0.001	−0.068	0.046	0.139
Severe				−1.626	0.254	<0.001	−0.124	0.044	0.006
Household head's formal education (reference = none)									
Any formal education	−0.132	0.173	0.445	0.247	0.151	0.103	0.026	0.027	0.344
Dietary diversity score§	−0.345	0.043	<0.001				−0.004	0.008	0.584
Household size	−0.026	0.029	0.369	0.087	0.023	<0.001	0.011	0.004	0.006
Type of household (reference = non-farming)									
Farming	0.015	0.204	0.941	−0.528	0.180	0.003	−0.026	0.032	0.405
Caregiver									
Marital status (reference = single)									
Married/cohabitating	0.416	0.225	0.064	0.488	0.237	0.04	−0.015	0.044	0.735
Educational status (reference = none)									
Any formal education	−0.323	0.181	0.075	0.649	0.151	<0.001	0.018	0.027	0.506
Children									
Age, mo							−0.041	0.014	0.003

*Data from the mean of 2 d of 12-h weighed food intake of children; micronutrients included: vitamins A, B_6, B_{12}, and C; folate, calcium, iron, and zinc for a subsample of 120 children.
†Household wealth rank was determined by peers within each community, as previously described [16].
‡Household food security was measured with a 10-item pretested tool that was adapted from the USDA Household Food Security Core Module to emphasize animal source food consumption as the indicator of diet quality [18].
§Dietary diversity: Based on summative score consumed during the past 7 d for 12 food groups (roots and tubers, cereal, red meat, fish, poultry, egg, milk, legume and seeds, fats, green vegetables, other vegetables, and fruits).

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