Dietary Intakes and Nutritional Status of Mother-Child (6-23 Months Old) Pair Targeted through the "Organic Residual Products for Biofortified Foods for Africa Project" in Rural Area in Senegal

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Abstract: *Background*: Despite micronutrient supplementation and food fortification strategies carried out for decades, micronutrient deficiencies remain prevalent among children under 5 years old in rural area in Senegal. The OR4FOOD project was implemented as a preventive and long-term approach to reduce malnutrition through biofortification.

Objective: We aimed to assess the baseline dietary intakes and nutritional status of the mother-child (6-23 months old) pair in a rural community in Senegal.

Methods: Dietary intakes were assessed using dietary recall questionnaires and weight food records. All foods and beverages consumed from waking to bedtime were quantified, and nutrient intakes were calculated. The nutritional status was measured by anthropometry.

Results: Results showed that 77.2% of children had low dietary diversity score. Only 18% of them received an appropriate complementary feeding according to the minimum acceptable diet. Cereals and legumes were among the most consumed food groups, whereas orange-fleshed sweet potato (OFSP) and animal food products were rarely consumed. Median dietary intakes of iron, zinc, and vitamin A were lower than the recommended dietary allowances. Acute malnutrition and stunting affected 14.6% and 16.9% of children, respectively. Overall, 20.8% of mothers were underweighted, and overweight/obesity affected 23.1% of them.

Conclusion: Malnutrition remains prevalent in rural areas of Senegal and affects both mothers and children. Furthermore, their nutrient requirements were not covered by the diet. Millet and cowpea being widely consumed, optimizing their iron and zinc content through biofortification and the introduction of OFSP might improve micronutrient intakes and would be promising strategies to prevent child malnutrition.

Keywords: Dietary intakes, nutritional status, mother-child (6-23 months old) pair, rural area, biofortification, Senegal.

INTRODUCTION

Optimal nutrition depends on the balance between nutritional requirements and dietary intakes. In women of reproductive age (WRA) and children, a healthy and balanced diet is essential to prevent all forms of malnutrition, as stated in Pelletier *et al.* [1] and Black *et al.* [2]. The first 1 000 days of life are significant for children. At this stage, the nutritional status of children and mothers is closely linked [2, 3]. Furthermore, good nutrition during this period is important to reduce morbidity and mortality among children and the risk of non-communicable diseases during adulthood. As related by Bhutta *et al.* [4] and Stewart *et al.* [5], good nutrition is essential to break the inter-generational cycle of maternal and child malnutrition. Therefore, the nutritional adequacy of the diet is fundamental.

In rural areas in Senegal, diets are often monotonous and mainly based on cereals with low animal source foods and micronutrients (vitamin A, iron, and zinc) rich foods [3, 6]. This was confirmed by the national food security survey, which showed that food consumption was twice very poor in rural households than in urban ones and that this disparity was more prevalent during the lean season [7]. The poor diet observed in these areas leads to an increase in maternal and child malnutrition, predominantly micronutrient deficiencies, as previously shown [8-10]. Like most sub-Saharan African countries, Senegal faces different forms of malnutrition [11, 12]. An outstanding work by Badiane and collaborators has shown that in the Kaffrine region (groundnut basin), 16.4% of WRA were affected by wasting, and 11.7% had overweight issues [3]. Micronutrient (iron, zinc, and

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vitamin A) deficiencies and anemia are also prevalent in this region and affect both children under five years of age and lactating women [13-15]. Different strategies such as vitamin A supplementation among children 6-59 months old, iron/folic acid in pregnant and lactating women, and food fortification were implemented to prevent maternal and child malnutrition. Despite these efforts, it is worth mentioning that malnutrition remains a public health issue in rural areas in Senegal. Nowadays, dietary diversity and nutrition education strategies are increasingly promoted to improve the quality of the diets [3, 4, 10]. Biofortification through nutrition-sensitive agriculture programs is also used as a new approach for optimizing the nutrients contents of staple crops consumed widely in order to address malnutrition, particularly the hidden hunger.

In this context, the OR4FOOD (Organic Residual Product for Biofortified Foods for Africa) project is implemented in a rural community in the Kaffrine region of Senegal as a long-term approach to promote the production and the consumption of vitamin A, iron, and zinc biofortified foods to prevent child and maternal malnutrition. The present study was carried out to assess the baseline dietary intakes (food consumption, nutrient intakes) and nutritional status of the mother-child (6-23 months old) pair (MCPs) targeted through this project.

MATERIALS AND METHODS

Study Design and Subjects

This community-based cross-sectional study was carried out in Mbarocounda and Malem Thialen, two villages located in the Kaffrine region (central groundnut basin of Senegal), selected as intervention and control villages, respectively. Data were collected between July and August 2019 among 130 MCPs. The sample size was calculated using the mean dietary diversity score of peer-age children in a neighboring rural area of the Kaffrine region [3]. Overall, MCPs were selected from the children's monthly weighing registers from the health post in Mbarocounda and with the support of community health workers (CHWs) in Malem Thialen.

Local and health authorities were informed, and written consent forms were signed by the head of the households, mothers, and/or caregivers of children. The study participants were informed about the objectives, expected outcomes, and benefits or risks, and all measures were taken to ensure the confidentiality of the collected information.

DATA COLLECTION

Dietary Assessment

The minimum dietary diversity (MDD) was assessed using 24-h dietary recall questionnaire. Dietary and nutrient intakes were measured by weight food record method, and a 7 days food frequency questionnaire was used to estimate the usual diet/consumption of specific foods [16].

Minimum Dietary Diversity Measurement

Among mothers, the MDD was defined by the proportion of mothers who consumed at least five (5) out of the ten (10) defined food groups (cereals, roots, and tubers; legumes; nuts and seeds; dairy; meat, poultry, and fish; eggs; dark green leafy vegetables; other vitamin-A rich fruits and vegetables; other fruits; and other vegetables) during the previous 24 hours [17].

In children, optimal breastfeeding and complementary feeding data were collected using standardized indicators of infant and young child feeding practices [18]. MDD was defined as the proportion of children who have consumed at least five (5) out of the eight (8) following food groups: breast milk; cereals, roots, and tubers; legumes and nuts; milk and dairy products; meat, fish, poultry, and liver/organ meats; eggs; vitamin A-rich fruits and vegetables; and other fruits and vegetables [19]. Minimum meal frequency (MMF) corresponds to the proportion of children who received during the previous 24 h at least two meals for breastfed children and four meals for non-breastfed children (with two milk meals). The minimum acceptable diet (MAD) was computed according to both MMF and MDD.

Weight Food Record

The weight food record (gold-standard method) was used to quantify all the food and beverages consumed throughout the day among 59 MCPs (24 hours, from waking to bedtime). Each simple food or meal consumed by mothers as well as by their children was accurately weighted. Weighting was performed by the investigators using dietary scales (Gram, Barcelona, Spain; Soehenle, Roma, 65847) to the nearest 1 g. Each ingredient was weighed and recorded for homemade mixed dishes before and after cooking. The total amount of each mixed dish after cooking was recorded. The total amount of each cooked mixed dish consumed by the mother/child was obtained by weighting the first spoon/handle and multiplying it by the number of spoon/handles ingested by each of them. After that, nutrient intakes, namely proteins, iron, zinc, and vitamin A, and the energy intakes were calculated using the west African food composition tables and the estimation method described by Gibson and Ferguson [20-22]. The weight equivalent of each raw ingredient consumed by the mother or the child was obtained by multiplying the proportion consumed in the total mixed dish by the weight of each raw ingredient in the recipe [22]. The energy and proteins requirements were estimated using the Institute of Medicine's dietary reference intakes (DRI) [23]. Energy requirements were calculated according to age, weight, height, and physical activity level. The prevalence of adequacy of micronutrients was determined using the recommended nutrient intakes [24]. For iron and zinc, the adequacy was calculated according to their bioavailability in meals based on cereals, roots, and tubers containing some animal source foods [24].

Food Frequency Measurement

The food frequency consumption was evaluated with a food frequency questionnaire (FFQ). FFQ consists of a list of specific foods or food groups associated with the frequency of consumption. The questionnaire includes the following food groups: cereals; tubers; legumes; oilseeds and nuts; vitamin-A rich vegetables; green leafy vegetables; other vegetables; yellow and red fruits, vitamin C rich fruits; other fruits; fruit juices; dairy; meats; liver and organ meats; fish and fishery products; oils and fats; eggs; tea; seasoning. The frequency of consumption of cowpea, millet, and orange-fleshed sweet potato (OFSP) targeted by the OR4FOOD project for the biofortification was also assessed.

Anthropometry

Anthropometric parameters were measured according to standardized procedures. Body weight was measured to the nearest 0.1 kg using electronic scales (SECA 877, GmbH & Co, Hamburg, Germany). The mothers were weighed with a light loincloth, and the children were measured without clothes. The height of the mothers and length of children were measured to the nearest 0.1 cm with a Seca board (SECA 216, GmbH et Co, Hamburg, Germany). Body mass index (BMI) was calculated, and mothers were classified according to their nutritional status as normal weight, underweight, and overweight/obese [25, 26]. For children, weight-for-length (WLZ) and length-for-age (LAZ) were calculated using WHO Anthro software [27], and malnutrition (wasting: WLZ < -2 z-scores and stunting: LAZ < -2 z-scores) was defined according to WHO child growth standards references [27].

Statistical Analysis

Data were computed using Epi-Info 3.5.1 (Centers for Disease Control and Prevention, Atlanta, USA), Microsoft Excel 2016 (Microsoft Corporation, Redmond, USA), ODK (open data kit), Stata SE 12 (Stata Corporation, Texas, USA), WHO Anthro version 2.0.2 and WHO anthro-Plus version 1.0.4 softwares (www.who.int/child growth). Socio-demographic characteristics, food consumption, and nutritional status of the MCPs are presented as mean ± SD, median with interquartile ranges and percentages. Pearson chi-square was used to compare percentages. Median differences between groups were compared using the Wilcoxon rank-sum test.

Pearson correlation and linear and logistic regressions were used to assess the association between nutritional status and dietary intake variables. For all the analyses, a *p*-value < 0.05 was considered significant.

RESULTS

Characteristics of the Mothers and Children

The mean age of the mothers was 26 ± 6 years, and 7% (n = 9) of them were under 19 years old. According to the results, most of the mothers (81.5%) were housewives. Only 18.5% of them had an income-generating activity. Only 15.4% of the mothers had formal education (primary, middle, or secondary). The children's mean age was 13 ± 4 months, with no difference between boys and girls.

Dietary Intakes

Dietary Diversity and Food Frequency Consumption of the Mothers and Children

The mean dietary diversity score (DDS) of the mothers was 5.5 ± 1.7, and 77.7% of them have reached the minimum dietary diversity (≥ 5 groups). In children, the mean DDS was 3.6 ± 1.3, and the majority (77.2%) had a low dietary diversity score (< 5 groups). Overall, 22.8% (24.6% in boys and 20.9% in girls, $p > 0.05$) had consumed at least 5 food groups the previous 24 hours (Table **1**), and only 2% and 34% of them had consumed eggs and flesh foods, respectively (Figure **1**).

Table 1: Dietary Diversity and Food Frequency Consumption of the Mothers and Children

Dietary diversity	Mothers (n=130)	Children		
		All (n=127)	Boys (n=65)	Girls (n=62)
Mean score ± SD	5.5 ± 1.7	3.6 ± 1.3	3.6 ± 1.3	3.7 ± 1.2
Diversified, % (n)	77.7 (101)	22.8 (29)	24.6 (16)	20.9 (13)
Non-Diversified, % (n)	22.3 (29)	77.2 (98)	75.4 (49)	79 (49)

Food frequency consumption,%	Mothers (n=130)	Children (n=130)
Cereals	99.2	89.1
Seasoning	96.9	85.9
Fish/fishery products	98.4	78.9
Oilseeds and nuts	96.9	82.8
Others vegetables	97	82.8
Tea	92.9	28.1
Oils/fat	89.1	81.3
Vitamin A rich vegetables	79.7	65.6
Yellow and red fruits	73.4	50
Others fruits	74.2	50
Legumes	68	60.2
Tubers	68	59.4
Green leafy vegetables	60.2	50.4
Juice	28.9	29.6
Milk, dairy products	25.3	36.7
Meats	15.6	3.1
Eggs	14	14.8
Liver/others organ meats	3.1	1.6

Results were presented as percentage (%) and mean ± standard deviation (M±SD).
Minimum dietary diversity - Mother: consumption of at least 5 food groups of ten (10).
Children: consumption of at least 5 food groups of seven (8) defined.

The most consumed food groups during the week (at least once a day or 2 to 6 times a week) by the mothers and children were: cereals (millet), seasoning (pepper, garlic, salt), other vegetables and fruits (cabbage, onion, Cordyla *pinnata ou dimb,* and eggplant), oilseeds and nuts (cowpea, peanut), oils/fat, vitamin A-rich vegetables, green leafy vegetables, tubers and fish/fishery products. However, results showed a low consumption of meat, organ meats, eggs, and dairy products, particularly among children, as shown in Table **1**. The frequency of consumption of the crops targeted for the biofortification by the OR4FOOD project showed that orange-fleshed sweet potato (OFSP) was seldom or never consumed in this area compared to the millet and cowpea consumed by 91.5% and 47.7% of the MCPs, respectively (Table **2**).

Minimum meal Frequency and Minimum Acceptable Diet of the Children

Among children aged 6-8 months old still breastfed, 50% have received the minimum meal frequency (MMF) (≥ 2 meals per day) the previous day. For those between 9 and 23 months of age, the proportion of children who have reached the MMF (≥ 3 meals per day) was 54%. Only 18% of non-breastfed children aged 6-23 months have achieved the MMF (≥ 4 meals per day) (Figure **2**).

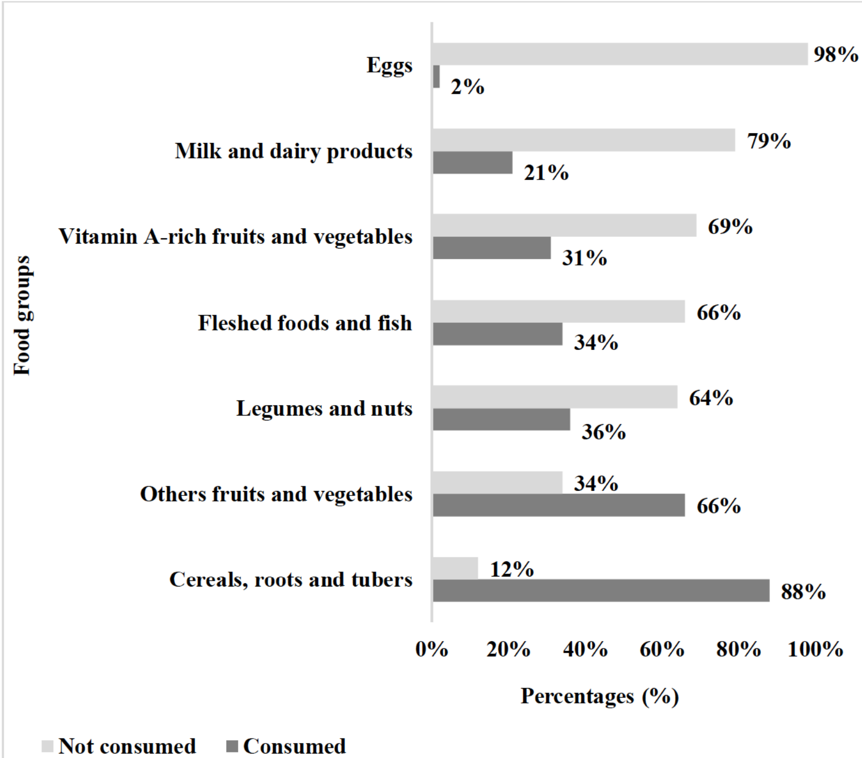

Figure 1: Food groups consumed during the previous 24 hours by children.

Table 2: The Frequency of Consumption of Millet, Cowpea, and Orange-Fleshed Sweet Potato by the Mothers and Children

	At least once per day	2 to 6 times per week	Once per week	Never
Millet	91.5%	5.4%	-	3.1%
Cowpea	13.1%	47.7%	10.8%	28.4%
OFSP†	8.5%	6.9%	-	84.6%

†Orange-fleshed sweet potato.

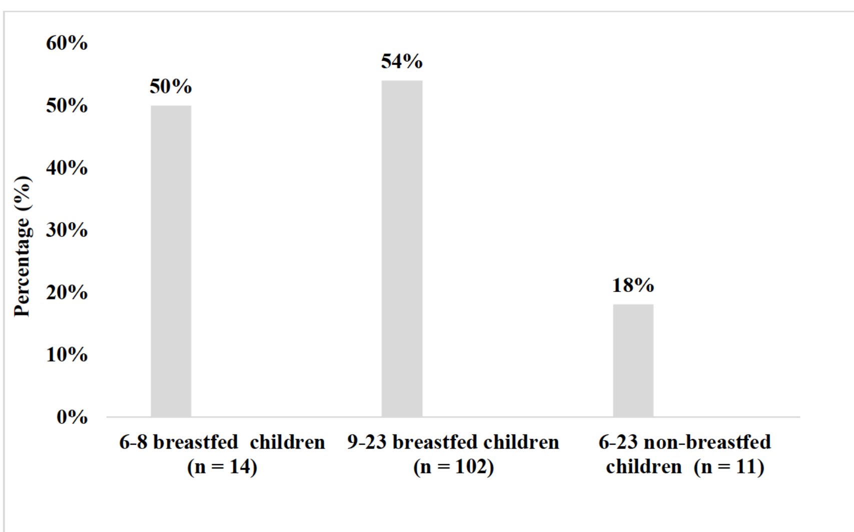

Figure 2: Minimum meal frequency among breastfed and non-breastfed children.

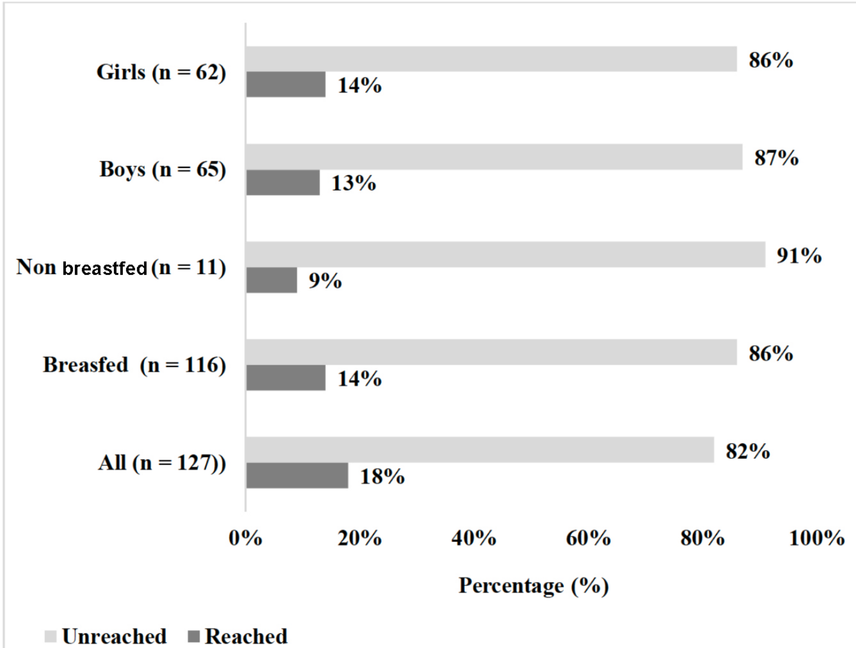

Figure 3: Minimum acceptable diet of children.

Our results also show that 18% of children have achieved the MAD, with any difference between girls and boys (Figure **3**).

Nutrient Intakes of the Mothers and Children

Table **3** shows the daily energy, proteins, iron, zinc, and vitamin A intakes of the mothers and children expressed in kcal, g, mg, and µgRE (median with 95% CI), respectively. Median energy intakes were 1824.1 kcal [95% CI: 1291.6 – 2354.4] for mothers and 127.1 kcal 95% CI: 43.4 – 266.0 in children. The diet covered 70% and 18% of their energy requirements, respectively. For proteins, the median intakes were 54.4 g [95% CI: 33 – 74.5] in mothers and 2.7 g 95% CI: 1.3 – 7.1 in children. Proteins requirements were covered up to 50% among mothers and less than 30% among children. The median iron, zinc and vitamin A intakes were 1.7 mg [95% CI: 1.0 – 2.9]; 1.8 mg [95% CI: 1.1 – 2.6] and 29.4 µgRE [95% CI: 9.3 – 84.7]. In children, the results showed that the median intakes

Table 3: Nutrient Intakes of Mothers and Children

	EAR†/RDA‡	Median intakes	[95% CI]
Mothers (n = 59)			
Energy (kcal)	2620.7	1824.1	[1291.6 - 2354.4]
Proteins (g)	76.6	54.4	[33 - 74.5]
Iron (mg)	15	1.7	[1.0 - 2.9]
Zinc (mg)	7.2	1.8	[1.1 - 2.6]
Vitamin A (µgRE)	850	29.4	[9.3 - 84.7]
Children (n = 59)			
Energy (kcal)	690.3	127.1	[43.4–266.0]
Proteins (g)	9.5	2.7	[1.3–7.1]
Iron (mg)	5.8	0.1	[0.02 – 0.2]
Zinc (mg)	4.1	0.1	[0.04 – 0.2]
Vitamin A (µgRE)	400[2]	1.6	[0.1 – 4.8]

†Estimated Average Requirements; ‡RDA: Recommended Dietary Allowance (FAO/WHO, 2004); Institute of Medicine, 2005 (for energy and protein requirements among mothers).
For iron and zinc, the nutrient requirements were calculated according to their bioavailability (10% for iron and 30% for zinc).

were 0.1 mg 95% CI: 0.02 – 0.2 for iron, 0.1 mg 95% CI: 0.04 – 0.2 for zinc and 1.6 µgRE 95% CI: 0.1 – 4.8 for vitamin A. Overall, the daily intakes of macro and micronutrients were under the estimated average requirements (EAR) and the recommended dietary allowances (RDA).

Relation between Dietary Diversity and Nutrient Intakes of the Mothers and Children

The median nutrients intakes among mothers and their children according to the dietary diversity was presented in Table **4**. Results showed that among mothers, the median intakes were comparable between mothers with a diversified diet and those who had a non-diversified diet (*$p > 0.05$)* for energy (1916.4 kcal vs. 1550.6 kcal), proteins (54.7 g vs. 45.1 g), iron (2.0 mg vs. 1.2 mg), zinc (1.9 mg vs. 1.7 mg) and vitamin A (33.0 µgRE vs. 13.7 µgRE). Also, for the children, no significant difference was observed regardless the dietary diversity.

Nutritional Status of the Mothers and Children

Overall, the mean BMI of the mothers over 19 years old was 22.7 ± 8.3 kg/m². For those under 19 years of age, the mean BMI-for-age (z-score) was -1.17 ± 0.7. Over 20% of the mothers were underweight. Overweight/obesity affects 23.1% of oldest mothers (Over 19 yrs).

Among children, the mean WLZ and LAZ were -0.85 ± 1.1 z-score and 1.17 ± 0.4 z-score, respectively, with any difference between boys and girls. The prevalence of acute malnutrition was 14.6% (19.4% in boys and 9.5% in girls), and that of stunting was 16.9%, without any difference between boys and girls ($p > 0.05$) (Table **5**).

Association between Dietary Intakes and Nutritional Status of the Mothers and Children

Mother's results showed that the consumption of vegetables, wild fruits, meat, other organ meat, tea, the DDS, and the proteins intakes was significantly associated with the BMI (kg/m²) and iron intakes ($p < 0.05$). Results presented in Table **6** revealed that the consumption of wild fruits like Cordyla *pinnata* was the main factor significantly associated with the mothers' BMI (β = 2.17; 95% CI: 0.40 – 3.94, $p = 0.017$). The model confirmed that DDS (β = 2.73; 95% CI: 0.49 – 4.96; $p = 0.017$) and proteins intakes (β = 0.03; 95% CI: 0.02 – 0.04; $p < 0.001$) were the most relevant factors associated with iron intakes ($R^2 = 68\%; p < 0.001$). Similar results were found for zinc intakes, where the adjusted R-squared of the model ($R^2 = 88\%$, $p < 0.001$) means that the increase in the dietary diversity score and the proteins intakes were the main predictors.

As for iron and zinc, the proteins intakes and the frequency of consumption of vitamin A-rich vegetables explained around *33%* of the variability of vitamin A intake among mothers.

In children, the simple linear and logistic regressions showed that the consumption of millet, tubers, eggs, the MMF, the proteins, zinc and iron intakes, the consumption of dairies, meat, liver and

Table 4: Nutrient Intakes Related to the Dietary Diversity of the Mothers and the Children

	Diversified	Non-diversified	p
Mothers (n = 59)			
Energy (kcal)	1916.4 [1296.7 - 2356.5]	1550.6 [94.35 - 2051.9]	0.291
Proteins (g)	54.7 [33.0 - 77.1]	45.1 [35.0 - 65.5]	0.497
Iron (mg)	2.0 [1.2 - 2.9]	1.2 [0.7 - 1.5]	0.086
Zinc (mg)	1.9 [1.22 - 2.6]	1.7 [1.0 - 2.1]	0.376
Vitamin A (µgRE)	33.0 [11.4 - 116.2]	13.7 [3.6 - 3.4]	0.083
Children (n = 59)			
Energy (kcal)	168.7 [65.7 - 410.1]	127.1 [33.7 - 249.7]	0.219
Proteins (g)	2.6 [1.6 - 9.3]	2.7 [0.9 - 7.1]	0.360
Iron (mg)	0.1 [0.06 - 0.3]	0.08 [0.01 - 0.2]	0.239
Zinc (mg)	0.1 [0.06 - 0.3]	0.1 [0.01 - 0.2]	0.308
Vitamin A (µgRE)	1.5 [0.2 - 4.1]	1.5 [0.009 - 4.9]	0.951

Results were presented as median with 95% CI.

Table 5: Nutritional Status of the Mothers and Children

	All (n = 130)	Age	
		≤ 19 years (n = 9)	> 19 years (n = 121)
Mothers			
BMI† (kg/m²) [Mean ± SD]	-	-	22.7 ± 8.3
BMI (z-score) [Mean ± SD]	-	-1.17 ± 0.7	-
Underweight	20.8 (27)	22.2 (2)	20.7 (25)
Normal weight	57.7 (75)	77.8 (7)	56.2 (68)
Overweight/Obesity	23.1 (28)	-	23.1 (28)
	All (n = 130)	**Sex**	
		Boys (n = 67)	**Girls (n = 63)**
Children			
WLZ‡ (z-score) [Mean ± SD]	-0.85 ± 1.1	-0.83 ± 1.1	-0.87 ± 1.1
LAZ§ (z-score) [Mean ± SD]	1.17 ± 0.4	-0.81 ± 1.2	-0.74 ± 1.9
Wasting [WLZ < -2 z-score]	14.6 (19)	19.4 (13)	9.5 (6)
Stunting [LAZ < -2 z-score]	16.9 (22)	17.9 (12)	15.8 (10)

Results was expressed as percentage (%), mean ± standard deviation (M ± SD), number (n).
†BMI: Body Mass Index; ‡WLZ: Weight-for-Length z-score; § LAZ: Lengh-for-Age z-score.
Nutritional status of mothers ≤ 19 years: Underweight (BMI z-score < -2); Normal weight (-1 ≤ BMI z-score ≥ +1).
Overweight/Obesity (BMI z-score > + 1); Nutritional status of mothers > 19 years: Thinness (BMI < 18.5 kg/m²).
Normal weight (18.5 kg/m² ≤ BMI ≤ 24.9 kg/m²); Overweight/Obesity (BMI ≥ 25 kg/m²).

Table 6: Association between Food Consumption and Nutritional Status of Mothers and Children

	β/OR	95% CI	*p*
Mothers			
BMI (kg/m²) *(R² = 7.3%, n=119)*			
Frequency of consumption of wild fruits	2.17	[0.40; 3.94]	*0.017*
Iron intakes (mg) *(R² = 68%, n=59)*			
Dietary diversity score	0.14	[0.003; 0.29]	*0.045*
Proteins intakes	0.03	[0.02; 0.04]	*< 0.001*
Zinc intakes (mg) *(R² = 9.1%, n=59)*			
Proteins intakes	0.04	[0.03; 0.05]	*< 0.001*
Dietary diversity score	0.77	[0.006; 0.14]	*0.033*
Vitamin A intakes (µgRE) *(R² = 33.5%, n=59)*			
Frequency of consumption of vitamin A rich vegetables	58.15	[19.3; 96.9]	*0.004*
Protein intakes	4.56	[0.53; 8.58]	*0.027*
Children			
WLZ (z-score) *(R² = 5.9%, n=127)*			
Frequency of consumption of millet	0.17	[0.01; 0.33]	*0.035*
Wasting *(R² = 10.3%, n=127)*			
Frequency of consumption of eggs	-0.54	[-1.00; -0.07]	*0.022*
Iron intakes (mg) *(R² = 6.9%, n=59)*			
Zinc intakes	0.83	[0.67; 0.98]	*< 0.001*
Zinc intakes (mg) *(R² = 9.6%, n=59)*			
Proteins intakes	0.03	[0.03; 0.41]	*< 0.001*
Vitamin A intakes (µgRE) *(R² = 6.5%, n=45)*			
Frequency of consumption of vitamin A rich vegetables	5.86	[2.04; 9.68]	*0.004*
Frequency of consumption of fish	3.03	[0.86; 5.21]	*0.008*

OR=Odds Ratio; R=coefficient of regression; *p* = p-value; R²= R-squared (coefficient of determination); WLZ: Weight-for-Lenght z-scores; BMI: Body mass index.

organ meat, fish, vitamin A-rich vegetables, and the DDS was significantly associated with the nutritional status (WLZ index, wasting, stunting) and the food consumption variables ($p < 0.05$). The models showed that the frequency of consumption of millet and eggs were the main predictors of WLZ (β = 0.17; 95% CI: 0.01; 0.33, $p = 0.035$) and wasting (OR = -0.54; 95% CI: -1.00; -0.07, $p = 0.022$) respectively. The consumption of eggs was responsible for 10.3% of the variability of wasting in children. Regarding micronutrients intakes, a positive and strong association was found between iron and zinc intakes among children (β = 0.83; 95% CI: 0.67; 0.98, $p < 0.001$). Very low association was found between zinc and proteins intakes (β = 0.03; 95% CI: 0.03; 0.41, $p < 0.001$). Our findings revealed a significant association between vitamin A intakes and the frequency of consumption of vitamin A rich vegetables (β = 5.86; 95% CI: 2.04; 9.68, $p = 0.004$) and fish (β = 3.03; 95% CI: 0.86; 5.21, $p = 0.008$). These factors explained around 6.5% of the variability of the vitamin A intake in children.

DISCUSSION

The purpose of this study was to establish the baseline situation of the dietary intakes and nutritional status of the MCPs targeted by the OR4FOOD project. Results revealed that around three-quarters of the mothers (77.7%) and less than 25% of children (22.8%) had met the minimum dietary diversity. These proportions are in line with those obtained by Badiane in 2018 in a neighboring area [3]. Our results were also similar to those reported in the DHS survey (25%) among children of age 6-23 months at the national level and those found by UNICEF (29%) in some West and Central African countries [12, 28]. However, higher proportions were revealed in Egypt (56.8%) and Ghana (48.2%) [29]. And this is despite the fact of using the eight food groups currently recommended by WHO/UNICEF [19]. The weakness of the DDS among Senegalese children can be explained by the monotonous diets related to food habits and the inadequate complementary feeding practices. In terms of practices, many children did not receive the MMF required the day before the interview regardless the "type of breastfeeding". Moreover, several studies previously performed in rural areas in Senegal pointed out the monotonicity of the diet, which is mainly based on cereals and low consumption of flesh foods [3, 6, 30]). Indeed, our results revealed that grains such as rice and millet, tubers, vegetables (cabbage, onions, eggplant), and fisheries are widely consumed by mothers and their children. At the same time, low consumption of animal food was observed and might be explained probably by the socio-economic level of Senegalese rural households, which does not give access to some nutritious food like flesh foods and others [30].

Moreover, the education level of the mothers and their limited knowledge of IYCF practices was revealed as factors associated with the non-diversified diet in children. All these factors may contribute to the low percentage of children who reached the MAD **(**18%). This is in the vicinity of the finded ones in Benin (18%) and Rwanda (17.6%) among toddlers aged from 6 to 23 months old [32]. However, our findings are higher than those of the national level [12], in some West African countries, in Zimbabwe (14.4%) [32] and lower than those reported by Senarath *et al.* [33] among Indian children 6 to 23 months of age. According to the latest author, in South Asia, precisely in Nepal, Bangladesh, and Sri Lanka, the MAD is respectively 32%, 40%, and 68% among breastfed children. Apart from the above factors, the inadequate antenatal care, the lack of post-natal contact by health workers, the financial autonomy of the mothers, and the limited exposure to media were among predictors of inappropriate feeding practices among infants and young children in South Asia [32, 33]. The related bias to the sample size, the areas, and the period of the surveys also could explain the differences found between all these studies and ours.

Among mothers, 70% of energy and protein requirements were covered by the diet, and the prevalence of adequacy of iron, zinc, and vitamin A, was low. Few data exist in the literature relating to assessing nutrient intakes in WRA from West Africa. However, some studies revealed that the mean energy intakes, as well as the prevalence of adequacy of micronutrients, were higher among Nigerian lactating women compared to Senegalese mothers [34, 35]. In children, the medians' nutrient intakes observed both for macro- and micronutrients were similar to the results found in other studies in Senegal and South Africa among children 6-23 months [31, 36]. These findings corroborated those obtained in Bangladesh, where low estimated average requirements for micronutrients have been demonstrated both in women and children. Adequate intakes of energy and proteins among mothers of Mbarocounda and Malem Thialen, the target villages, can be related to their location in an extensive groundnut and cereal production and consumption area. In these villages, the population consumed millet and peanut at least twice per day, precisely during breakfast and dinner. Moreover, the unavailability of micronutrient-rich foods and their low consumption due to the household's poverty, the seasonality, as well as the cultural norms and beliefs linked to the food taboos limit the nutrients intakes consequently and increase the risk of malnutrition and micronutrients deficiencies. Indeed, the prevalence of wasting (14.6%) found in children was almost twice as higher as the national prevalence (8%) reported in the last Demographic and Health Survey and by Badiane in a rural area in Kaffrine [3, 12]. In contrast, the proportion of children with stunting (16.4%) was relatively close to that obtained at the national level (18%). The differences in the present study compared to that mentioned above can be attributed to the periods where the surveys were carried out (abundance and lean season) and probably to the sample size. Among mothers, the higher prevalences of underweight (20.8%) and overweight/obesity (23.1%) found in our study confirm the existence of the double burden of malnutrition in rural areas. In the past decades, almost all the nutrition programs performed in a rural areas in Senegal have focused on reducing undernutrition and micronutrient deficiencies among children under five years old and women. Our findings on overweight/obesity highlight that nowadays, triple function actions are relevant to address more than one form of malnutrition in the rural area. The frequency of consumption of wild fruits (like Cordyla *pinnata*) was associated with the mothers' BMI. Cordyla *pinnata,* also locally called the meat of *Serere* (Senegalese ethnic), was the picking fruit most available and consumed daily during the period of the survey (lean season). It is frequently used in the groundnut basin to replace meat in some local dishes. Their useful incomes were previously predicted by Ayessou *et al*. [37] in a study on the nutritional contribution of some Senegalese forest fruits running across the Soudano-Sahelian zone. According to Nouhoum *et al.* [38], in sight of their nutrient contents, the picking products such as Cordyla *pinnata* can contribute to the fight against malnutrition, especially in the lean season.

CONCLUSION

This study showed that millet and cowpea targeted by the OR4FOOD project are among the many food groups consumed by mothers and their children in the rural area of Senegal. Optimizing the iron and zinc content of these crops through biofortification and the introduction of biofortified orange-fleshed sweet potato might be a good strategy to improve the food consumption, dietary diversity, and the nutrients intakes of the MCPs. Our results highlighted the persistence of undernutrition (wasting, stunting) among children and the existence of the double burden of malnutrition in women of childbearing age. And, it's worth noting that a few percent of children had met the minimum acceptable diet. Additionally, we pointed out that the diet did not cover the micronutrient requirements of the MCPs. Linear modeling could thus be used to optimize the diet with biofortified foods and prevent maternal and child malnutrition, especially micronutrient deficiencies. Elsewhere, in the light of the secondary results about the relationship between dietary intake and nutrition status, OR4FOOD project has to promote the consumption of wild products, flesh foods, and eggs to enhance dietary diversity and the infant and young child feeding practices indicators.

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CONFLICTS OF INTEREST

The authors declare that they do not have any conflict of interest.

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