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DIETARY DIVERSITY AND NUTRITIONAL STATUS AMONG WOMEN OF CHILDBEARING AGE (WCA) AND YOUNG CHILDREN (YC) IN THE CITY OF NIAMEY, NIGER

Garba GHO[1]*, Dan Dano I[2], Zoungrana S[3,4], Theodore YA[5], Seini SH[1] and C Mouquet-Rivier[3,4]

Ousseini Garba Dit Gado Halidou

*Corresponding author email: garbagadoousseini@gmail.com
ORCID: https://orcid.org/0009-0000-6879-8221

[1]Abdou Moumouni University of Niamey, Niger, Faculty of Science and Technology, Department of Chemistry, Laboratory of Nutrition and Valorization of Agro-Resources, quality team, hygiene and food safety: study and improvement of traditional processes; BP: 10.662 Niamey, Niger

[2]Toxicology, food and water quality control laboratories, Medical and Health Research Center (CERMES); Niamey-Niger

[3]IRD (French national Institute for sustainable Development), Montpellier, France

[4]UMR QualiSud, Univ Montpellier, Avignon University, CIRAD, Institut Agro, IRD, Université de la Réunion, Montpellier, France

[5]National Information Platform for Nutrition (NIPN), National Statistics Institute

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ABSTRACT

Maternal and child malnutrition is widespread in low-income countries, leading to a substantial increase in mortality and the overall burden of disease. In Niger, despite some progress in recent years, the prevalence of the three forms of undernutrition (stunting, wasting and micronutrient deficiencies) remains above World Health Organization (WHO) thresholds among children, according to national studies. The objective of this study was to examine the associations between dietary diversity and the nutritional and anemia status of women of reproductive age (15-49 years) and young children (6-23 months) in the city of Niamey. A descriptive cross-sectional survey was conducted in August and September 2022, among 856 WCA and 387 YC selected at random in the five districts of the city of Niamey. Socio-economic demographic data collected using a questionnaire were used to characterize the sample and establish wealth quintiles using multiple correspondence analysis of household possessions. Anthropometric and hemoglobin levels measurements were used to assess the nutritional status and anemia of the targets (Hemoglobin levels below 12 for WCA and 11 for YC). A 24-hour dietary recall was used to calculate dietary diversity scores (DDS, for example number of food groups consumed out of 10 for WCA, and out of 8 including breast milk for YC) and prevalences of minimum dietary diversity (MDD - DDS > 5). Logistic regression was used for association. Regarding women, 33% achieved the minimum dietary diversity (MDD_W). Their DDS was significantly associated with the Body Mass Index (BMI) (p=0.039) and wealth quintiles (p<0.001), but not with anemia (p=0,2). Among YC, the opposite was found between dietary diversity scores and their nutritional status (height-for-age LAZ and weight-for-height WLZ), but the same was true for anemia (p=0.2). The MDD in young children was 36%. DDS increased significantly from 3.97 (±1.10 SD) for the "least well-off" to 4.37 (±1.5 SD) for the "most well-off." Low prevalences of MDD, indicated that around two thirds of YCs and WACs were at high risk of micronutrient deficiencies. Maternal DDS and anemia were not significantly associated to those of young children. Given this worrying nutritional situation in Niamey, further study would necessary to measure micronutrient intakes and the meeting of nutrient requirements of WCA and YC through their diets and determine the contribution of fortified products.

Key words: Dietary diversity, nutritional status, anemia, women of childbearing age, young children, Niamey

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INTRODUCTION

Malnutrition in its various forms, as well as anemia, are widespread health problems in the Sahelian region [1,2]. Maternal and child undernutrition is highly prevalent in these low-income countries, leading to a substantial increase in mortality and the overall burden of disease [3]. A framework developed by UNICEF recognizes the root causes of undernutrition, including environmental, economic and sociopolitical contextual factors, with poverty playing a central role [4].

In Niger, a Sahelian country, infants, young children, adolescents, and women of childbearing age are among the groups most affected by malnutrition and micronutrient deficiencies due to their monotonous and poor-quality diets [5]. Anemia is particularly concerning in this population, as it affects maternal health, children's cognitive development, and countries' economic productivity [6].

Indeed, the prevalence of malnutrition (stunting, wasting) and anemia remains among the highest in the subregion and has stagnated for more than a decade, despite countless efforts by the government and its partners [7]. According to the 2022 SMART survey, among children under five, the prevalence of malnutrition (12.2% for MAG and 47% for stunting) is above the 10% and 40% thresholds set by the WHO [8]. Malnutrition is identified as the main risk factor for infant mortality in the country [9]. The prevalence of anemia was 72% in 2022 among children aged 6 to 59 months [10]. The 2022 survey also reported a prevalence of global acute malnutrition of 3.6% among women aged 15 to 49. The national prevalence of anemia among these women was 46.1% [8].

This situation is exacerbated by food insecurity, climate change, traditional dietary practices, limited economic resources, and rapid population growth [7,11]. According to studies, households in low-income settings are vulnerable to seasonal changes in dietary diversity due to fluctuations in food availability and access [12, 13], as dietary diversity and food sources are seasonal [14]. Thus, according to the National Institute of Statistics (INS), the proportion of women aged 15-49 with adequate minimum dietary diversity, already low, declined steadily at the national level between 2020 (53.3%) and 2022 (37.0%) [15].

This dietary diversity is a qualitative and quantitative indicator of nutrition, reflecting access to a variety of essential nutrients [16]. It is the most desirable and sustainable approach of all strategies for preventing micronutrient deficiencies [17]. Although insufficient food quantity is an important factor in undernutrition, food quantity alone is not sufficient to ensure optimal health [11]. It is important to consume a diverse diet to prevent malnutrition and micronutrient deficiencies [14]. It is generally considered that half of all cases of anemia are due to iron deficiency [18]. Low dietary

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diversity is associated with an increased risk of anemia and malnutrition. Nutritional status is strongly correlated with an individual's dietary diversity [19, 20].

Furthermore, in the case of women of childbearing age, studies have shown that an increase in dietary diversity scores is associated with a decrease in the incidence of maternal micronutrient deficiencies and improved pregnancy outcomes [19,21,22]. The most sustainable way to combat malnutrition is therefore, to promote a diverse and high-quality diet [5,23]. Dietary diversity is crucial for meeting micronutrient needs and improving nutritional status. In children over 6 months of age, adequate dietary diversification is essential to prevent micronutrient deficiencies. Low dietary diversity is associated with a high risk of micronutrient deficiencies [24].

This study is part of the independent evaluation of the MERIEM project (Mobilizing Sahelian Enterprises for Innovative Large-Scale Responses to Malnutrition) implemented by the non-governmental organization for international solidarity (GRET) and the consulting firm (Hystra) in Niger. The project deploys a strategy for the production and marketing of fortified local products, including Foura Soga (a milk-based drink made from millet and yogurt with added vitamins and minerals tailored to the needs of women, produced and marketed by a local company: "La *Laitière du Sahel*") for women of childbearing age (WCA) and Vitamil+ (infant flour for cooking with added amylase and a complex tailored to the nutritional needs of young children, produced and marketed by a local company: The food processing company "*STA*") for young children (YC). It also focuses on strengthening the nutritional knowledge of WCA and promoting behaviors that are conducive to maternal and child health, including dietary diversification. This study was conducted to assess the effect of the MERIEM project on its target population.

MATERIALS AND METHODS

Study site

Niamey, the capital of Niger, is located in the heart of the country between latitudes 13°28 and 13°35 North and longitudes 2°03 and 2°10 East. It covers an area of approximately 240 km², between 180 and 240 meters above sea level. The city is built on a plateau overlooking the left bank of the Niger River and on an alluvial plain occupying its right bank, giving it a strategic geographical position. Niamey has a semi-arid Sahelian climate, with annual rainfall between 500 and 750 mm. This climate largely determines the economic and social life of the capital. Administratively, Niamey is subdivided into five municipalities. Municipalities I, II, III and IV are located on the left bank of the river, while municipality V occupies the right bank. This territorial organization facilitates the management of a constantly growing urban population. In 2025, Niamey's population is estimated at 1,561,490,

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making it the most populous city in the country. It is also home to most of Niger's industries, thus playing a central role in the national economy.

The study was conducted in the five municipalities of Niamey.

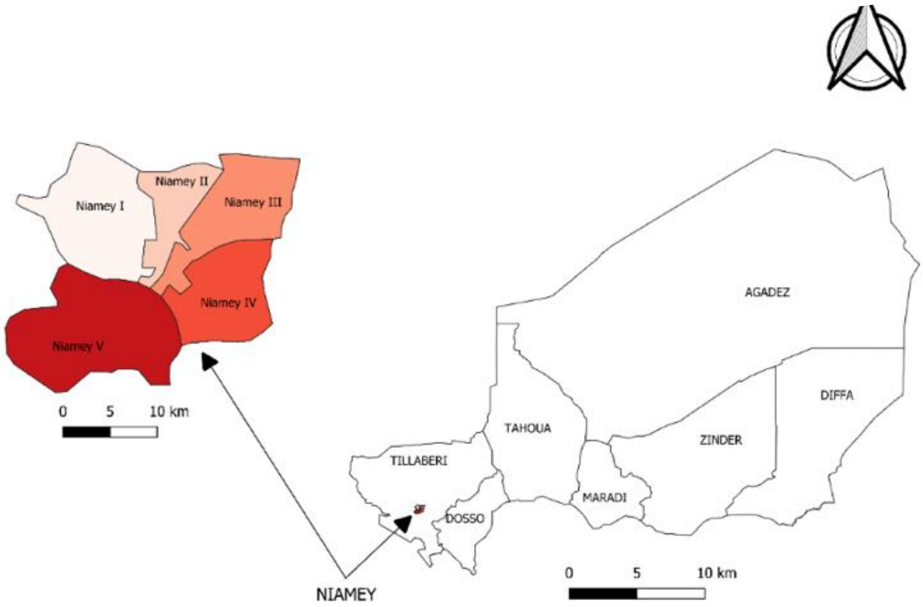

Figure 1: Location of the city of Niamey

Study population

The survey was conducted between 18 August and 12 September 2022. The target groups for this study were women of childbearing age (15-49 years old) and young children (6 to 24 months old) in the city of Niamey.

The population samples surveyed were stratified according to age for YC (6-11 months, 12-17 months and 18-23 months) and to physiological state for WCA:

- Pregnant women (including pregnant and breastfeeding women)
- Breastfeeding women
- Women who are neither pregnant nor breastfeeding

An additional level of stratification was added based on the consumption status of MERIEM fortified products, defined as follows:

Among WCA: Consumers (Consu): women who consumed the fortified MERIEM Foura Soga product at least once during the previous week. Non-consumers (Non-consu): those who did not meet the “consumer” criterion.

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Among YC: Consumers (Consu): young children who consume infant flour (local or imported). Those who have consumed any type of fortified infant cereal at least once during the week prior to the interview were considered consumers. Non-consumers (Non-consu): non-consumers are young children who did not meet the "consumer" criteria.

Sample size determination

The sample size was calculated using the following formula [25]:

$$n = (1 + \lambda) \times \mathrm{Deff} \times \frac{2\sigma^2(1-\rho)\left[Z_{1-\frac{\alpha}{2}} + Z_{1-\beta}\right]^2}{(X_2 - X_1)^2}$$

Where:

n= Sample size; Deff= Design effect; λ= Percentage of data loss; σ^2= Variance; ρ= Correlation coefficient; X_1= Estimated level of an indicator at the time of the first survey (baseline); X_2= Expected level of the indicator at a future date for the project area, such that the quantity ; (X_2-X_1) either the size of the magnitude of change that one wishes to be able to detect; Z_(1-α/2) = the Z score corresponding to the confidence level, for the index (1-α/2), that wish to have in order to conclude that an observed change of magnitude (X_2-X_1) is not due to chance (statistical significance); Z_(1-β) = The Z score corresponding to the degree of confidence, for the index (1-β), that wish to have in order to detect with certainty a change in size (X_2-X_1) if such a change has actually occurred (statistical power).

The objective was to detect, when it exists, a difference ε in a specified indicator between the comparison groups.

Based on the number of individuals to be surveyed and the demographic data for the region, the number of households was determined, followed by the number of enumeration areas. Thus, 39 enumeration areas comprising 5,383 households were identified, from which 780 households were randomly selected. In each selected household, all individuals belonging to the two target groups were surveyed.

Different components of the study and data collected

These are cross-sectional surveys with descriptive and analytical objectives conducted among women of childbearing age (15-49 years) and mothers of children aged 6 to 24 months in the city of Niamey. The survey consisted of four data collection components carried out at different times. These were:

- ✓ A general data questionnaire, including a questionnaire on feeding practices and knowledge, known as the "broad questionnaire".
- ✓ Anthropometric measurements: weight (to the nearest 100g) and height (to the nearest cm).

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- ✓ Hemoglobin level measurements using a Hemocue device (via a finger prick).
- ✓ Food consumption measurements using a 24-hour recall with the Inddex24 platform.

Conduct of the large-scale survey

Data were collected using a standardized questionnaire administered directly in the respondent's home. The questionnaire was divided into four main sections: a "household" section, a "child" section, a 'woman' section, and a "knowledge" section. This survey enabled to characterize women of childbearing age and children aged 6-23 months using sociodemographic and socioeconomic criteria. Secondly, to measure the knowledge and practices of women and mothers in terms of food and nutrition.

Anthropometry

The height and weight of children and women (excluding pregnant women) were measured according to WHO standard procedures [26]. The anthropometric measurements enabled to calculate nutritional status indicators in order to better characterize our sample. The analyses were performed using WHO ENA (version 2020) software for children's anthropometric data and R version 4.2.3 software for women's data. The World Health Organization thresholds were used in the calculation of indicators.

The age of the children was expressed in months. The information reported by the mothers was systematically verified using civil status documents. In the absence of official documents, age was estimated using the calendar of events.

For women of childbearing age (WCA), age was recorded in full years, based on civil status documents when available, or, failing that, according to the declaration of the person concerned.

Hemoglobin level measurements

Hemoglobin levels in children and women of childbearing age were measured in their homes. Among the methods used to diagnose anemia, rapid tests with portable Hemocue Hb 301 automated devices were used. The procedure consisted of taking a drop of blood to measure the hemoglobin level in the blood using a rapid test with the device. The World Health Organization WHO thresholds [27, 28] were used in calculating the indicators.

Capillary hemoglobin measurement using the Hemocue device was performed in a standardized manner with precise and strict health regulations.

24-hour recall

This method consists of identifying and quantifying all the foods eaten by the respondent. Data was collected from the 24 hours preceding the day of the survey,

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from waking up to going to bed the night before, including meals eaten during the night [29, 30]. Data from the 24h quantitative recall were used to calculate dietary diversity for YC and WCA. A special module was dedicated to the assessment of dietary diversity, with key questions on food groups as defined in reference documents, notably the FAO guide [16].

Construction of wealth quintiles using Multiple Correspondence Analysis (MCA)

Creation of a socioeconomic status score or wealth score

The socioeconomic status index for households in Niger is usually constructed using data from the Living Standards Measurement Study (LSMS). However, in the absence of complete data, information collected on the quality of housing and household assets was used to construct a proxy for this indicator. A total of 25 variables were used, including 10 variables on housing quality and 15 variables on assets owned. The variables selected for constructing the score are categorical, and the Multiple Correspondence Analysis (MCA) method is ideal for summarizing the information they contain [31]. The two factor axes alone account for 82% of the total information. This high percentage indicates that these axes can be used to construct the socioeconomic status index. Wealth quintiles were created to categorize households according to their socioeconomic status index values [32].

Construction of wealth quintiles

Households are ranked in order of increasing socioeconomic status index (from least wealthy to most wealthy) and divided into quintiles (each quintile corresponds to 20% of households) ranging from E (least wealthy) to A (most wealthy) [32].

Data analysis

The data were analyzed using the appropriate statistical software programs "R" and "STATA." The statistics are mainly descriptive (frequency, mean, median, standard deviation, standard error, normality and proportions) and allow for an assessment of the distribution (extreme, outlier, or missing values, quintiles) as well as the characteristics of the different variables in the study.

Various statistical analyses and tests were also performed to investigate possible associations between variables.

Classification levels for anthropometric indicators

- In children

Prevalence of wasting. This is defined by the weight-for-height z-score. It corresponds to the percentage of children with a z-score <-2 for moderate and severe wasting and <-3 for severe wasting.

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Prevalence of stunting. The height-for-age z-score is used to define this indicator. It is the percentage of children with z-scores <-2 for global stunting and <-3 for severe stunting.

Prevalence of overweight. This corresponds to the percentage of children with weight-for-age z-scores >+2SD.

- Among women
  - The prevalence of underweight is the percentage of women with a BMI<18.5 kg/m2.
  - Normal body weight prevalence is the percentage of women with a BMI in the range [18.5 - 24.9 kg/m2].
  - Overweight prevalence corresponds to women with a BMI in the range [25-29.9 kg/m2].
  - The prevalence of obesity is the percentage of women with a BMI ≥ 30 kg/m2.

Anemia classification

- The prevalence of global anemia is the percentage of children with a blood hemoglobin level < 110 g/l.
- The prevalence of mild anemia is the percentage of children with a blood hemoglobin level between [100 and 109 g/l].
- The prevalence of moderate anemia is the percentage of children with a blood hemoglobin level in the range [70 and 99 g/l].
- The prevalence of severe anemia corresponds to the percentage of children with a blood hemoglobin level <70 g/l.

Assessment of dietary diversity

Dietary diversity score

Using data from quantitative 24-hour recalls, dietary diversity scores for young children (DDS_YC) and women (DDS_W) were calculated according to the standardized methods as defined by WHO & UNICEF for YC and FAO & FHI360 for WCA [33, 34].

The Dietary diversity score (DDS) was calculated for each subject by summing the number of food groups consumed on the day before the survey.

For women of childbearing age (WCA): The different foods, dishes, and beverages were classified into 10 different food groups, namely: (1) cereals, roots, tubers, and plantains, (2) legumes, (3) nuts and seeds, (4) dairy products, (5) meat products, (6) eggs, (7) dark green leafy vegetables, (8) other vegetables and fruits rich in vitamin A, (9) other vegetables, (10) other fruits.

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For young children (YC): Eight groups were considered, including breast milk. (1) breast milk, (2) cereals, roots, tubers, and plantains, (3) legumes, seeds, and nuts, (4) dairy products (milk, yogurt, cheese), (5) meat products (meat, fish, poultry, liver/offal), (6) eggs, (7) fruits and vegetables rich in vitamin A, (8) other fruits and vegetables.

Ethical considerations

The data collected was subject to a detailed protocol that was approved by the National Ethics Committee for Health Research, housed within the Ministry of Public Health and Social Affairs (see deliberation No. 055/2022/CNERS of October 2, 2022). Before each phase of the survey, local administrative and traditional authorities were informed of the objectives and conduct of the study. The study was conducted in such a way that “taboos,” traditions, and “customs” were considered and respected.

Individuals selected to participate in the survey were informed that their participation was voluntary. It was therefore, clearly specified that they were free to refuse to participate. If they agreed to take part in the study, they could withdraw at any time, postpone visits from interviewers, or refuse to answer certain questions without having to justify their decision.

Written consent was submitted for signature by the respondent and the head of the household when the latter was also surveyed (for the household section of the comprehensive questionnaires) or when the respondent was a minor.

RESULTS AND DISCUSSION

Nutritional status (based on BMI) of WCA in the study sample of Niamey population

The prevalence of overweight and obesity among women aged 15 to 49 was 32.2% and 25.2%, respectively (Table 1). Overweight and obesity affected more than 57% of the WCA in the study population. This result may be justified by socio-cultural phenomena in Niger, where there is a cultural preference for the round shape. These prevalences vary little and not significantly between consumers and non-consumers of the fortified product Foura Soga (p=0.8). The prevalence of underweight (3.5%) was marginal in this population, although higher than that reported by the last SMART survey, (1.8% of women in the Niamey region in 2022) [8].

The prevalence of overweight and obesity was higher among breastfeeding women than among women who were neither pregnant nor breastfeeding (Table 1), which could also be explained by socio-cultural factors in Niger, or by the fact that after giving birth, women overeat in order to build up energy reserves for themselves and their babies. Studies refer to postpartum weight retention linked to weight gain during

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pregnancy. Women who gain a lot of weight during pregnancy find it more difficult to return to their initial weight, even with breastfeeding [35]. The prevalence of obesity was 28.3% among WB versus 20.9% among WNB. The prevalence of overweight was 33.3% among WB and 30.5% among WNB. Overall, overweight and obesity affect more than 61% of WB. The prevalence of underweight is lower among WB (2.8%) than among WNB (4.6%).

The nutritional status of WCA was not statistically significantly (p=0.3) associated with wealth quintiles (Table 1). The prevalence of underweight remained virtually identical between households in quintile E (less affluent) (27%) and those in quintile A (more affluent) (27%). Nevertheless, overweight and obesity were more prevalent among women from households in quintile A (24% and 23% respectively), compared with 14% and 11% among the poorest (quintile E). These results are in line with those of the national level reported by the INS in 2023, which also found no significant association between the nutritional status of WCA and socio-economic well-being quintiles. Many researchers in other countries have reported highly significant associations between the nutritional status of women of childbearing age and the household's socio-economic standard of living [1]. Undernutrition is linked to several risk factors. Gregory et *al*. [35] points out that multiple socio-economic and bio-physical factors influence food security and nutritional status.

Anemic condition of WCA in the study population of Niamey

More than 50% of the WCA aged 15-49 years surveyed were anemic (Table 2). This prevalence is above the WHO's severity threshold (40%). It is also higher than the national prevalence for the WCA, which is 46.1% according to the 2022 SMART survey. The prevalence of anemia was higher among non-consumers (55%) than among consumers (41%), but the difference was not significant (p=0.13).

Anemia affected pregnant women (80.4%) more than breastfeeding women (50.0%) and women who are neither pregnant nor breastfeeding (52.3%). The difference was highly significant (p<0.001) (Table 2). The etiology of anemia is multifactorial, and includes nutritional deficiencies, chronic infections, hereditary blood disorders, obesity and chronic non-communicable diseases [18]. Iron deficiency is among the most common cause of anemia in pregnant women, whose needs increase during pregnancy. It has adverse effects on reproductivity and general cognition in the population. The prevalence of anemia among pregnant women aged 15-49 years is 54.9% nationwide.

Anemia was highest among women from very poor households (61%) and the prevalence slightly decreases progressively from poor to wealthiest households (Table 2). But this association was not statistically significant according to the chi2 test (p=0.5). The risk factors for anemia most often reported in the literature are low

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family income and mothers' low level of education, lack of access to health services, inadequate sanitary conditions and an iron-poor diet [36].

Dietary diversity in WCA in the study population of Niamey

Among the women surveyed, only 33% had achieved the minimum dietary diversity (MDD_W), and were therefore more likely to have more adequate micronutrient intakes than the 67% who had not (Table 3). This prevalence is lower than that observed at time T0 (before the start of MERIEM's activities), which was 48% among WCA in Niamey [37]. The prevalence also remains lower than that provided by the INS in 2023, which is 65.5% among women aged 15-49 years in Niamey. This difference may be due to the collection periods, as this study was carried out in August 2022, corresponding to the lean season in the country, when food is less available. Indeed, according to several authors, dietary diversity is seasonal [14]. Lourme-Ruiz *et al*. [14] reported in their study that dietary diversity was relatively moderate in rural Burkina Faso from August to January, when agricultural production predominated, and gradually increased from February onwards [14]. A study carried out in Tanzania clearly demonstrated that women's dietary diversity is positively associated with cash crop diversity [11]. Also, in a study report published in 2023, the INS assert that minimum dietary diversity has seen a progressive decline in Niger since 2020 [15]. The average dietary diversity score is 3.92 ±1.38 SD.

Consumers of the fortified product “foura soga” had higher dietary diversity scores resulting in higher minimum dietary diversity (Table 3). The average score was 4.27 ±1.4 SD, and 48% achieved minimum dietary diversity, compared with 31% of non-consumers, with an average score of 3.87 ±1.37 SD. The difference was statistically significant according to Pearson's chi2 test ($p=0.011 < 0.05$). This difference may be due to a more favorable economic environment, as the majority of women consumers are in the affluent quintiles. Indeed, among 94 WCA who had consumed the Foura Soga during the previous week, 6 were in the quintile E, 15 in the quintile D, 21 in the quintile 5, 23 in the quintile B and 29 in the quintile A.

The prevalence of minimum dietary diversity in WCA varied according to their physiological status (Table 3). According to results, 30% of not pregnant or breastfeeding women achieved the minimum dietary diversity, compared with 37% of pregnant women and 34% of breastfeeding women, with mean dietary diversity scores of 3.87 ±1.3 SD, 4.08 ±1.7 SD and 3.92 ±1.3 SD respectively. But the difference was not statistically significant between the three groups. The same observation was made by INS in 2023 [15]. The mean DDS of the WCA was below 5, irrespective of the women's physiological status. Arimond *et al.* [5] assert that this simple indicator based on food group diversity can predict the micronutrient adequacy of women's diets [5].

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Household standard of living (wealth quintile) correlated significantly with women's dietary diversity (p<0.001) (Table 3). The percentage of women achieving the minimum dietary diversity score ranged from 16% in very poor households (quintile E) to 46% in the wealthiest (quintile A). This same finding has been made by several authors, including Maureen et *al*. [38] who found a highly significant association (p < 0.05) between dietary diversity and standard of living [38]. The mean DDS increases progressively and significantly from the poorest quintile (3.31 ±1.30 SD) to the wealthiest (4.43 ± 1.39 SD). However, the average DDS of WCA remained below 5, regardless of the wealth quintiles to which they belonged.

Dietary diversity and nutritional status of WCA in the study population of Niamey

Dietary diversity is crucial to meeting micronutrient needs and improving nutritional status (Table 4). The minimal dietary diversity of women of childbearing age in the study was significantly associated with their underweight (p=0.039), not controlling for other variables. In contrast, INS (2023) found no association between nutritional status and dietary diversity among women aged 15-49 years in Niger, and therefore asserts that dietary diversity is not significantly different according to the nutritional status of women of childbearing age [15].

When we used multivariate logistic regression to model the association (adjustments for wealth quintile), the nutritional status was not anymore significantly associated with the minimum dietary diversity (p > 0.05 in all cases). Indeed, the model here was a strong association between nutritional status and wealth quintiles, with a tendency for wealthier people to be more likely to be “normal weight” (or underweight “moderately malnourished”, depending on the results) category compared with the reference category.

The proportion of women with minimum dietary diversity was lower among anemic women aged 15-49 years than among not anemic (48% versus 52%), but this there was no significant association (p=0.5) (Table 4). The same trend was observed by the INS at national level, where minimum dietary diversity among anemic women was 30.5% among women aged 15 49 years with anemia, compared to 44.8% among those without anemia in 2022 [15]. According to INS 2023, analysis of the determinants of dietary diversity among women of childbearing age and its disparities between administrative regions in Niger reveals that women living in the Agadez and Niamey regions have higher proportions of dietary diversity than in other regions. Some explanatory hypotheses can be identified, such as more diversified and efficient food supply systems in Niamey throughout the year, better access to social services (health and education), and lower total fertility rates than in other regions.

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Food group consumption by WCA physiological status in the study population of Niamey

The food groups consumed by women in descending order of frequency are cereals, roots and tubers (consumed by 100% of WCA), Dark green leafy vegetables (64% of WCA), Legumes (34% of WCA), meat and fish (34% of WCA). The least consumed food groups are other fruits, other vegetables, and eggs, consumed by only 6.2%, 7.3% for vegetables, and 7.3% for eggs by WAC, respectively (Table 5). The staple diet in Niger consists mainly of cereals (millet, sorghum, corn and rice). Pulses and vegetables are mainly used as ingredients in sauces that accompany cereals, while fruits are consumed according to their seasonal availability.

The study looked for associations between the consumption of any food group and the occurrence of anemia, and found a significant association between the consumption of vitamin A-rich fruits and vegetables and the occurrence of anemia among women in Niamey ($p < 0.028$). However, studies have shown that consumption of vitamin A-rich fruits and vegetables is low among women of childbearing age in Niger, and that there is a wide disparity according to socio-economic status [39]. The women's diets are monotonous, consisting essentially of dark green leafy vegetables and, to a lesser extent, cowpeas. Eggs and other animal products, nuts, fruits and vegetables rich in vitamin A are not widely consumed [7].

Nutritional status of young children in the study sample of Niamey population

The prevalence of wasting was 10% in the sample of young children surveyed (Table 6). This prevalence corresponds to the high public health threshold of 10% set by the World Health Organization (WHO). However, this prevalence is slightly lower than that reported by the 2022 SMART survey (11.9% in Niamey and 17.6% nationally in the 6-23-month age group). There was no significant difference in the prevalence of wasting between consumers and non-consumers of fortified infant flour ($p=0.7$).

The distribution of young children suffering from wasting by age group shows that the prevalence of moderate or severe wasting was estimated at 13.0% among young children aged 6-11 months, for example a bit higher than in the 12-17 and 18-23-month-old groups.

Adjustment for wealth quintiles shows that the prevalence of global wasting falls from 12% among the very poor to 1.8% among children from wealthy households, however this is not significant ($p=0.7$).

The prevalence of chronic malnutrition or stunting among children aged 6-23 months surveyed was estimated at 19.4%, which corresponds to the WHO's medium-to-high severity threshold (Table 6). According to the authors of the SMART 2022 survey, "all regions of Niger recorded prevalences above 30%, the very high severity

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threshold defined by the WHO, with the exception of Niamey, which had a lower prevalence for years".

Despite the small number of FIF consumers in our sample, the prevalence of stunting was significantly lower among children consuming fortified infant flour (11.8%) than among non-consumers (20.8%). This difference can be attributed to an overall more favorable environment for children consuming fortified infant flour.

The distribution of young children suffering from stunting (moderate or severe) by age group shows that stunting increases with age, affecting 25.5 % children in the 18-23-month age group, and 14.3 % in the 6-11-month age group.

The prevalence of stunting drops from 25% among the poorest to 13% among children from wealthiest households, but this difference was not significant (p=0.6). The same observation was made in a study in Ethiopia, where the author stated that children from households with a medium or low/poor wealth index had a higher risk of stunting than children from households with a high wealth index [40].

Anemic state of young children in the study population of Niamey

Parental consent for anemia measurement was obtained for 236 out of the 387 young children surveyed (with) (Table 7). The prevalence of global anemia (mild, moderate and severe) in the 6-23-month-old children surveyed was 78% (Table 7). This prevalence is well above the WHO's high threshold of 40%. The prevalence among 6-59-month-olds reported by the SMART survey was 47.4% [10]. Children who did not consume fortified infant flour (79.6%) were more affected by anemia than those who did (66.7%). These results should be treated with caution, since, as in the case of stunted growth, this may be due to a more favorable overall environment, including the socio-economic level of households. Indeed, adjustment for wealth quintiles shows that anemic status of children was significantly associated with wealth quintiles according to the chi2 test (P= 0.014). Prevalence fell from 88% among the poorest to 66% among children from the wealthiest households. The prevalence of severe anemia was also found among non-consumers, at 4.4%.

Boys were more affected by anemia (81%) than girls (76%), but the difference was not significant. This is probably due to the fact that the higher growth rate in boys during the growth stages results in a higher prevalence of anemia, as their bodies require a greater amount of iron, which cannot be supplied by the diet.

According to SMART (2022), the prevalence of anemia was 72% in 2022 among children aged 6-59 months. This high prevalence According to Petry *et al* [18], iron deficiency could account for approximately 25% of anemia cases. And iron deficiency in children under two years of age can have serious and irreversible

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effects on brain development. It can adversely affect learning and academic performance later in life.

Dietary diversity in young children in the study population of Niamey

The prevalence of minimum dietary diversity (MDD_Y) in our sample of young children was 36% (figure 7), indicating that almost two third (2/3) of children were at risk of micronutrient deficiencies [24] (Table 8). This is higher than the national figure of 23.1% for 2022, according to the representative SMART survey [41]. Adequate dietary diversity increases children's chances of meeting their micronutrient requirements. The mean dietary diversity score was 4.15 ±1.27 SD, and was non-significantly higher in consumers (4.26 ± 1.43 SD) than in non-consumers (4.13 ± 1.24). The prevalence of minimum dietary diversity among children (MDD_Y) was 46% among FIF consumers, compared to 35% among non-consumers.

Stratification by age group shows that the mean dietary diversity score was lower in younger children (3.97 ±1.27 for 6-11-month-olds) (Table 8). The prevalence of minimum dietary diversity was highest in the 12-17-month-old group. The minimum dietary diversity showed a trend to increase with the children's age group (p=0.061), from 31% in 6-11 months to 46% and 34% in 12-17 months and 18-23 months, respectively.

Across wealth quintiles, scores increased significantly from 3.97 (±1.10) for the "poorest" quintile E to 4.37 (±1.5) for the "wealthiest" quintile A. The prevalence of MDD also increased significantly (p=0.048) with wealth quintiles, from 27% among the poorest to 48% among the wealthiest.

Dietary diversity and malnutrition in young children in the study population of Niamey

Minimum dietary diversity (MDD) did not correlate with malnutrition in young children in the study sample (Table 9). The prevalence of malnutrition was 73% among children who had not reached the MDD and 23% among those who had. The prevalence of stunting was non-significantly higher among children who had not reached the MDD (55%) than among those who had reached the 5-group threshold (45%).

Food group consumption in young children in the study sample of Niamey population

Consumption of breast milk on the day before the survey was high, especially among the youngest (95% among 6-11-month-olds), but decreased significantly with age (p<0.001) (still 88% among 12-17-month-olds, and 46% among the 18-23-month-olds). Indeed, breastfeeding is a very common practice among Nigerien women. The seven other food groups consumed, in descending order, were: cereals, roots, tubers and plantains (99%), other fruits and vegetables (89%), legumes, seeds, and

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nuts (56%), milk and dairy products (39%), meat, poultry and fish (28%), fruits/vegetables rich in vit. A (9.4%), eggs and egg products (28%) (Table 10). Depending on the quintile (from quintile E of the least affluent to quintile A of the most affluent), there was a non-significant increase in the consumption of eggs (15% - 37%), milk and dairy products (18% - 49%), and meat and fish (27%-30%). Some others have found statistically significant links between the consumption of these meat products and the household's socio-economic standard of living [42].

Association between maternal anemia and infant anemia and between MDD_W and MDD_YC

A possible association was sought between anemia in mothers and anemia in their children aged 6-23 months in our sample (Table 11), but the link is not statistically significant (p=0.5). It should be noted that the number of individuals screened is very low and does not allow for sufficient statistical power. However, some authors [36] have reported very significant links between maternal anemia and child anemia. In other words, the more anemic the mother is, the greater the risk of the child being anemic. Similarly, no association was found between maternal and infant dietary diversity (p=0.5) (Table 12).

CONCLUSION AND RECOMMENDATIONS FOR DEVELOPMENT

This study revealed low dietary diversity scores (DDS) and high prevalence of minimum dietary diversity (MDD), indicating that almost two thirds of children aged 6-23 months and women of childbearing age aged between 15 and 49 years of our sample of Niamey population were at high risk of micronutrient deficiencies. Unlike in the case of children, dietary diversity in women was significantly associated to their nutritional status (BMI) and consumption status of the MERIEM Foura Soga product. But this association disappeared after adjustment for wealth quintiles. The model adjusted for wealth quintiles showed a strong association between nutritional status and wealth quintiles, with a tendency for wealthier individuals to be more likely to be in the “normal weight” category than individuals from the poorest households. This study did not find any statistical link between maternal and young child dietary diversity or anemia.

To alleviate the problem of malnutrition among women and young children in Niamey, it would be strategic to implement initiatives aimed at increasing household incomes and making foods from less commonly consumed food groups, as well as locally-produced fortified products with good nutritional value accessible and affordable. At the same time, it would also be desirable to raise awareness of the health benefits of these food products to ensure their widespread consumption.

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Conflict of interest

The authors of this work declare no conflict of interest regarding this manuscript.

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Table 1: Nutritional status of women by physiological, consumption status and wealth quintile in the study sample of Niamey population

Nutritional status	Underweight[1] (BMI < 18.5)	Normal weight[1] (BMI ≥ 18.5 to < 25.0)	Overweight[1] (BMI ≥ 25.0 to <30.0)	Obesity[1] (BMI ≥ 30.0)	p-value[2]
Total (n=679) *	24 (3.5%)	265 (39%)	219 (32.2%)	171 (25.2%)	
Physiological status					
Neither pregnant nor breastfeeding (281)	13 (4.6%)	125 (44%)	83 (30%)	60 (21%)	0.027
Breastfeeding (398)	11 (2.8%)	140 (35%)	136 (34%)	111 (28%)	
Consumption status					
Consumer (79)	4 (5.1%)	29 (37%)	28 (35%)	18 (23%)	0.8
Non-consumer (600)	20 (3.3%)	236 (39%)	191 (32%)	153 (26%)	
Quintile of wealth					
E (130) poorest	6 (4.6%)	60 (46%)	38 (29%)	26 (20%)	
D (140)	4 (2.9%)	56 (40%)	49 (35%)	31 (22%)	
C (139)	6 (4.3%)	56 (40%)	40 (29%)	37 (27%)	0.3
B (133)	1 (0.8%)	48 (36%)	48 (36%)	36 (27%)	
A (137) wealthiest	7 (5.1%)	45 (33%)	44 (32%)	41 (30%)	

*71 Pregnant women not measured
[1]n (%)
[2]chi-squares tests of independence

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Table 2: Anemia status of women by physiological, consumption status and wealth quintile in Niamey

Anemic status	Anemia[1]	Non-Anemic[1]	p-value[2]
Total (n=501)	271 (54%)	230 (45.9%)	
Physiological status			
Not pregnant or breastfeeding (177)	92 (52%)	85 (48%)	**<0.001**
Pregnant (56)	45 (80%)	11 (20%)	
Breastfeeding (268)	134 (50%)	134 (50%)	
Consumption status			
Consumer (41)	17 (41%)	24 (59%)	0.13
Non-consumer (460)	254 (55%)	206 (45%)	
Quintile of wealth			
E (106) poorest	65 (61%)	41 (39%)	0.5
D (111)	60 (54%)	51 (46%)	
C (99)	52 (53%)	47 (47%)	
B (99)	50 (51%)	49 (49%)	
A (86) wealthiest	44 (51%)	42 (49%)	

[1]n (%)

[2]chi-squares tests of independence

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Table 3: Women's minimum dietary diversity by physiological, consumption status and wealth quintile in Niamey

MDD_W	Diversified[1]	Non-Diversified[1]	p-value[2]
Total (n=440)	146 (33%)	294 (67%)	
Physiological status			
Not pregnant or breastfeeding (191)	58 (30%)	133 (70%)	
Pregnant (75)	28 (37%)	47 (63%)	
Breastfeeding (174)	60 (34%)	114 (66%)	0.5
Consumption status			
Consumer (60)	29 (48%)	31 (52%)	0.011
Non-consumer (380)	117 (31%)	263 (69%)	
Quintile of wealth			
E (81) poorest	13 (16%)	68 (84%)	<0.001
D (94)	26 (28%)	68 (72%)	
C (81)	38 (47%)	43 (53%)	
B (86)	24 (28%)	62 (72%)	
A (98) wealthiest	45 (46%)	53 (54%)	

[1]Diversified: DDS ≥5; non-diversified: DDS <5

[2]chi-square test of independence

Table 4: Association between dietary diversity and women's nutritional and anemic status

MDD_W	Diversified[1]	Non-Diversified[1]	p-value[2]
Total (n=440)	146 (33%)	294 (67%)	
underweight (BMI < 18.5)	7 (6,4%)	8 (3,3%)	0,039
Normal weight (BMI ≥ 18.5 to < 25.0)	36 (33%)	118 (48%)	
Overweight (BMI ≥ 25.0 to <30.0)	37 (34%)	68 (28%)	
Obesity (BMI ≥ 30.0)	30 (27%)	50 (20%)	
Anemic status			
Anemia (Hb<12)	43 (52%)	102 (58%)	0,5
Non-Anemic (Hb>12)	39 (48%)	73 (42%)	

[1]Diversified: DDS ≥5; non-diversified: DDS <5

[2]chi-square tests of independence

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Table 5: Food group consumption by WCA physiological status in the study population of Niamey

WAC	Breastfeeding (174)	Pregnant (75)	Not pregnant or breastfeeding (190)	Total (439)
Group MDD				
Cereals, roots, tubers, and plantains	174 (100%)	74 (99%)	190 (100%)	438 (100%)
Legumes	58 (33%)	24 (32%)	69 (36%)	151 (34%)
Nuts and seeds	27 (16%)	9 (12%)	17 (8,9%)	53 (12%)
Dairy products	33 (19%)	23 (31%)	46 (24%)	102 (23%)
Meat products	54 (31%)	27 (36%)	69 (36%)	150 (34%)
eggs	9 (5,2%)	7 (9,3%)	16 (8,4%)	32 (7,3%)
Dark green leafy vegetables	120 (69%)	52 (69%)	111 (58%)	283 (64%)
Vegetables and fruits rich in vitamin A	45 (26%)	23 (31%)	56 (29%)	124 (28%)
other vegetables	9 (5,2%)	7 (9,3%)	16 (8,4%)	32 (7,3%)
other fruits	5 (2,9%)	11 (15%)	11 (5,8%)	27 (6,2%)

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Table 6: Prevalence of malnutrition in young children in the study population

	Wasting[1]				Stunting[1]			
	Normal	**MAM**	**MAS**	**p-value**	**Normal**	**MCM**	**SCM**	**p-value[2]**
Total (342)	**308 (90%)**	**29(8%)**	**5(1%)**		**266 (81%)**	**43 (13%)**	**21 (6%)**	
Child's gender (308)								
feminine	156 (90%)	14 (8.0%)	4 (2.3%)	0,4	140 (82%)	21 (12%)	9 (5.3%)	0,6
masculine	152 (90%)	15 (8.9%)	1 (0.6%)		126 (79%)	22 (14%)	12 (7.5%)	
Age groups (342)								
6-11 months (108)	94 (87%)	12 (11%)	2 (1.9%)		90 (86%)	12 (11%)	3 (2.9%)	
12-17 months (86)	79 (92%)	7 (8.1%)	0 (0%)	0,5	71 (85%)	6 (7.1%)	7 (8.3%)	0.061
18-23 months (148)	135 (91%)	10 (6.8%)	3 (2.0%)		105 (74%)	25 (18%)	11 (7.8%)	
Consumption status (322)								
Consumer (48)	44 (92%)	4 (8.3%)	0 (0%)	0,7	42 (89%)	3 (6.4%)	2 (4.3%)	0.3
Non-consumer (274)	248 (91%)	22 (8.0%)	4 (1.5%)		211 (80%)	37 (14%)	17 (6.4%)	
Quintile of wealth (322)								
E (65) poorest	56 (86%)	8 (12%)	1 (1.5%)		45 (75%)	11 (18%)	4 (6.7%)	
D (64)	58 (91%)	5 (7.8%)	1 (1.6%)		50 (81%)	9 (15%)	3 (4.8%)	
C (73)	66 (90%)	6 (8.2%)	1 (1.4%)	0,7	58 (83%)	8 (11%)	4 (5.7%)	0.7
B (63)	56 (89%)	6 (9.5%)	1 (1.6%)		50 (79%)	7 (11%)	6 (9.5%)	
A (57) wealthiest	56 (98%)	1 (1.8%)	0 (0%)		50 (88%)	5 (8.8%)	2 (3.5%)	

[1]n (%)

[2]chi-square tests of independence

MAM= Moderate wasting

MAS= Severe wasting

MCM= Moderate stunting

SCM= Severe stunting

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Table 7: Prevalence of anemia in YC in the study population

Anemic status	Anemic[1]	Non-anemic[1]	p-valeur[2]
Total (236)	184 (78%)	52 (22%)	
Child's gender			
feminine (105)	80 (76%)	25 (24%)	0.5
masculine (106)	86 (81%)	20 (19%)	
Age group			
6-11 Months (60)	51 (85%)	9 (15%)	
12-17 Months (58)	45 (78%)	13 (22%)	0.3
18-23 Months (93)	70 (75%)	23 (25%)	
Consumption status			
Consumer (30)	20 (67%)	10 (33%)	0.2
Non-consumer (206)	164 (80%)	42 (20%)	
Quintile of wealth			
E (51) poorest	44 (86%)	7 (14%)	
D (53)	46 (87%)	7 (13%)	
C (52)	42 (81%)	10 (19%)	0.014
B (44)	29 (66%)	15 (34%)	
A (36) wealthiest	23 (64%)	13 (36%)	

Hb rate < 12 mg/l

[2]chi-square tests of independence

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Table 8: Dietary diversity in young children in the study population of Niamey

MDD_YC	Diversified[1]	Non-Diversified[1]	p-value[2]
Total (352)	128 (36%)	225 (64%)	
Child's gender			
feminine (162)	57 (35%)	105 (65%)	0.9
masculine (158)	58 (37%)	100 (63%)	
Age groups			
6-11 Months (98)	30 (31%)	68 (69%)	0.2
12-17 Months (82)	36 (44%)	46 (56%)	
18-23 Months (140)	49 (35%)	91 (65%)	
Consumption status			
Consumer (50)	23 (46%)	27 (54%)	0.2
Non-consumer (303)	105 (35%)	198 (65%)	
quintile of wealth			
E (75) poorest	20 (27%)	55 (73%)	0.048
D (68)	19 (28%)	49 (72%)	
C (77)	31 (40%)	46 (60%)	
B (68)	27 (40%)	41 (60%)	
A (65) wealthiest	31 (48%)	34 (52%)	

[1]Diversified: DDS ≥5; non-diversified: DDS <5

[2]chi-square tests of independence

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Table 9: Association of minimum dietary diversity and prevalence of undernutrition and anemia in young children in the study population of Niamey

MDD_YC	Diversified[1]	Non-Diversified[1]	p-value[2]
Wasting	128 (36%)	225 (64%)	
not wasted (285)	106 (93%)	179 (89%)	
Moderately wasted (26)	8 (7.0%)	18 (9.0%)	0,3
Severely wasted (4)	0 (0%)	4 (2.0%)	
Stunting			
Not stunted (247)	86 (77%)	161 (83%)	
Moderately stunted (39)	17 (15%)	22 (11%)	0,3
RCS (19)	9 (8.0%)	10 (5.2%)	
Anemic status (n=225)			
Anemia (177)	57 (73%)	120 (82%)	0,2
Non-anemic (48)	21 (27%)	27 (18%)	

[1]Diversified: DDS ≥5; non-diversified: DDS <5

[2]chi-square tests of independence

MAM= Moderate acute malnutrition
MAS= Severe acute malnutrition
RCM= Moderate chronic malnutrition
RCS= Severe chronic malnutrition

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Table 10: Food group consumption in young children in the study population of Niamey

YC	6-11 months 98 (31%)	12-17 months 82 (26%)	18-23 months 140 (44%)	Total 320 (100%)
Group MDD				
Breastmilk	111 (95%)	78 (88%)	67 (46%)	256 (73%)
Cereals, roots, tubers, and plantains	96 (98%)	81 (99%)	140 (100%)	317 (99%)
Legumes, seeds, and nuts	43 (44%)	49 (60%)	88 (63%)	180 (56%)
Dairy products	18 (18%)	37 (45%)	69 (49%)	124 (39%)
Meat products	26 (27%)	20 (24%)	42 (30%)	88 (28%)
Eggs	7 (7,1%)	8 (9,8%)	15 (11%)	30 (9,4%)
Fruits and vegetables rich in vitamin A	24 (24%)	24 (29%)	33 (24%)	81 (25%)
Other fruits and vegetables.	77 (79%)	71 (87%)	137 (98%)	285 (89%)

Table 11: Association between maternal anemia and infant anemia in the study population of Niamey

	Anemic status YC		
	Anemia (84.2%)	16 Non-Anemic 3 (15.7 %)	p-value [2]
Anemic status WAC			
Anemia (13)	12 (75%)	1 (33%)	0,5
Non-Anemic (6)	4 (25%)	2 (67%)	

Hb rate < 12 mg/l

[2] chi-square tests of independence

Table 12: Association between maternal and young child minimum dietary diversity in the study population (n=51)

	MDD_W		
MDD_YC	Diversified[1] 22 (43.1%)	Non-Diversified[1] 29 (56.8%)	p-value[2]
Diversified[1] (17)	9 (41%)	8 (28%)	0,5
Non-Diversified[1] (34)	13 (59%)	21 (72%)	

[1]Diversified: DDS ≥5; non-diversified: DDS <5

[2]chi-square tests of independence

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