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ORIGINAL ARTICLE

Human and Clinical Nutrition

Assessment of energy and nutrient intake adequacy and dietary diversity of pregnant women in Abidjan

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ABSTRACT

Background: Dietary diversity is a potential indicator of adequate nutrient intake. **Aims:** The study assessed dietary diversity and adequacy of nutrient intake among pregnant women in Abidjan (Côte d'Ivoire). **Subjects and Methods:** A cross-sectional study was conducted on 389 healthy pregnant adult women aged 20 to 43. Participants completed a three-day, 24-hour dietary recall questionnaire and dietary data were converted into nutrient amounts using Nutrisurvey software. Dietary Diversity Score (DDS) was based on nine food groups aggregated from a 15-item questionnaire. Nutrient intake was assessed using the Nutrient Adequacy Ratio (NAR) with the mean adequacy ratio (MAR) serving as an overall indicator of diet quality. Data were analyzed using SPSS version 25. **Results:** The mean DDS among pregnant women was low at 4.30 ± 1.04, with diet primarily consisting of cereals, white tubers, roots, vegetables and fish. The average energy intake of pregnant women was 2429 kcal/day for over 60 % of participants. While the majority met the Recommended Daily Allowance (RDA) for carbohydrates, fats, proteins, and vitamin B_{12}. However, intakes of calcium, iron, magnesium, zinc, folates and vitamin C were below the RDAs for most pregnant women. The average MAR for pregnant women was 70.86% and exhibited a positive correlation with DDS ($r = 0.37$; $p < 0.001$). NAR for energy and other nutrients was positively correlated with DDS, except for vitamins B_{12} and C. **Conclusions:** Pregnant women with adequate nutrient intakes consumed a diverse range of foods. Dietary diversity can therefore provide be a reliable indicator of nutrient adequacy in the diets of pregnant women in Abidjan's hospital.

Keywords: Dietary diversity, nutrient intake, nutrient adequacy ratio, pregnant women, Côte d'Ivoire.

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1 Introduction

Adequacy of nutrient intakes is the average ratio of intake to recommendations for energy and selected nutrients (Torheim et al., 2004). It is one of the indices of dietary quality, which is increasingly used as a tool to monitor compliance with dietary advice by the population, mainly in industrialized countries. Since no single food alone can provide all the nutrients needed to achieve optimal health, the greater the dietary diversity in the daily diet, the more likely it is that nutrient requirements will be met. Several studies have shown that dietary diversity is strongly associated with the adequacy of nutrient intakes (Torheim et al., 2004, Arimond et al., 2010) particularly among pregnant adolescents (Nguyen et al., 2018), youth (Sultana et al., 2019), pregnant women (Hjertholm et al., 2019) and non-pregnant women (Mirmiran et al., 2006; Kennedy et al., 2009).

Dietary diversity is a potential indicator to reflect the adequacy of nutrient intakes (Labadarios et al., 2011). Thus, the overall nutritional quality of the diet is improved through dietary diversity (Rathnayake et al., 2012). Dietary diversity thus helps to meet the needs for energy and other essential nutrients, particularly for people at risk of nutritional deficiencies. It's also the means of choice for improving the nutritional status of vulnerable people such as children and women because it offers the possibility of simultaneously improving intakes of many food components, particularly in micronutrients (Allen et al., 2011).

During pregnancy, women need to pay particular attention to their diet, not only to meet the mother's increased nutritional needs but also to adapt to the physiological changes of pregnancy and contribute to the health of both mother and fetus (Institute of Medicine, 1990). Women of childbearing age in most developing countries frequently encounter difficulties in meeting their micronutrient needs during pregnancy, due to poor diet (Torheim et al., 2010) and insufficient dietary intake (Mirmiran et al., 2006; Rathnayake et al., 2012). The World Bank has even estimated that the impact of poor maternal and child nutrition reduces countries' economic output by 2-3% per year (Horton et al., 2010). Studies conducted in several regions of Africa have shown significant gaps in women's macro- and micronutrient intakes before and during pregnancy (Oguntona & Akinyele, 2002; Asayehu et al., 2017; Huybregts et al., 2009) but also poor quality and low diversification of the diet (Kamau-Mbuthia & Eladfa, 2007).

Information on the dietary intake of pregnant women is therefore essential for appropriate planning and interventions that can effectively improve the nutritional status of mothers and infants (Bhutta et al., 2008; Haider & Bhutta, 2017), especially for a country like Côte d'Ivoire where no studies have yet been conducted on dietary diversity and nutritional intakes of pregnant women. In order to improve maternal and child health, the objective of this study was to assess the adequacy of macro and micronutrient intakes through dietary diversity during pregnancy.

2 Subjects and Methods

2.1 Population and study design

This cross-sectional study was conducted among 389 pregnant women aged 20 to 43 years old followed in the maternity hospitals of Yopougon-Attié General Hospital, Adjamé General Hospital, Abobo-Sud General Hospital, and the Community-Based Urban Health Centers (CSUCOM in French) of Abobo-Té and Anono Riviera-2 in Abidjan. Information was collected from July 2017 to August 2018 and subjects were recruited through a call for applications. The study began only after ethical approval and informed consent had been obtained from the pregnant women who took part. Their participation was voluntary, and no financial compensation was paid.

2.2 Inclusion and non-inclusion criteria

Only pregnant women aged 20 years or older, with a singleton pregnancy and no underlying medical conditions, were invited to participate in the study. Women younger than 20, those with multiple pregnancies, or those considered at risk due to conditions such as gestational diabetes, hypertension, rheumatism, hemoglobinopathies, malaria, HIV/AIDS, as well as those undergoing medical treatment, were excluded from the study.

2.3 Data collection

Structured and semi-structured questionnaires were employed in the data collection process.

2.3.1 Dietary diversity assessment

A 24-hour dietary recall was employed to assess the overall quality of participants' diets, using the Dietary Diversity Score (DDS). For each respondent, the DDS was calculated based on the nine food groups recommended by the Food and Agriculture Organization of the United Nations (FAO) (Gina Kennedy & Division, 2011). These groups include starchy foods, dark green leafy vegetables, eggs, legumes, nuts and seeds, milk and dairy products, meat and fish, offal, fruits and vegetables, other vitamin A-rich fruits and vegetables, and red palm oil. The DDS ranged from 0 to 9. Based on their dietary diversity, women were categorized into three categories: low (1 – 3 food groups), medium (4 – 5 food groups), and high (6 – 9 food groups).

2.3.2 Dietary intakes assessment

The study assessed the quantities of food consumed per person per meal over a three-day period, utilizing a 24 hours quantitative recall method. Participants estimated their food intake using household utensils with seasonal fruits serving as reference points for portion size estimation. These estimated intakes were then converted into grams using the food conversion factors of the National Nutrition Program (NNP) of Côte d'Ivoire. For pregnant women, daily nutrient intakes were calculated using Nutrisurvey software in conjunction with the 2012 West African food composition tables. Participants were classified into two groups based to whether or not their intake met the Recommended Daily Allowance (RDA) for pregnant women.

2.3.3 Nutrient adequacy ratio (NAR)

To assess the adequacy of pregnant women's diet in relation to nutritional recommendations, quantitative indices were calculated for each nutrient. Data from the three 24-hour dietary recalls were utilized to calculate the Nutrient Adequacy Ratio (NAR) of energy and for each macro-, and micronutrient intakes. For pregnant women, the NAR was calculated by dividing the respondent's energy or nutrient intake by the corresponding reference intake (see equation 1):

$$\text{NAR} = \frac{\text{Daily mean nutrient intake}}{\text{Recommanded daily allowance}} \times 100 \ldots\ldots\ldots \text{(1)}$$

2.3.4 Mean adequacy ratio (MAR)

The mean adequacy ratio (MAR) was employed to evaluate the overall dietary quality. The MAR was calculated by averaging the NAR for energy intake and the 11 selected nutrients. To prevent the overestimation of dietary adequacy, all NAR values exceeding the RDA have been reduced to "one". This approach ensures that excess intake of certain nutrients (e.g., carbohydrates, lipids, proteins, fiber, calcium, iron, magnesium, zinc, and vitamins B_9, B_{12}, and C) does not compensate for deficiencies in others. Thus, the maximum NAR value has been capped at "one" (Hatløy et al., 1998). A MAR value of "one", indicates a diet fully aligned with 100% of the RDA, reflecting an optimal adherence to nutritional recommendations (see equation 2).

$$\text{MAR} = \frac{\sum \text{NAR (each troncated at 1)}}{\text{Numbers of nutrients}} \ldots\ldots\ldots \text{(2)}$$

2.4 Statistical Analysis

The data were analyzed using descriptive statistics, including frequencies, means, and standard deviations with SPSS 25 software. Spearman's correlation coefficient was applied to assess the relationship between DDS and NARs. A significance threshold of $p < 0.05$ was used for all statistical tests.

3 Results

3.1 Characteristics of the pregnant women

Table 1 presents the socio-demographic and obstetrical characteristics of the respondents. The age of participants ranged from 20 to 43 years, with a mean age of 28.4 ± 5.2 years. Among the pregnant women, 22% had no formal education, while 26% had attained higher education. A majority worked in commerce (32.4%), while 17.9% had a monthly salary, and 23.9% were housewives. The average number of births was 1.2 (range 1 – 9), and the number of pregnancies ranged from 1 to 10, with an average of 3.1. The majority of respondents were in their second (41.9%) or third trimester (37.3 %) of pregnancy.

Table 1. Sociodemographic and obstetrical characteristics of pregnant women

Variables	Frequency	Percentage
Age mean ± SD (min–max)	28.4 ± 5.2 (20 – 43) years	
Educational level		
None	87	22.4
Primary	82	21.1
Secondary	119	30.6
Superior	101	26
Occupation status		
Trade	126	32.4
Hairdresser/Tailor	75	19.3
Employed (Public or Private)	70	18
Housewife	93	23.9
Student	25	6.4
Trimester of pregnancy		
First	80	20.6
Second	163	41.9
Third	146	37.5
Gravidity mean ± SD (min–max)	3.1 ± 1.7 (1 – 10) pregnancy	
Parity mean ± SD (min–max)	1.2 ± 0.58 (1 – 7) Births	

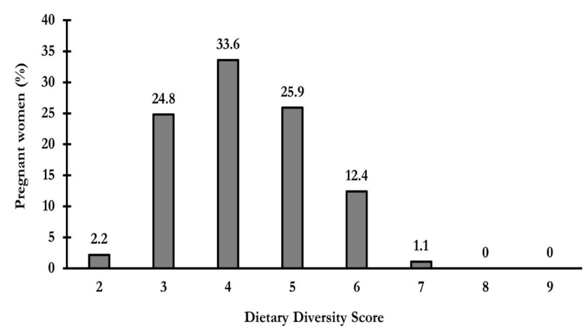

Figure 1. Distribution of pregnant women by dietary diversity score based on 9 food groups

3.2 Dietary diversity and food group consumption

Food consumption among the pregnant women ranged from 2 and 7 food groups, with a mean DDS of 4.30 ± 1.04 (Figure 1). The majority of participants demonstrated limited dietary diversity, with 58.4% consuming only three to four food groups. None of the pregnant women consumed all the nine recommended food groups. In addition, 60.6% of the women showed inadequate DDS ≤ 4, while only 39.4% demonstrated adequate DDS > 4.

Over 80% of the women's diet consisted mainly of cereals, tubers, cooked vegetables, and fish (Figure 2). In contrast, fewer than 50% consumed nutrient-dense foods, such as meat, eggs, offal, dairy products, dark green leafy vegetables, fruits, legumes, and red palm oil.

3.3 Energy and nutrient intake

Table 2 presents the mean values and proportions of pregnant women meeting the RDA for energy, macro- and micronutrient intake. The average daily energy intake was 2429 ± 528 kcal, and 62.5% of the participants meeting the RDA for energy. While the majority of pregnant women satisfied their macronutrient requirements, intakes of folate, calcium, magnesium, iron, and zinc were generally insufficient. In contrast, vitamin B_{12} and vitamin C intake was adequate, although only a small percentage of participants met the RDA for most other essential micronutrients (Table 2).

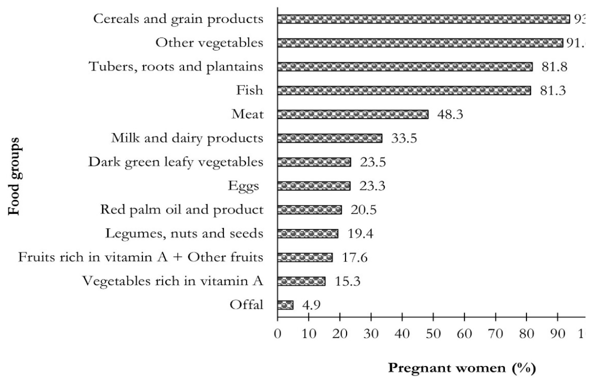

Figure 2. Distribution of pregnant women by food group consumption

This refers to participants who affirmed to have consumed a food group within the past 24 hours at the time of the survey.

Table 2. Mean energy and nutrient intakes and proportion of pregnant women with adequate intakes (⩾RDA)

Nutrients	Mean ± SD	RDA	% of pregnant women with intakes ≥ RDA
Energy (kcal)	2429.07 ± 527.65	2400	62.5
Proteins (g)	91.09 ± 26.80	74	61.7
Fat (g)	73.48 ± 32.35	94	54
Carbohydrates (g)	283.52 ± 79.16	175	93.1
Fiber (g)	20.73 ± 17.19	28	13.1
Iron (mg)	21.56 ± 12.57	30	13.1
Zinc (mg)	9.71 ± 6.11	11	18
Calcium (mg)	589.22 ± 380.59	1000	10.3
Magnesium (mg)	222.39 ± 157.88	400	6.4
Folates (µg)	212.74 ± 146.56	600	5.6
Vitamin B_{12} (µg)	3.92 ± 3.21	2,6	53.5
Vitamin C	84.58 ± 55.70	85	44.2
% of TEI from Proteins	14.99 ± 4.38	(10–15%)	
% of TEI from lipids	27.2 ± 9.87	(30–35%)	
% of TEI from carbohydrates	57.78 ± 10.02	(50–55%)	

TEI: Total Energy Intake; SD: Standard deviation; RDA: Recommended dietary allowance (FAO/WHO, 2001)

3.4 Nutrient adequacy and correlation with dietary diversity score

Table 3 presents the mean values of MAR, NARs, and their correlation with the DDS. The MAR of the pregnant women surveyed was 70.86 ± 13.31%, below the ideal threshold of 100%. NARs varied by nutrient, with the highest values observed for proteins and carbohydrates, exceeding their respective RDAs 1.2 and 1.6 times, respectively. Fat and fiber NARs met at least 78% of the RDA, while energy intake reached 100% of the RDA for pregnant women. In contrast, NARs for most micronutrients fell significantly below the RDA, except for vitamins B_{12} and C. Folate intake displayed the lowest NAR at 35.72 ± 24.42%.

In the correlation study, NARs for all macronutrients and energy, as well as the MARs, were significantly positively correlated with the DDS with correlation coefficients ranging from $r = 0.216$ to $r = 0.722$ ($p < 0.001$). An identical trend was recorded for NAR values of micronutrients, with the exception of vitamins B_{12} and C.

Table 3. Mean values of MAR and NARs for energy and nutrients and correlation with DDS

		DDS	
	Mean ± SD	r	p
%MAR*	70.86 ± 13.31	0.366	< 0.001
%NAR**			
Energy	103.23 ± 22.67	0.722	< 0.001
Proteins	123.09 ± 55.34	0.333	< 0.001
Fat	78.17 ± 34.41	0.409	< 0.001
Carbohydrates	161.39 ± 43.29	0.472	< 0.001
Fiber	84.84 ± 41.01	0.216	< 0.001
Calcium	58.83 ± 37.88	0.252	0.001
Iron	71.86 ± 46.30	0.235	0.004
Magnesium	50.19 ± 30.18	0.262	0.001
Zinc	88.27 ± 51.11	0.393	< 0.001
Vitamin B9	35.72 ± 24.42	0.282	0.001
Vitamin B_{12}	147.95 ± 11.14	0.065	0.457
Vitamin C	99.51 ± 61.76	0.076	0.053

p: significance at the 5% cut-off, r: Spearman's correlation coefficients, DDS: Dietary Diversity Score, %MAR: Percentage of Mean Adequacy Ratio, %NAR: Percentage of Nutrient Adequacy Ratio, *Value calculated after reduction of excess NARs to value "hundred", **Gross values.

3.4.1 Relationship between dietary diversity score and NAR of macronutrients and energy

In this study, the relationship between DDS and NARs for energy and macronutrients showed an increase in NARs for all nutrients as DDS increased (Figure 3). However, when DDS reached its maximum value of 7, a decline in protein and fiber NARs was observed, in contrast to the sustained increase for carbohydrates, lipids, and energy.

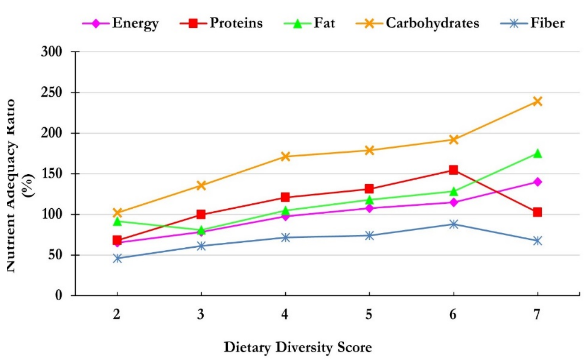

Figure 3. Evolution of percentage of NAR of macronutrients, fiber and energy according to dietary diversity score

3.4.2 Relationship between dietary diversity score and NAR of micronutrients

The results indicate that NAR values of all minerals, except calcium, iron, and magnesium, reached at least 50% with the consumption of 3 food groups (DDS = 3). For calcium, iron and magnesium the NAR reached 50% at DDS levels of to 5 and 6, respectively (Figure 4A).

For vitamin B_{12}, the NAR achieved 100% with the consumption of at least 3 food groups (DDS = 3), whereas vitamins B9 and C only reached 100% with DDS levels of 5 and 6 food groups, respectively (Figure 4B).

4 Discussion

Recent scientific attention has emphasized the critical importance of adequate nutrition during the first thousand days of life to prevent both short- and long-term adverse effects of malnutrition during pregnancy. This study evaluated the dietary intake and dietary diversity of pregnant women in Abidjan and explored its association with nutrient adequacy.

The mean of DDS, in this study (4.30 ± 1.04) was higher than findings from similar studies conducted in Ethiopia (3.68) (Yeneabat et al., 2019) and Ghana (3.81) (Ayensu et al., 2020). Comparable results were observed among households in Abidjan (Kouassi et al., 2013). However, our results are lower than those reported in Kenya by Kiboi et al. (2017). This discrepancy may be attributed to differences in the measurement of dietary diversity, as some studies used 14 food groups, which could result in a higher DDS compared to the 9 food groups used in this study.

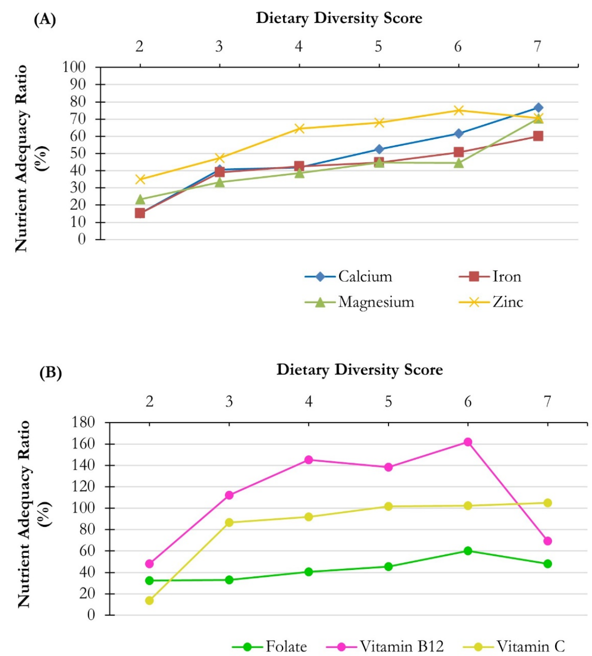

Figure 4. Evolution of percentage of NAR of Minerals (A) and Vitamins (B) according to dietary diversity score

Our study revealed that pregnant women attending maternity hospitals in Abidjan seldom adjust their nutritional intake during pregnancy, despite the recommendation to increase intake to meet the heightened nutritional demands of this period. This is crucial for the health of the mother, fetus, and newborn. While average daily intake for certain nutrients, such as energy, protein, carbohydrates, fat, and vitamins C and B_{12}, are within recommended levels. other micronutrients including folate, iron, magnesium, calcium, and zinc do not meet the RDA during pregnancy.

Concerning energy intake, the average daily intake (2429 Kcal/day) aligns with the RDA of 2400 Kcal/day for pregnant women. These findings are consistent with those of Denguezli et al. (2007) in Algeria. Despite adequate energy intake for the majority (62.4%) of pregnant women, a substantial portion (37.8%) demonstrated insufficient energy intake. This may be attributed to low food consumption or socio-economic constraints. The inadequate energy intake observed among pregnant women in this study is lower than figures reported in Sri Lanka (Adikari et al., 2016) and rural areas of KwaZulu-Natal, South Africa (Napier et al., 2019).

In terms of macronutrient intake, carbohydrate, protein, and fat generally met the recommended levels. The mean daily protein intake (91.1 g) was sufficient compared to the RDA, aligning with findings from other studies (Touati-Mecheri et al., 2007), though higher than the 50.44 g and 73.2 g reported by Napier et al. (2019) and Kesa & Oldewage-Theron (2005), respectively.

Despite the overall adequacy in protein intake, 38% of the study participants exhibited inadequate protein consumption, a figure remarkably higher than the 24% reported among pregnant women in Limpopo, where protein intake fell below 67% of the RDA Mostert et al. (2005). This deficiency could be attributed to the limited consumption of protein-rich foods such as meat, fish, and eggs.

The mean daily fat intake of 73.48 ± 32.25 g was adequate compared to the RDA of 71 g, though higher than the 62.3 g reported by Kesa & Oldewage-Theron (2005). In addition, more than half of the pregnant women achieved fat intakes consistent with the RDA. The average lipid contribution to total energy intake (TEI) was 27.2%, close to the recommended range 30 – 35%. Our results corroborate those reported in 1674 Norwegian pregnant women (Saunders et al., 2019) but differ from studies conducted in Quebec (Dubois et al., 2017) and Spain (Aparicio et al., 2020), where lipids accounted for more than 50% of TEI.

Regarding carbohydrate intake, only 6.9% of the pregnant women surveyed had inadequate carbohydrate intake. The average daily intake of 350.9 g exceeded the RDA, likely due to the high consumption of starchy foods by at least 80% of participants. Our results differ from those of studies observing inadequate carbohydrate intakes in pregnant women in Europe (Saunders et al., 2019; Aparicio et al., 2020) but are consistent with findings from African studies (Kesa & Oldewage-Theron, 2005; Mostert et al., 2005). Moreover, the 57.8% contribution of carbohydrates to TEI aligns with the recommended 50 – 55% range.

Our findings indicate that fiber intake fell below recommended levels, with the majority (80.3%) of the study population not meeting the daily fiber recommendations. This suggests a low intake of fruits (17.6%), dark green leafy vegetables (23.5%), and legumes (19.4%) among the participants. Similar findings have been reported by other study (Aparicio et al., 2020). Adequate fiber intake is essential for preventing several pregnancy-related health issues, including constipation and gestational diabetes (Mousa et al., 2019).

While macronutrient intake in this study was generally adequate, the nutritional quality of the diet was compromised by insufficient micronutrient intake. The most limiting nutrients, consumed at less than 75% of the RDA by more than 50% of pregnant women, were iron, calcium, magnesium, and folate. This highlights the risk associated with low consumption of nutrient-dense food such as fruits, dark green leafy vegetables, dairy products, eggs, and meat. These findings align with previous studies that have similarly reported inadequate intake of folate and iron, magnesium, calcium, and zinc, often below estimated average requirements (Lee et al., 2013; Saunders et al., 2019; Aparicio et al., 2020).

The RDAs for iron, calcium, magnesium, zinc, folate, and fiber were not met, whereas the intake of energy, carbohydrates, fat, vitamin C and B_{12} reached or exceeded 100% of their respective RDAs. The MAR of 70.86 ± 13.31 suggests that the diets of these pregnant women did not include all nutrients at recommended levels. In contrast, Torheim et al. (2004) reported a MAR of 93% among Malian adolescents and adults, reflecting better alignment with nutritional guidelines.

This study examined the correlation between nutrient adequacy, as measured by NAR and MAR and DDS. DDS was positively correlated with NAR for most nutrients, except vitamins B_{12} and C. Similarly, MAR showed a positive and significant correlation with DDS. These findings are consistent with previous studies that have demonstrated a positive relationship between dietary diversity and nutrient adequacy in women of childbearing age (Nguyen et al., 2018; Hjertholm et al., 2019).

A comparison of energy and 11 nutrient RDAs across different DDS level revealed a general increase in nutrient adequacy as DDS increased. However, even with the consumption of seven food groups, optimal adequacy (MAR = 1) was not achieved in pregnant women. This highlights the importance of dietary diversity in meeting energy and essential micronutrient requirements during pregnancy in this study population.

5 Conclusion

This study revealed low dietary diversity among the majority of pregnant women (60%) in maternity wards in the communes of Abobo, Adjamé, Cocody, and Yopougon. While maintaining their caloric intake, their diets were of lower nutritional quality, characterized by the absence of nutrient-dense foods such as fruits, dark leafy green vegetables, dairy products, and offal. This dietary pattern resulted in inadequate intakes of key micronutrients including iron, folate, zinc, calcium, and magnesium, and fiber which poses a risk for conditions such as anemia. To address this issue, it is essential to intensify nutritional education programs during prenatal care (ANC) visits and ensure that pregnant women are key beneficiaries of nutrition and dietetics services in these maternity wards.

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