World Nutrition 2020;11(1):145-164

Adequacy of nutrient intakes among pregnant women in northern Ghana

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Abstract

Introduction: Adequate nutrition during pregnancy is a pre-requisite for good pregnancy outcomes as well as future wellbeing, development and quality of life of the unborn child. This analytical cross-sectional study evaluated the adequacy of nutrient intakes of pregnant women resident in northern Ghana.

Methods: A total of 400 pregnant women in 25 communities in the Northern, Upper East and Upper West regions of Ghana were interviewed at the household level. The nutrient intakes were assessed using a structured 24-hour dietary recall questionnaire. A dietary diversity score (DDS) was measured as a count of food groups. A nutrient adequacy ratio (NAR) of 14 nutrients as well as mean adequacy ratio (MAR) were calculated based on the 24-hour dietary recall.

Results: The average energy, protein and fat intakes were 2,770.8 ± 1,127.5 Kcal/day, 59.2 ±27.5 g/day, and 105.25±58.0 g/day, respectively. The proportion of women meeting the recommended dietary allowance (RDA) of these macro-nutrients were 58.8%, 27.0% and 50.3% respectively. The average MAR of 14 nutrients was calculated to be 68% as the overall measure of nutrient adequacy. MAR correlated positively with DDS ($r = 0.24$ $P < 0.001$). Over 50% pregnant women obtained less than 66% of the RDA for iron, calcium, riboflavin, folic acid and vitamin B12.

Conclusion: Diets of the majority of these pregnant women were deficient in several nutrients. Dietary diversity scores served as a useful proxy indicator of nutrient adequacy in this sample. In order to meet the requirements for essential nutrients, more effort should be made to promote dietary diversity among pregnant women in northern Ghana.

Keywords: dietary quality; mean adequacy ratio; dietary diversity scores; 24-hour dietary recall; pregnancy, Northern Ghana

Introduction

Malnutrition, including micronutrient deficiencies such as iron, zinc, vitamin A and iodine, are still of public health significance in Africa, including Ghana (Muthayya et al. 2013). For example, in the Ghana Micronutrient Survey carried out in 2017, the prevalence of anaemia among pregnant women was 45.1% (University of Ghana et al. 2017).

Women of reproductive age, particularly during pregnancy, are the most vulnerable because of increased needs of these nutrient. Usually, inadequate intakes of foods rich in the micronutrients, losses or malabsorption associated with infections such as malaria and worm infestations, geographical region, culture, dietary habits and socioeconomic level are major contributory factors (Jensen et al. 2010; Michaelsen et al. 1994; Subcommittee for a Clinical Application Guide et al. 1992).

Adequate maternal nutrition before and during pregnancy is a pre-requisite for good pregnancy outcomes as well as future wellbeing, development and quality of life of the unborn child (FAO/WHO 1992; Pollitt 1990). It is also known that maternal nutrition influences the nutrition and birthweight of infants as well as to some extent the supply and composition of breastmilk post-partum (Ares Segura et al. 2016; Dewey 2004).

A well-nourished pregnant woman will have a good reserve of several nutrients that meets the needs of the growing foetus and enhances the chance of the child entering life in good health. Available scientific evidence strongly shows that diet quality during pregnancy is critical for foetal development, the health of a pregnant woman and her care-giving capabilities (Al-Shoshan 2007; Cheng et al. 2009; Lee et al. 2013).

The UN Sustainable Development Goals (SDGs) include a target of addressing the nutritional needs of adolescent girls, as well as pregnant and lactating women, by 2030 (United Nations 2015). To reach this target effectively, there is the need for up to date data on micronutrient status and intake, especially that of pregnant women. Little is however known about the micro- and macro-nutrient intakes of pregnant women in Ghana. The Ghana National Micronutrient Survey 2017 (GMS) which was conducted to provide understanding of the severity of micronutrient deficiencies, focused on vitamin A, iron, folate, vitamin B12, but coverage of pregnant women was rather low. In addition, dietary diversity scores have been reported to serve as a simple proxy measure of micronutrient adequacy (Swindale and Bilinsky 2006), but very little documentation exists on the relation between dietary diversity and adequacy of nutrient intake among pregnant women in Ghana.

This study therefore evaluated the adequacy of nutrients intakes of pregnant women resident in five districts of Northern Ghana. We also assessed the relationship among maternal dietary diversity and/or individual food groups, nutrient adequacy ratio (NAR) and mean adequacy ratio (MAR).

Methods

The Study location

This study was conducted in five districts of Northern Ghana using a community-based analytical cross-sectional study design. The study area is characterized by high poverty and recurrent droughts and floods which predispose communities to increased vulnerability to food insecurity and malnutrition. The Ghana Living Standards Survey Round 6 Report showed that the three study regions have higher proportions of households in the lowest income quintile than in the highest quintile. The UWR has the highest proportion of households in the lowest quintile (55.7%) and the NR recorded the lowest proportion in the highest quintile (10.2%) (Ghana statistical Service (GSS) 2014).

The majority of the people in the study area have agriculture as their main occupation whilst some are involved in trading. The main staple foods, including maize, sorghum, millet, and yam, are usually harvested from October through December. The rainfall pattern is unimodal, and the period is usually short and lasts from May to August, followed by a long dry season (September–April) with dry harmattan winds.

Although the food security situation is usually good during the harvesting time, childcare tends to suffer because of lack of time on the part of rural mothers. A high proportion of rural women work daily away from home and therefore frequently face challenges in the care of their children.

Study population and sampling

The study population consisted of pregnant women who were randomly selected from 25 rural communities in Nadowli, Wa West in the Upper West Region (UWR), Tolon and Savelugu in the Northern Region (NR), and Kassena-Nankana in the Upper East Region (UER) where the African RISING Project was being implemented. Systematic random sampling was then used to select participants from each community.

This study was part of a larger research project that investigated diet diversity, coping strategies and food access of pregnant women in Northern Ghana. The proportion of pregnant women that had access to adequate foods was unknown. So, the sample size was determined on the assumption that 50% of the pregnant mothers had access to adequate food with 5% margin of error and 95% confidence level and a nonresponse rate of 5%. Based on this assumption, a sample size of 400 for the study was determined using the formula for one-point sample estimation:

$$n = \frac{t^2 \times p(1-p)}{m^2}$$

Where n = required sample size, **t =** confidence level at 95% (standard value of 1.96), **p =** estimated proportion of pregnant women having access to adequate food (50.0%) and **m =** margin of error at 5%.

Data collection

A semi-structured questionnaire was used to collect data on socio-demographic status, anthropometry and dietary intake. The questionnaire was pretested on 20 pregnant women. These subjects were not included in the final sample of the study.

One round of quantitative 24-hour dietary recall for the previous day was used to estimate consumption of food at the individual level. A detailed description of all the foods and beverages consumed was recorded. Handy measures were used to quantify portion sizes.

The women dietary diversity score (WDDS) for each woman was calculated from 10 food groups used for the minimum dietary diversity for women (MDD-W) indicator (FAO and FHI

360 2016). The food groups were 1) grains, white roots, and tubers; 2) pulses; 3) nuts and seeds; 4) dairy; 5) meat, poultry, and fish; 6) eggs; 7) dark green leafy vegetables; 8) vitamin A-rich fruits and vegetables; 9) other vegetables; 10) other fruits. No minimal amount was re-quired for a food item to be included. Each food group was weighted equally with the value 1. The WDDS was also categorized into whether or not pregnant women had consumed at least five out of 10 food groups previous day or night, that is, a 24 h recall, which did include quantities consumed.

The appropriate weights in grams of the handy measures of foods eaten were imputed into the Ghana Food Database (GFD) software for the calculation of the various nutrients in the food items eaten by pregnant women. In instances where a particular food item could not be found in the GFD, nutrient intakes (e.g. energy, protein, fat, crude fibre, calcium, iron and vitamin 'A') were calculated with reference to the West Africa Food Composition Table.

Nutrient Adequacy Ratio

The main outcome variable was adequacy of the macro and micronutrient intake as measured by a nutrient adequacy ratio (NAR).

The NAR was computed for energy and 14 nutrients for every subject, based on the 24-h dietary recall data, using the following equation (Guthrie and Scheer 1981):

$$NAR = \frac{\text{Actual intake of nutrient by the subject x 100}}{\text{Subject's RDA for that nutrient}}$$

The following macro- and micronutrients and energy were assessed: protein, fat, vitamin B6, folic acid, folate, vitamin B12, vitamin A, vitamin C, thiamine, riboflavin, niacin, iron, zinc, and calcium. The NAR was truncated at one in order that a nutrient with a lower NAR could not be recompensed by a nutrient with a higher NAR (Hatloy et al. 1998).

To calculate the NAR of each nutrient, mean intakes were calculated and these were compared with the Recommended Dietary Allowances (RDA) for pregnant women. Classification was also based on the following criteria:

i. Inadequate intake: NAR<0.66 (intake being less than 66% of the RDA)
ii. Fairly adequate intake: NAR=0.66 to <1.00 (intake of 66% to <100% of RDA
iii. Adequate intake: NAR>1.00 (intake being >100% of the RDA).

A Nutrient Adequacy Ratio of >0.66 for a particular nutrient was considered to be adequate (Gupta 2017). The Mean Adequacy Ratio (MAR) was calculated as an overall measure of nutrient adequacy. This was done by averaging all the NAR values together: MAR = SUM of NAR/Number of nutrients x 100.

Measurement of household wealth index

A household wealth index based on household assets and housing quality was used as a proxy indicator for socio-economic status (SES) of households. Principal component analysis (PCA*)* was used to determine household wealth index from information collected on housing quality (floor, walls, and roof material), source of drinking water, type of toilet facility, the presence of electricity, type of cooking fuel, livestock, and ownership of modern household durable goods (e.g. bicycle, television, radio, motorcycle, sewing machine, telephone, cars, refrigerator, mattress, bed, computer and mobile phone) (Filmer and Pritchett 2001; Howe et al. 2008; Rutstein and Johnson 2004; Vyas and Kumaranayake 2006).

Statistical analysis

The data were coded and analysed using Statistical Package for Social Sciences (SPSS). Data were analysed by using descriptive statistics like frequency distributions, percentages, mean and standard deviations. Analysis of variance (ANOVA) was applied to assess whether there was significant difference with regards to quantitative outcome variables in groups of interest. Associations between qualitative variables were analysed using chi-square test and the strength of the association was established using odds ratios.

Pearson's correlation analysis was also applied to understand the relationship between NAR, MAR and dietary diversity. All data were log trans-formed to meet the criteria for Pearson's correlations. Multiple regression analysis was also performed to identify the significant independent determinants of MAR.

Ethical Considerations

The study protocol was approved by the School of Allied Health Sciences, University for Development Studies. Ethical clearance was obtained from the Institutional Review Board (IRB) of the Tamale Teaching Hospital (Ref no. TTH/10/11/15/01).

Informed consent was also obtained from study participants after needed information and explanation. In situations, where the respondent could not write or read, verbal informed consent was sought from all the study participants before the commencement of any interview.

Results

Socio-demographic characteristics

As shown in Table 1, the mean age of the respondents was 26.2 years with a standard deviation of ±6.3 years. The minimum and maximum ages were 15 and 48 years respectively.

More than 50% of the study participants were Muslims and most of them (85.5%) were married. In terms of education, only 9% attained at least Senior High School (SHS) and 55.8% were from households of high wealth index. The main ethnic groups in the sample comprised Dagombas (29.8%) and Dagao's (27.5%). The main source of income of most of the pregnant women was through farming and trading whereas 25.5% reported having no source of income. The proportion of the women who initiated first ANC visit in the first trimester was 68.3%.

Dietary diversity and frequency of consuming specific foods

Individual dietary diversity score was used as the proxy measure of diet quality. The mean dietary diversity score (DDS) of study population from ten food groups was 4.2±1.5; 46.1% (95% CI: 40.0 to 52.2) met the MDD-W. Table 2 shows the results of the 24-hour dietary recall. Starchy staple foods, flesh food, dark green leafy vegetables and nuts and seeds were the most commonly consumed foods, while beans and peas, dairy products, egg, and fruit were less eaten.

Mean energy and nutrient intake

From Table 3, it shows excess consumption of carbohydrate and fibre-rich foods. The average daily energy intake was 2770.81 (±1127.52 SD) kilocalories.

The mean protein intake was 59.2±27.5g, accounting for 80.0% of the RDA. However, only 27.3% met the full daily reference intake for protein. The mean intake of iron was 17.0±8.6 mg covering 56.7% of RDA, while mean calcium intake (391.2±195.4 mg) and met 39.1% of RDA.

With respect to the NAR of these nutrients, iron, calcium, riboflavin, folic acid, folate and vitamin B12 did not reach 100%. The intake of energy, carbohydrates, total fat, fibre, zinc, vitamin A, thiamine, vitamin C, niacin and vitamin B6 exceeded the RDA/RNI and so the NAR was capped at 100%.

The mean adequacy ratio (MAR) of the 14 nutrients was calculated to be 0.68±0.14%. About 15.9% of the respondents were reported to have a MAR lower than 0.55 and 56.6% had MAR≥ 0.70. None had a MAR of 1.

Distribution of Nutrient Adequacy Ratio (NAR) of macro- and micro-nutrients intakes of pregnant women

The most limiting nutrients in the diet of over 50% pregnant women were iron, calcium, riboflavin, folic acid and vitamin B12 where intakes were inadequate (that is, less than 66% of the RDA) (Table 4).

Correlation between nutrient adequacy ratio (NAR) of selected nutrients and women's dietary diversity score

The Maternal DDS correlated significantly and positively with NAR of most nutrients except total fat, vitamins A and C, folic acid and vitamin B12. The mean adequacy ratio (MAR) correlated more with dietary diversity than the individual NAR (Table 5).

Relationship between mean nutrient intake and minimum dietary diversity

The intake of energy and the major macro and micronutrients were compared between respondents with high DDS (≥ five food groups) and those who had low DDS. There were significant differences in the intake of some nutrients (e.g. of protein, iron, zinc, niacin) between women of low and high minimum dietary diversity (Table 6).

Geographical distribution of Nutrient adequacy ratio

Table 7 shows the nutrient adequacy ratio of nutrients that differed significantly among respondents in the study districts. No discernible difference in energy and protein NAR was observed among the districts. The nutrient adequacy ratio was highest in the Nadowli District with respect to iron, calcium, riboflavin, vitamin A and folate. NAR for niacin was 100% in all districts but calcium NAR was less than 48% in all districts. Vitamin A NAR was also good in all districts (> 80%).

Table 1. Socio-demographic characteristics of the study sample (N =400)

Variable	Frequency (n)	Percentage (%)
Age of mother (years)		
Under 18	8	2.0
18-34	358	89.5
35^+	34	8.5
Maternal education		
None	207	51.8
Low (Primary & JHS)	157	39.3
High (At least SHS)	36	9.0
Marital status		
Single	8	2.0
Married	342	85.5
Widowed	5	1.3
Co-habiting	33	8.3
Separated	12	3.0
Religion		
Christianity	176	44.0
Islam	216	54.0
African Traditional Religion (ATR)	8	2.0
Trimester of first ANC visit		
First	273	68.3
Second	119	29.7
Third	8	2.0
Frequency of ANC visits		
Less than 4	277	69.2
At least 4	123	30.8
Classification of wealth index		
Low	223	55.8
High	177	44.2
Ethnicity		
Dagomba	119	29.8
Kassena	71	17.8
Dagaba	110	27.5
Kukomba	2	0.5
Frafra	14	3.5
Wala	55	13.8
Fulani	2	0.5
Dorimor	27	6.8
Occupation		
Trader	98	24.5
Farmer	123	30.8
Civil servant	2	.5
Service worker	67	16.8
Education/teacher	5	1.3
Health worker	3	.8
Nothing	102	25.5

Table 2. Food groups consumed in the past 24 hours by pregnant women

Serial no.	Food groups (variable)	Frequency (400)	Percentage (%)
1	Starchy staple foods (cereals, roots & tubers)	367	91.8
2	Beans and peas	105	26.3
3	Nuts and seeds (e.g. *nieri*, groundnuts)	234	58.5
4	Dairy products	69	17.3
5	Flesh food (beef. lamb, fish, poultry etc)	299	74.8
6	Egg	42	10.5
7	Vitamin A -rich dark green leafy vegetables	288	72.0
8	Other vitamin A-rich vegetables and fruits	186	46.5
9	Other vegetables	69	17.3
10	Other Fruits	31	7.8

Table 3. Proportion of pregnant women meeting recommended dietary allowance (RDA), NAR of energy/nutrient intakes and MAR

Dietary intake	mean ± SD	RDA[1]	n (%) of women meeting RDA	NAR (%)
Energy, kcal/d	2,770.8 ± 1,127.5	2,400	235 (58.8)	100.0
Total carbohydrate, g/d	416.8±178.6	175g/d	377 (238.2)	100.0
Total fat, g/d	105.2472±58.0	94	201 (50.3)	100.0
Total protein, g/d	59.2 ±27.5	74	108 (27.0)	80.0
Fibre (g/day)	42.84±18.10	28	316 (153)	100.0
Iron (mg)	17.0± 8.6	30	33 (8.3)	56.7
Calcium (mg)	391.23 ± 195.4	1000.0	3 (0.8)	39.1
Zinc (mg)	11.21±5.14	11.0	182 (45.5)	100.0
Vitamin A (IU)	14,565.13±14211.93	2,565	338 (84.5)	100.0
Thiamine (mg)	1.79±0.97	1.4	249 (62.3)	100.0
Riboflavin (mg)	0.99 ± 0.76	1.4	78 (19.5)	70.7
Folic acid (µg)	26.55 ± 142.19	400	9 (2.3)	6.6
Vitamin C (mg)	171.87±95.97	80	342 (85.5)	100.0
Vitamin B12 (µg)	0.52 ± 2.80	**2.6**	9 (2.3)	20.0
Folate(µg)	565.39 ±447.2	600.0	106 (26.5)	94.2
Niacin (mg)	20.63 ±14.1	18.0	191 (47.8)	100.0
Vitamin B6 (mg)	2.57 ±1.2	1.9	287 (71.8)	100.0
	Mean Adequacy Ratio (MAR) of Nutrients			
Mean Adequacy Ratio (MAR)	0.68±0.0.14			
MAR < 0.55				15.9%
MAR 0.55-0.59				9.4%
MAR 0.60 - 0.69				21.0%
MAR ≥0.70				53.6%

RDA[1:] Recommended Daily Allowance (FAO/WHO, 2001).

Table 4. Distribution of macro- and micro-nutrients intakes of pregnant women according to Nutrient Adequacy Ratio (NAR)

	Adequacy of Intake n (%)		
Nutrient	**Inadequate**	**Fairly adequate**	**Adequate**
Energy, kcal/d	50 (12.5)	114 (28.5)	236 (59.0)
Total carbohydrate, g/d	3 (0.8)	20 (5.0)	377 (94.3)
Total fat, g/d	93 (23.3)	105 (26.3)	202 (50.5)
Total protein, g/d	161 (40.3)	130 (32.5)	109 (27.3)
Fibre (g/day)	20 (5.0)	64 (16.0)	316 (79.0)
Iron (mg)	269 (67.3)	98 (24.5)	33 (8.3)
Calcium (mg)	366 (91.5)	31 (7.8)	3 (0.8)
Zinc (mg)	78 (19.5)	139 (34.8)	183 (45.8)
Vitamin A (IU)	38 (9.5)	24 (6.0)	338 (84.5)
Thiamine (mg)	53 (13.3)	98 (24.5)	249 (62.3)
Riboflavin (mg)	230 (57.5)	91 (22.8)	79 (19.8)
Folic acid (µg)	387 (96.8)	4 (1.0)	9 (2.3)
Vitamin C (mg)	24 (6.0)	32 (8.0)	344 (86.0)
Vitamin B12 (µg)	377 (94.3)	14 (3.5)	9 (2.3)
Folate (µg)	177 (44.3)	115 (28.8)	108 (27.0)
Niacin (mg)	0 (0.0)	0 (0.0)	400 (100.0)
Vitamin B6 (mg)	20 (5.0)	96 (24.0)	284 (71.0)

i. Inadequate intake: NAR<0.66 (intake being less than 66% of the RDA)
ii. Fairly adequate intake: NAR=0.66 to <1.00 (intake of 66% to <100% of RDA)
iii. Adequate intake: NAR>1.00 (intake being >100% of the RDA).

Table 5. Correlation between NARs and MARs and the dietary diversity indices

NAR	Pearson correlation coefficient	Significance (p value)
Energy, kcal/d	0.119	P = 0.02
Total carbohydrate, g/d	0.112	P= 0.03
Total fat, g/d	0.076	P = 0.13
Total protein, g/d	0.183	P < 0.001
Fibre (g/day)	0.120	P= 0.02
Iron (mg)	0.154	P= 0.002
Calcium (mg)	0.136	P= 0.006
Zinc (mg)	0.155	P= 0.002
Vitamin A (IU)	0.007	P= 0.89
Thiamine (mg)	0.141	P= 0.005
Riboflavin (mg)	0.105	P= 0.04
Folic acid (µg)	0.090	P= 0.07
Vitamin C (mg)	0.074	P= 0.14
Vitamin B12 (µg)	0.006	P= 0.91
Folate (µg)	0.121	P= 0.02
Niacin (mg)	0.121	P= 0.02
Vitamin B6 (mg)	0.119	P= 0.017
Mean Adequacy Ratio (MAR)	0.24	P < 0.001

Table 6. The relationship between women minimum dietary diversity (MDD-W) and intake of macro and micronutrients

Nutrient intake	Indicator category	N	Mean intake	Std. Deviation	95% Confidence Interval for Mean		ANOVA Test Statistic
					Lower Bound	Upper Bound	
Total protein, (g/d)	**Minimum dietary diversity**						
	< 5 groups	227	55.6	27.9	51.90	59.20	F (1,399) = 9.6 p= 0. 002
	≥ 5 groups	173	64.1	26.3	60.14	68.02	
Niacin (mg)	**Minimum dietary diversity**						
	< 5 groups	227	18.9	13.8	17.07	20.69	F (1,399) = 8.2, p= 0.004
	≥ 5 groups	173	22.9	14.1	20.81	25.03	
Zinc (mg)	**Minimum dietary diversity**						
	< 5 groups	227	10.8	5.4	10.06	11.47	F (1,399) = 4.1, p= 0.05
	≥ 5 groups	173	11.8	4.8	11.09	12.52	
Poly-unsaturated fatty acids (PUFA)	**Minimum dietary diversity**						
	< 5 groups	227	18.5	11.4	17.06	20.04	F (1,399) =7.0, p= 0.008
	≥ 5 groups	173	21.6	11.1	19.89	23.23	
Iron (mg)	**Minimum dietary diversity**						
	< 5 groups	227	16.2	8.9	15.01	17.34	F (1,399) = 4.4, p= 0. 04
	≥ 5 groups	173	18.0	8.2	16.75	19.22	

Table 7. Distribution of nutrient adequacy ratio of study subjects according to district of residence

NAR	District	N	mean ± SD	ANOVA Test Statistic
Total fat, g/d	Tolon	76	0.74±**0.27**	
	Saveligu	50	0.80± **0.26**	
	kassena-Nankana	67	0.85±**0.22**	
	Bongo	17	0.93±**0.12**	
	Wa west	107	0.80±**0.28**	
	Nadowli	83	0.92±**0.17**	F (5,399) = 5.49, p < 0. 001
Iron (mg)				
	Tolon	76	0.54±**0.21**	
	Saveligu	50	0.58±**0.21**	
	kassena-Nankana	67	0.53±**0.23**	F (5,399) = 4.44, p = 0. 001
	Bongo	17	0.35±**0.09**	
	Wa west	107	0.52±**0.26**	
	Nadowli	83	0.62±**0.27**	
Calcium (mg)	Tolon	76	0.36±**0.15**	F (5,399) = 8.13, p < 0. 001
	Saveligu	50	0.43±**0.18**	
	kassena-Nankana	67	0.32±**0.15**	
	Bongo	17	0.27±**0.08**	
	Wa west	107	0.39±**0.18**	
	Nadowli	83	0.47±**0.21**	
Thiamine (mg)	Tolon	76	0.93±**0.15**	F (5,399) = 5.46, p < 0. 001
	Saveligu	50	0.94±**0.13**	
	kassena-Nankana	67	0.87±**0.19**	
	Bongo	17	0.70±**0.18**	
	Wa west	107	0.87±**0.22**	
	Nadowli	83	0.91±**0.19**	
	Tolon	76	0.57±**0.24**	F (5,399) = 10.65, p < 0. 001
	Saveligu	50	0.60±**0.24**	
	kassena-Nankana	67	0.52±**0.23**	
	Bongo	17	0.36±**0.10**	
Riboflavin	Wa west	107	0.66±**0.27**	
(mg)	Nadowli	83	0.74±**0.28**	
	Tolon	76	0.93±**0.18**	F (5,399) = 3.13, p = 0. 009
	Saveligu	50	0.96±**0.16**	
	kassena-Nankana	67	0.87±**0.23**	
	Bongo	17	0.91±**0.20**	
	Wa west	107	0.92±**0.22**	
Vitamin A (IU)	Nadowli	83	0.98±**0.08**	
	Tolon	76	0.66±**0.26**	F (5,399) = 3.97, p = 0. 002
	Saveligu	50	0.70±**0.25**	
	kassena-Nankana	67	0.66±**0.26**	
	Bongo	17	0.57±**0.19**	
	Wa west	107	0.69±**0.27**	
Folate_(µg)	Nadowli	83	0.80±**0.25**	
	Tolon	76	1.00±**0.0**	No difference
Niacin_(mg)	Saveligu	50	1.00± **0.0**	

	kassena-Nankana	67	1.00±0.0	
	Bongo	17	1.00±0.0	
	Wa west	107	1.00±0.0	
	Nadowli	83	1.00±0.0	

Determinants of mean adequacy ratio (Multivariate linear regression)

A number of potential factors which explained the variation in mean adequacy ratio (MAR) were investigated. These included types of food groups consumed in the past 24 hours, age of mother, marital status, educational level, household wealth index, stage of gestation (trimester), frequency of antenatal care during pregnancy, number of malaria infection during pregnancy, household food insecurity access scale score and household size.

Multiple regression analysis showed that, after adjusting for potential confounders, the significant independent determinants of MAR were the consumption of dairy products, vitamin A rich foods such as leafy green vegetables, and fruits (Table 8). Consumption of vitamin A rich foods was associated with 0.22 standard units increase in MAR (beta = 0.22, $p < 0.001$). Similarly, consumption of animal source foods associated positively with MAR (β =0. 14, p= 0.004). Pregnant women who consumed beans had a significant higher MAR of 0.17 standard units (β =0. 17, p= 0.001).

This set of variables accounted for 8.5% of the variability in MAR (Adjusted R Square = 0.085). This suggests that MAR is largely explained by other variables that were not measured in this study.

Table 8. Determinants of mean adequacy ratio

Model	Standardised Coefficients	t	Sig.	95.0% Confidence Interval for β		Collinearity Statistics	
	Beta			Lower Bound	Upper Bound	Tolerance	VIF
(Constant)		39.57	<0.001	0.604	0.67		
Consumption of beans	0.17	3.51	0.001	0.022	0.08	0.968	1.033
Consumption of dairy	0.10	1.99	0.04	0.02	0.07	0.980	1.020
Consumption of flesh foods	0.14	2.92	0.004	0.014	0.07	0.959	1.042
Consumption of vitamin A rich foods	0.20	3.99	<0.001	0.028	0.08	0.962	1.039

Discussion

Macro and micronutrient deficiencies are public health concerns in most developing countries and women living in low-income countries often find it difficult to meet the micronutrient demands of pregnancy due to persistent poor diet (Torheim et al. 2010a). This study assessed dietary intake of pregnant women in northern Ghana, dietary diversity and its association with micronutrient adequacy. Factors associated with mean adequacy ratio were also identified.

Adequacy of macro and micronutrients intakes of pregnant women

Micronutrients are not only essential for children to ensure proper growth and development, but also in adults for continued work productivity, healthy pregnancies, and overall cognitive and physical health (Müller and Krawinkel 2005). In our sample, the nutrient adequacy ratio (NAR) of iron, calcium, riboflavin, folic acid, folate and vitamin B12 did not reach 100%. However, intake of energy, carbohydrates, total fat, fibre, zinc, vitamin A, thiamine, vitamin C, niacin and vitamin B6 exceeded the RDA/RNI.

In the present study, the mean adequacy ratio MAR was 0.68. The ideal value for MAR should be 1, indicating the intake of all nutrients at recommended levels. However, none of the pregnant women in the study sample could achieve that.

The diet of the pregnant women in many developing countries is predominantly cereal-based and characterized by inadequate micronutrient intakes (Ekesa et al. 2011; Kennedy et al. 2007; Lee et al. 2013). The findings of this study add evidence to this, since almost all participants (91.8%) of this study reported having consumed food items from starchy staple foods (cereals, roots & tubers). The study results showed that the consumption of food groups rich in micronutrient (pulses, vegetables, fruits, nuts and oil seeds, flesh foods) was inadequate. This is consistent with the findings of Pathak et al. (2004) who reported that the consumption of food groups rich in micronutrient was low in northern India. Animal-source foods such as meat provide many of the macro and micronutrients humans need to function and yet they were not consumed much in our sample.

The average energy intake in our sample was within the recommended range. However, only 28.50% met the RDA for protein. Some other studies have reported that the average energy and protein intake of pregnant women was lower than recommended dietary allowances (Kharade and A 2002; Miridula et al. 2003).

Pregnancy is a critical and vulnerable stage of life which is characterized by rapid growth and development and enormous maternal physiologic changes from the time of conception to birth, adequate dietary protein is crucial to ensure a healthy outcome (WHO 2007)**.** Maternal malnutrition has been shown to be a major predisposing factor for maternal morbidity and mortality (Lartey 2008). Ironically, most pregnant women do not meet recommended dietary allowances (RDA's) for essential nutrients including protein as was the case in this study. The lower intake of protein for example, might be due to the fact that they consume less protein rich animal foods, probably due largely to their high cost.

The most limiting nutrients (that is, less than 66% of the RDA) in the diet of over 50% pregnant women were iron, calcium, riboflavin, folic acid and vitamin B12. with iron, calcium, folic acid and vitamin B12 particularly low. This finding is consistent with previously published data, which reported folate and iron, calcium and zinc intakes to be frequently below the estimated average requirements (Black et al. 2008; Lee et al. 2012; Merialdi et al. 2005; Ortiz-Andrellucchi et al. 2009).

Calcium supplementation is reported to reduce the risk of pre-eclampsia, mainly in women with low calcium intakes (Hofmeyr et al. 2007). The low dietary intake of calcium further underscores the critical need to promote the consumption of calcium-rich foods such as dairy products for pregnant women.

The intake of energy, carbohydrates, total fat, fibre, zinc, vitamin A, thiamine, vitamin C, niacin and vitamin B6 exceeded the RDA/RNI in this study population. As reported in other studies, the results of the present study reflect a situation where consumption of vitamin A, vitamin C and riboflavin is relatively high (Torheim et al. 2010b).

The relationship between mean adequacy ratio (MAR) and dietary diversity scores

This study assessed the association between nutrient adequacy (as measured by NAR and MAR) with DDS or consumption of individual food groups. The DDS correlated significantly and positively with NAR of most nutrients except total fat, vitamins A and C, folic acid and vitamin B12. MAR correlated more with dietary diversity than the individual NAR. This illustrates the potential of simple scores of dietary diversity for use as indicators of nutrient adequacy of the diet.

Correlation coefficients (r) between DDS, NAR, and MAR of the 14 micronutrients were significant. This collaborate findings in earlier studies that diversity in the diet is positively associated with nutrient adequacy among women of reproductive age (Acham et al. 2012; Arimond et al. 2010; Drewnowski et al. 1997; Foote et al. 2004; Hjertholm et al. 2019; Lee et al. 2013; Mirmiran et al. 2006; Nguyen et al. 2018; Ogle et al. 2001; Ruel 2003; Sultana et al. 2019; Torheim et al. 2003; Torheim et al. 2004). Therefore, diversity in the diet is important to meet the requirements for energy and other essential micronutrients.

Determinants of mean adequacy ratio

MAR was largely determined by some individual food groups. The consumption of vitamin A rich fruits and vegetables, green leaves, flesh foods and dairy products significantly contributed to explaining the variation in MAR. These food groups were the important sources of the nutrients (that is, vitamin A, vitamin C and calcium) most limiting in the diet of the pregnant women.

Possible interventions to address micronutrient deficiencies in pregnancy

A key determinant of MAR was diversified diets. This means that a wide variety of nutrient deficiencies among pregnant women requires the provision of multiple micronutrients through holistic integrated interventions, in particular efforts to sustainably improve dietary intakes. Currently in Ghana, there are on-going isolated programmes that seek to address particular nutrient deficiencies, but multiple approaches are needed to concurrently tackle the multiple nutrient deficiencies. Iron and folic acids supplements are routinely given to pregnant women but multiple micronutrient supplements may be more useful in reducing risks of being born low birth weight, small for gestational age or stillborn in deprived settings like Northern Ghana.

A number of fortification programs to combat micronutrient deficiencies in Ghana have started but have to be strengthened to have the desired impact. Attempts have been made to fortify wheat flour with iron, zinc, B-vitamins and vitamin A in vegetable oil.

However, the Ghana Micronutrient survey (GMS) found that less than 6% of wheat flour samples were adequately fortified (≥ 58.5 mg/kg for iron) (University of Ghana et al. 2017). This prevalence is lower than the 13% estimate reported by Ghana's Food and Drug Board in 2011(Nyumuah et al. 2012).

Food-based interventions (including food production diversity, dietary diversification and biofortification) have a great potential to ensure food and nutrition security, combat micro-nutrient deficiencies, improve diets and raise levels of nutrition (Thomson and Amororso 2014) especially among vulnerable groups including pregnant women. In addition, social behaviour change communication programs that promote and support increased production and consumption of nutrient-dense foods (i.e. green leafy vegetables) are needed to bring about positive food and nutrition behavioural changes.

Limitations of the Study

Only one round of 24-hour dietary recall was used to calculate dietary intake of the pregnant women. This was due to time constraints. The method is retrospective and therefore depends on memory and the ability of respondents to recall accurately. Recall bias could not be ruled out completely. The 24-hour dietary recall may not truly represent the usual intake. However, a single 24-hour recall provides a widely used estimate of mean intake of foods and nutrients (Gibson and Ferguson 2008). The cross-sectional study design also makes it difficult to demonstrate cause-and-effect relationships.

Conclusions

Dietary intake of iron, calcium, riboflavin, folic acid and vitamin B12 were the most limiting nutrients in the diet of over 50% of pregnant women in northern Ghana. A strong relationship existed between dietary diversity and mean nutrient adequacy.

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