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ROLE OF DIETARY DIVERSITY IN ENSURING ADEQUATE HAEMATOLOGICAL STATUS DURING PREGNANCY

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ABSTRACT

Introduction: Though nutrition is a key input to blood formation, little is known about the extent maternal dietary quality contributes to the haematological status of pregnant women in Northern Region of Ghana. **Objective:** The aim of this study was to assess the independent contribution of dietary diversity to haematological status of pregnant women whilst controlling for potential confounding factors including malarial infection. **Methods:** A cross-sectional study design was used on a sample of 307 pregnant women in their third trimester. A structured questionnaire was used to collect socio-demographic characteristics, obstetric and dietary data related to anaemia. Overall dietary quality was assessed using the dietary diversity score. Haemoglobin concentration (Hb) was measured using portable HemoCueR Hb 301 system. Predictors of anaemia were estimated using multiple linear regression analysis. **Results:** The mean Hb was 10.8±1.4 g/dl and prevalence of anaemia (Hb < 11.0 g/dl) was 46.3 %. High dietary diversity score [Beta coefficient (β), = 0.141 p < 0.001], multi-gravidity (β=0.205) and high composite score for ANC content (β= 0.201) were associated with a decreased risk of anaemia in the third trimester of pregnancy. **Conclusion:** The findings suggest the need to strengthen interventions that focus on improving the consumption of diversified foods particularly during pregnancy.

INTRODUCTION

In most developing countries maternal under nutrition including micronutrient deficiencies is a leading cause of maternal and child mortality and morbidity[1]. Anaemia in particular is one of the most prevalent public health problems in Ghana. Anaemia is defined as a condition in which the number and size of red blood cells or haemoglobin concentration falls below an established cut -off, consequently impairing the capacity of the blood to transport oxygen around the body [2]. According to recent estimates, anaemia affects 60.0% pregnant women in developing countries including Ghana and about 7.0 % of cases are severe [3,4].

The aetiological factors responsible for anaemia in pregnancy are multiple and their relative contributions are said to vary by geographical area and by season [5]. Admittedly, several predisposing factors contribute to anaemia among pregnant women and these include socio-demographic, socio-economic status, multiparity, short inter-pregnancy intervals and nutritional factors [6]. The relative importance of each of these varies from place to place. In the Northern Region of Ghana, where anaemia is of public health significance, very little is documented regarding the role maternal dietary factors contribute to haematological status. The role of diet on blood biomarkers may be significant, but evidence of the magnitude of this benefit is limited.

An understanding of association between dietary diversity and haematological status may be complicated by other factors including malarial infection and household socio-economic status. This study sought to determine the independent contribution of dietary diversity to haematological status of pregnant women whilst controlling for potential confounding factors. We hypothesized that diversified diets during pregnancy would be associated with better haematological status compared to nutrient-poor diets.

MATERIAL AND METHODS

Study design: This study was analytical cross-sectional design from January- March 2013.

Sample size: 307 was calculated using single population proportion formula assuming the prevalence of all types of anaemia among pregnant women in Northern Region was estimated as 73.0 % [7], confidence interval 95%, margin of error 5.0 %. Systematic random sampling procedure was used to select the study participants. The attendance list of the women who sought ante-natal care services served as the sampling frame.

Ethical approval: The protocol for this study was approved by the School of Medicine and Health Sciences, University for Development Studies. Informed consent was obtained from all study participants. Information about objective of the study, procedures, potential risks, and benefits was given to mothers before they were enrolled to the study. Their full right to refuse participation was explained. Written informed consent was obtained from each mother/caregiver.

Inclusion criteria: The study population comprised pregnant women who sought antenatal care at four major hospitals in Tamale Metropolis of the Northern region of Ghana.

Data Collection; The study participants were recruited in their third trimester (34-36 weeks gestation). Study participants were then interviewed face-to-face by the investigators. A pre-tested questionnaire was used to collect information including haemoglobin concentration, blood pressure, weight, maternal age, parity, gestational age, level of education and occupation of the women, history of malarial infection in the index pregnancy (self-reported fever or laboratory-tested), presence of any chronic illnesses, and prophylactic medications received during pregnancy. Standard procedures were followed for the recording of blood pressure and weight.

Independent and dependent variables

The main outcome variable for this study was the prevalence of anaemia (Hb less than 11 g/dl). The independent variables for this study were maternal, child and household characteristics including antenatal care (ANC) attendance, malarial infection, maternal dietary intake.

A brief description of main independent and dependent variables is as follows:

Diagnosis of anaemia : Haemoglobin concentration levels were measured in late pregnancy (gestational age ≥34 weeks) using a portable haemoglobinometer made by HemoCue® Hb301. Capillary blood was collected from participants using a finger prick method under sterile conditions. The first drop of blood was wiped away using alcohol sterile wipes, and the next drop was placed into the Hemocue curvette for immediate testing of haemoglobin. Women were classified as anaemic if they had a haemoglobin concentration less than 11 g/dL. Anaemia was further classified as mild (9.0-10.9 g/dL), moderate (7.0-8.9 g/dL) or severe (<7.0 g/dL). Anaemia is said to be a severe public health problem when its prevalence is 40% or more in any group (all types of anaemia) or when severe anaemia (haemoglobin < 7 g/dL) exceeds 2% [8].

Assessment of Maternal Height, Weight and Gestational Weight Gain: Standard procedures were followed to take anthropometric measurements of the women [9].Maternal height was measured on the participant's first visit to the antenatal clinic. Height was measured to the nearest 0.1 cm. The Seca 767 digital adult scale was used to weigh participants to the nearest 0.05 kg. Gestational weight gain was determined by the difference in maternal weight in early pregnancy (5-10 weeks) gestation and late pregnancy (34-36 weeks).

Assessment of maternal dietary intake: The nutrient adequacy of diet during pregnancy was assessed based on dietary diversity. Maternal individual dietary diversity score (IDDS) was derived on the basis of the number of food groups consumed from a seven-day food frequency questionnaire and included 11 food groups. The food group frequency of consumption (past 7 days) was measured for each food group by assigning a score of 0 if not consumed during the previous week, 1 if consumed on 1–3 days, and 2 if consumed for at least 4 days. This composite index of dietary diversity which took into account the weekly food frequency varied from a minimum of 0 to a maximum of 22. Eleven food groups flesh meats (i.e. beef, pork, lamb, goat, poultry), fish, eggs, milk and milk products, organ meat (e.g. liver, kidney), legumes, cereals, roots & tubers, dark green leafy vegetables, vitamin A rich fruits and fats & oils were selected based on the dietary pattern of the study population.

The FAO validated 11-item food groups frequency questionnaire (FFQ) was used to quantify maternal dietary intake based on 7-day dietary diversity score[10].

Determination of Household Economic Status: 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, and ownership of modern household durable goods and livestock (e.g. bicycle, television, radio, motorcycle, sewing machine, telephone, cars, refrigerator, mattress, bed, computer and mobile phone) [11-14].

These facilities or durable goods are often regarded as modern goods that have been shown to reflect household wealth. A household of zero index score for example means that household had not a single modern good. The scores were thus added up to give the proxy household wealth index.

The main aim of creating the index was to categorize households into SES groupings in order that we could compare the difference in the prevalence of anaemia between the groups of lowest and highest SES.

Content of ANC Services: Women were asked whether specific services including taking of weight and height, measurement of blood pressure, and taking blood or urine samples were carried out for them. A composite index comprising ten of these essential services received during ANC was created by assigning a score of 1 for having received a particular service and zero for not receiving the service. The total score for each woman was then categorized as low (< 7) or high (≥7).

Data Processing and Analysis: Data were analyzed using SPSS version 20 statistical software. Both Bivarate and multivarate analyses were carried out to identify risk factors of anaemia. Association between anaemia and some risk factors in pregnancy was tested using chi-square and multivariable analysis of risk factors. Variables with p value less than 0.1 in bivariate analysis were entered in to multivariable logistic regression model. P value less than 0.05 were taken as statistically significant and adjusted odds ratio with 95% confidence interval (CI) was used to measure association. Multicollinearity was investigated by using the variance inflation factor (VIF). A VIF (the reciprocal of the tolerance statistics) of greater than 5 is generally considered evidence of multicollinearity.

RESULTS

Socio-demographic characteristics of the sample

A total of 307 pregnant women were approached and all of them consented and accepted to participate in the study, thus giving a response rate of 100%. The mean age of mothers was 27.2±4.0 years which ranged from 18 to 38 years. Majority (75.2%) of the respondents were Muslims. Majority, 245 (79.8%), of the respondents were married and (47.9 %) of the mothers had no formal education at all. Petty trading was common among the mothers and most of the participants (67.1%) were multigravida (Table 1).

Table 1: Sample Characteristics (N =307)

	Frequency (n)	Percentage (%)
Religion		
Islam	231	75.2
Christianity	76	24.8
Classification of occupation		
None	97	31.6
Petty trader	108	35.2
Farmer	72	23.5
Civil Servant	30	9.8
Tribe		
Dagomba	180	58.6
Gonja	36	11.7
Mamprusi	34	11.1
Nanumba	28	9.1
Akan	12	3.9
Others	17	5.5
Education level of mother		
None	147	47.9
Primary	41	13.4
JSS/Middle	50	16.3
Secondary	47	15.3
Tertiary	22	7.2
Marital status		
Single	62	20.2
Married	245	79.8
Gravidity		
Primigravida	32	10.4
Secundigravida	69	22.5
Multigravida	206	67.1

Magnitude of Anaemia: The mean hemoglobin level was about 10.8±1.4 g/dL which ranged from 7.3 g/dL to 14.3 g/dL. The prevalence of anaemia was 46.3%. In terms of severity, mild anaemia was 34.9 %, moderate anaemia was 11.4 % but there were no cases of severe anaemia**.**

Factors Associated with Anemia: Bivariate analyses were performed to assess association of socio-demographic and other maternal factors with child anemia (Table 2). There was an inverse relationship between the prevalence of anaemia and the level of education of the women. This means the proportion of anaemic women decreased with increased in the level of education. Anaemia was significantly more common in women of lower household wealth index. As maternal 7-day dietary diversity increased, the prevalence of anaemia decreased. As the number of sulfadoxine-pyrimethamine (SP) doses increased the prevalence of malaria decreased.

Dietary Diversity and Food Group Frequency Consumption

In late pregnancy, the minimum dietary diversity (that is, proportion of women who receive foods from 5 or more food groups in seven days was 85.5 %. The mean dietary diversity score (DDS) from 11 food groups was 9.1±1.4. The mean food group frequency of consumption (past 7 days) was 15.0±2.8. The minimum and maximum of the food group frequency of consumption index scores were 6.0 and 22 respectively. More than half of the pregnant women (52.8%) were on low diversified diet as measured by DDS over a period of one week. A significant proportion of the pregnant women rarely consumed dairy products and eggs though over 80 % of consumed cereals and roots & tubers on a daily basis (Table 3).

Table 2a: Bivariate Analysis of predictors of anaemia among pregnant women

Characteristic	N	Anaemia		
		No n (%)	Yes n (%)	Test statistic
Maternal Education				
None	147	78 (53.1)	69(46.9)	χ^2=15.2 p= .001
Low	91	36 (39.6)	55(60.4)	
High	63	45 (71.4)	18(28.6)	
Religion of mother				
Islam	227	110(48.5)	117(51.5)	χ^2= 7.1 p=.008
Christianity	74	49 (66.2)	25(33.8)	
Marital status				
Single	60	23 (38.3)	37(61.7)	
Married	241	136(56.4)	105(43.6)	χ^2= 6.3 p=.012
Malarial infection				
None	45	30 (66.7)	15 (33.3)	χ^2=14.5 p=0.001
1-2 times	223	121(54.3)	102(45.7)	
3-4 times	33	8 (24.2)	25 (75.8)	
Maternal 7-day dietary diversity				
Low	162	71 (43.8)	91 (56.2)	χ^2=11.4 p=.001
High	139	88 (63.3)	51 (36.7)	

Table 2b: Bivariate Analysis of predictors of anaemia among pregnant women

Characteristic	N	Anaemia		
		No n (%)	Yes n (%)	Test statistic
Household wealth index				
Low	160	71 (44.4)	89 (55.6)	χ^2= 9.7 p = 0.002
High	141	88 (62.4)	53 (37.6)	
ANC visit				
<4	146	58 (39.7)	88 (60.3)	χ^2= 19.5 p< 0.001
≥4	155	101(65.2)	54 (34.8)	
Timing of first ANC				
Late (After first trimester)	173	69 (39.9)	104 60.1)	χ^2= 27.3 p< 0.001
Early (First trimester)	128	90 (70.3)	38 (29.7)	
Parity				
0-1	77	35 (45.5)	42 (54.5)	χ^2 = 8.9 p= 0.011
2-3	194	114(58.8)	80 (41.2)	
At least 4	30	10 (33.3)	20 (66.7)	
Doses of antimalarial prophylaxis (IPTp) with (SP)				
None	18	7 (38.9)	11 (61.1)	χ^2 = 10.9 p=
1 dose	95	39 (41.1)	56 (58.9)	
2 doses	77	48 (62.3)	29 (37.7)	

3 doses	111	65 (58.6)	46(41.4)	0.012

Table 3: Food groups consumption frequency in the past week (n= 307)

	Frequency of foods consumption in the past week (% of women)			
Type of food	Usually every day	4 to 6 times per week	1- 3 times per week	Never/rarely
Meat	58.0	34.2	7.2	0.7
Poultry	2.3	19.2	50.8	27.7
Liver	14.3	43.0	53.8	6.8
Fish	18.6	30.6	41.7	9.1
Cereals	97.1	2.3	0.7	0.0
Roots & tubers	84.7	11.7	1.3	2.3
Legumes	58.0	34.9	7.1	0.0
Dairy products	2.0	22.8	45.0	30.2
Eggs	4.2	16.3	39.4	40.1
Fruits	22.5	30.6	36.2	10.7
Green leafy vegetables	37.5	44.6	14.3	3.6

Table 4: Determinants of Hb in the third trimester of pregnancy

Model	Standardized Coefficients	Sig.	95.0% Confidence Interval for (β)		Collinearity Statistics	
	Beta (β)		Lower Bound	Upper Bound	Tolerance	VIF
(Constant)		<0.001	6.52	8.54		
Marital status of respondent	0.148	0.003	0.18	0.86	0.909	1.100
ANC initiated in the first trimester	0.214	0.001	0.26	0.95	0.580	1.725
Multi-gravidity	0.205	0.003	0.15	0.71	0.476	2.103
High Parity (≥4)	-0.193	0.007	-0.80	-0.13	0.446	2.240
High composite score for ANC content	0.201	0.001	0.23	0.91	0.592	1.688
Maternal 7-day dietary diversity (FGFS > 7)	0.239	<0.001	0.39	0.95	0.866	1.155

Relationship between Maternal Dietary Diversity and Pregnancy Anaemia: In analysis of covariance (ANCOVA) model, there was a significant difference in adjusted mean Hb concentrations between women of low and high diversified diets. The adjusted mean Hb in the high diversified Group was 0.67 g/dl higher than in the group that was on low diversified diets (95 % CI: 0.39 to 0.95, p < 0.001). Mean Hb in the third trimester was adjusted for Hb in the first trimester, timing of first ANC visit, parity, gravidity, and composite ANC content received.

Determinants of third trimester hemoglobin concentrations: Multiple regression analysis showed significant positive associations between 7-day maternal dietary diversity as measured by food groups consumption frequency (FGFS) and a number of factors including parity of the mother (Table 4). The set of independent variables accounted for 32.0 % of the variance in the mean Hb concentrations of pregnant women in the third trimester (Adjusted $R^2 = 0.32$).

Considering the beta coefficients (β), women who initiated ANC in the first trimester had mean Hb concentration which was 0.214 standardized units significantly higher than women who initiated ANC from the second trimester. Mean Hb of multigravidae women was significantly higher by 0.205 units. Women of higher dietary diversity (Food Group Frequency Score) had higher Hb (Beta coefficient = 0.141 p < 0.001). On the average, women of lower parity (at least 4) had mean Hb which was 0.193 standardized units lower, compared to women of lower parity (0-1). Women who scored higher composite index of ANC content had mean Hb which was 0.201 standard units higher than those of lower score. Maternal 7-day dietary diversity was the strongest determinant of mean Hb (Table 4).

DISCUSSION

This study sought to assess the independent contribution of dietary diversity to haematological status of pregnant women whilst controlling for potential confounding factors. In the multivariable analysis, haemoglobin status of women was positively associated with maternal DDS, early initiation of ANC visits, and negatively associated with parity.

In bivariate analysis, some variables including household wealth index, malarial infection, antimalarial prophylaxis (IPT) and maternal educational level showed a weak association with anaemia but disappeared after adjusting for confounders in multivariate analysis.

The aetiology of anaemia in pregnancy does not seem to be the same in every geographical area and season. Whereas in Malawi, iron deficiency was an important contributor to anaemia in pregnancy 09, Mockenhaupt et al.[15] reported that iron deficiency did not appear to be a major risk factor for anaemia among pregnant women in the Agogo district of Ghana.

Prevalence of anaemia: The prevalence of anaemia among women in the third trimester of gestation was 46.3 % and this can be classified as a severe public health problem according to WHO [8]. The prevalence is lower than the 51.9–59.6 % estimated prevalence of anaemia in pregnancy in Africa [16]. The survey findings corroborate past research that showed a high prevalence of anaemia among women in Northern Ghana [7,17,18].

Most of the women in this study had anaemia of mild to moderate severity with no case being severely anaemic. These findings are similar to the findings from other studies in which 47.5 % of women aged 15-49 years had some form of anaemia [17].

Dietary diversity and haematological status: The results of this study showed that high maternal dietary diversity was associated with reduced risk of anaemia and so nutritional factors may be important. This finding is consistent with that of similar studies carried out elsewhere in India, where low dietary intake of multiple micronutrients, but higher intakes of nutrients that inhibit iron absorption such as calcium and phosphorus, may help explain high rates of maternal anaemia [19].

It has earlier been reported that some pregnant women do restrict dietary intake in order to have smaller babies, and therefore easier deliveries [20,21]. In Ethiopia, women with restrictive dietary habits were reported of 39 % higher risk of anaemia compared to those without restrictive dietary behavior[22] and where maternal dietary diversity was protective of pregnancy anaemia [23,24]. Studies conducted in Pakistan and Turkey also reported that consumption of fruit two or more times per week is associated with a decreased risk of anemia [25,26].

Diet is an important factor for anaemia, as some eating patterns or habits may predispose individuals to a higher risk for developing anaemia. For example, high fibre diets can inhibit the absorption of iron; low fat diets can equally inhibit iron absorption since fat is needed for iron absorption, high tea and coffee consumption but without vitamin C intake inhibits iron absorption. Poor dietary diversity leads to deficiency of minerals and vitamins which may increase bio-availability of iron then affects Iron status [27].

Dietary diversity is considered to be a key indicator for assessing the access, utilization, and quality of diet of individuals or household [28]. Individual dietary diversity scores have been shown to indicate adequate nutrient intake through diet and it can be used as a proxy indicator for measuring nutrient adequacy among pregnant females [29].

A pregnant woman's diet that lacks diversity is most likely to be deficient in essential nutrients and as a result the foetus will not be provided the nutrition it requires to have a healthy growth [30]. Women's dietary behaviours and intake during pregnancy are strongly influenced by different cultural practices, myths and taboos [31,32].

During pregnancy, dietary energy and nutrient requirements are generally increased to support increased maternal metabolism, blood volume and red cell mass expansion, and the delivery of nutrients to the fetus. Key nutrients including folate, iron, zinc, calcium, vitamin D, and essential fatty acids function to promote red blood cell production, enzyme activity, bone development, and brain development. Poor maternal dietary quality may thus have serious implications for anaemia during pregnancy [33].

Haematinics, particularly iron contributes to the rise in serum erythropoietin which often decreases during pregnancy. Deficiency of these essential haematinics arising from increased requirements and inadequate intake may have far reaching effects on both mother and foetus.

Parity, gravidity and haematological status: On the average, increased parity was associated with decreased Hb concentration. It is generally believed that anaemia in pregnancy increases with rising parity, due to repeated drain on iron stores [34]. However, the association between high parity and anaemia in pregnancy is not unequivocal. While some studies show high parity increases risk [35,36], others show no increased risk [19].

However, the prevalence of anaemia decreased with gravidity, ranging from 75% among primigravidae to 43.7 % among multigravidae.

ANC attendance and anaemia: The content of ANC services received and early initiation were found to be associated with lower odds of having anaemia in the third trimester. The percentage of women with anaemia was lowest among those that booked for antenatal care in the first trimester. This finding is in agreement with findings of Komolafe et al. [4] and Bukar et al. [37] in Nigeria. The positive contribution of early initiation of ANC attendance to haematological status is probably due to the benefits associated with ANC. For example, women who initiate ANC visits early are more likely to benefit from prophylactic measures against malarial infection, iron and folic acid supplementation and that of nutrition and health education. There is an increased foetal demand for haematopoietic factors as pregnancy progresses and so women who will not avail themselves to health services early enough may suffer the consequences of increased demand for nutrients. Such women are also more likely to take advantage of accessing health services to treat any underlying maternal diseases and untreated anaemia in early pregnancy that are likely to worsen in the course of pregnancy.

Limitation of the study: This study was hospital based and as such may not be truly reflective of the situation in the district due to selection bias. Pregnant women utilizing the health institutions are also more likely to be educated, of higher socioeconomic status than the typical pregnant woman in the community.

Dietary diversity was assessed based on responses obtained from participants (e.g. dietary recall) during the pregnancy and this depended on memory and their ability to recall accurately. Recall bias could not be ruled out completely. However, methods used in assessing dietary diversity are useful for ranking individuals but do not necessarily permit exact assessments of absolute nutrient intake.

The study also relied partly on secondary data about participants recorded by health professionals during the pregnancy. Therefore any error in measurements, readings or recordings of these parameters and indices will reflect in the results. However with the level of professionalism of health workers in the institutions involved in the study, this is expected to be minimal. The cross-sectional study design used to collect data also makes it difficult to demonstrate cause-and-effect relationships.

CONCLUSION

In the present study, there was statistically significant association between maternal DDS and anaemia in pregnancy. The content of ANC, as well as dietary diversity of women had positive effect on Hb in the third trimester and so women should be educated on the need for improved quality diets as well as quality and content of ANC services in the health facilities.

The study findings suggest the need to strengthen interventions that focus on improving the consumption of diversified foods particularly during pregnancy. Additionally, anaemia was higher with increased parity levels and among women who initiated ANC late. This implies the need to target interventions to these vulnerable groups of women.

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Conflict of Interest: Nil

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