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Assessing the Relationship between Individual Level Dietary Intake and the Occurrence of Preeclampsia/Eclampsia and Haemorrhage among Pregnant Women in Eastern Region of Ghana: A Prospective Cohort Study

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Abstract

Pre-eclampsia/eclampsia (PE-E) and haemorrhage are dangerous diseases that occur in pregnancy. This study seeks to assess the relationship between individual-level dietary intake and the occurrence of pre-eclampsia/eclampsia and haemorrhage among pregnant women in the Eastern Region of Ghana. The prospective cohort study involved all pregnant women in their third trimester of pregnancy (≥28 weeks gestational age) reporting for antenatal care (ANC) in seven Hospitals in the Eastern Region of Ghana. The study used a 24-hour repeated dietary recall to elicit dietary intake information from pregnant women until delivery. The majority of pregnant women in this study had adequate consumption of phosphorus far above the RDI, coupled with an inadequate intake of calcium, excess intake of sodium, and manganese. The average dietary intake for carbohydrates in this study was rather higher than the RDA. There was a statistically significant association between PE-E and the intake of vitamin C. A statistically significant association exists between the intake of calcium and vitamin A and haemorrhage. The findings show that pregnant women who consumed adequate and excess amounts of vitamin C reduced their odds of developing PE-E by 41.7% and 39.8%, respectively. The results show that pregnant women who had an excess intake of calcium were 6.128 times the odds of developing haemorrhage compared to those who had inadequate intake. Again, pregnant women who had adequate intake of vitamin A were 4.351 times the odds of developing haemorrhage compared to those who had inadequate intake. It is recommended that more nutrition specialists to be trained and posted to counsel pregnant women on nutrition in pregnancy to avert the consequences of PE-E and haemorrhage.

Keywords: *Dietary intake, Diet, Eclampsia, Ghana, Haemorrhage, Preeclampsia.*

Introduction

Pre-eclampsia (PE) is a dangerous disease that occurs in pregnancy. Globally, this contributes to about 14% of the recorded maternal mortalities [1-2]. It presents with an increase in blood pressure coupled with proteinuria and easily leads to high maternal morbidity and mortality. Pre-eclampsia can also be diagnosed without the presence of proteinuria if there is evidence of target organ damage [3-4]. About 5% to 10 % of pregnant women develop the disease, and this has increased tremendously by 25% within the last twenty years [5]. The World Health Organization (WHO) reveals those 3,000,000 annual preterm deliveries (20%

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of 15 million) occur as a result of preeclampsia (PE). It is significantly important to note that the developing world is bedeviled with a high burden of hypertension-related issues in pregnancy, leading to increased maternal morbidity and mortality [5]. Studies have also shown that PE is a significant risk factor for heart-related conditions later in life [6].

In 2006, haemorrhage was identified as the most dominant cause of maternal mortality across the globe, with 27·1% mortality. Out of that, 36·9% occurred in northern Africa [7]. In sub-Saharan Africa, haemorrhage accounted for 24.5% of maternal deaths in 2014. Study findings show [8] that high blood pressure and bleeding after delivery accounted for 29% and 15% respectively of maternal deaths in three countries in Africa (Benin, Ivory Coast, and Senegal). In Ghana, haemorrhage (postpartum, intrapartum, and ante partum) is a major contributory factor to maternal death [8], accounting for 21.8% of the maternal deaths throughout the country [9].

Reports from the Eastern Regional Health Directorate show that haemorrhage and PE are major contributory factors to maternal mortality in the Region. The region recorded an increasing trend of 85, 94, and 97 maternal deaths for 2018, 2019, and 2020 respectively. Haemorrhage contributed 33% and 23.4% to the deaths in 2018 and 2019, respectively. On the other hand, PE contributed 28% and 32.9% to maternal deaths in 2018 and 2019, respectively [10]. This merits an in-depth individual-level inquiry to the determinants of these deaths. Against this backdrop, it is necessary, therefore, to investigate the individual-level determinants of preeclampsia/eclampsia (PE-E) and hemorrhage among pregnant women in the Eastern Region of Ghana to find a remedial action to solving the persistent problem, especially in Ghana and the Eastern Region in particular.

Methods

The Eastern Region is one of the 16 administrative regions of Ghana and shares common boundaries with the Greater Accra, Central, Ashanti, Brong Ahafo, Oti, and Volta Regions of the country. The population of the region is 2.9million [11]. With a growth rate of 2.1% the population is estimated to increase to 4.5 million by 2040. Presently, 49.2% of the population are males, while females represent 50.8%. The age structure of the region indicates that the proportion of the population aged 0 - 14 (under 15 years) is 38.4%, while those aged 15 - 64 and 65+ are 55.9% and 5.7%, respectively. The region occupies a total landmass of approximately 19,323 sq. km, which makes it the sixth-largest region of the country in terms of land size. It has a population density of 136.3 people per sq. km and is 43.4% urban with an annual urban growth rate of 3.7%. The region experiences more outflows of people to other parts of the country than people migrating into it and accounts for the negative net migration value of -332,086 recorded in 2010. Regarding the economy, the labour force participation rate for the population aged 15- 64 is almost 74.2%. The study was conducted in New Juaben South Municipality at the Eastern Regional Hospital, Koforidua, Nsawam Adoagyiri Municipality (Nsawam Government Hospital), Birim Central Municipality (Oda Government Hospital), Akwapim North District (Tetteh Quarshie Memorial Hospital at Mampong), Suhum Municipality (Suhum Government Hospital), Denkyembour District (St. Dominic Hospital), and Asamankese Government Hospital at West Akim Municipality.

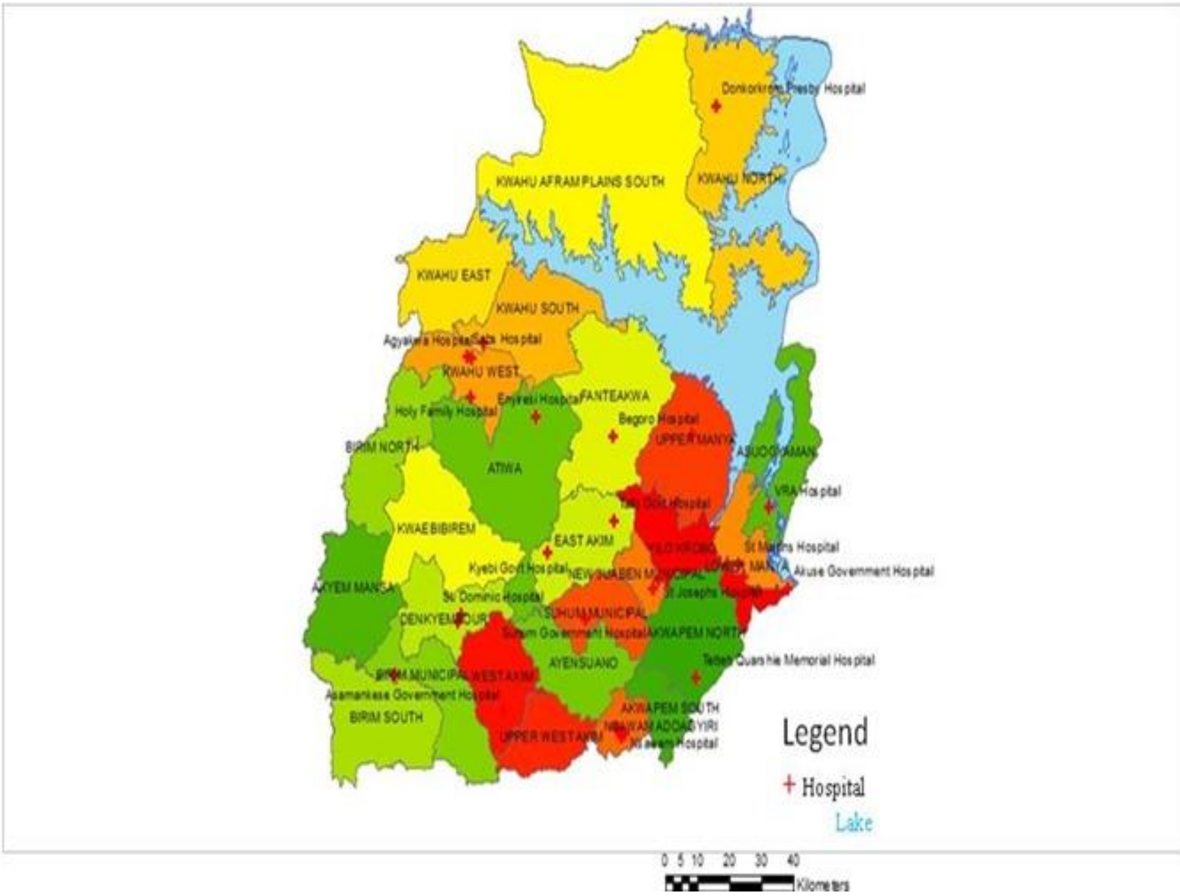

Figure 1. Map of Eastern Region showing the participating Districts and Hospitals, Ghana

Study Design

The study was a prospective cohort involving all pregnant women at ≥28 weeks gestational age reporting for antenatal care (ANC) in seven Hospitals in the Eastern Region of Ghana. The study used a 24-hour dietary recall designed template and a semi-structured questionnaire. Study participants were followed-up at every ANC visit for a maximum period of thirteen weeks until delivery, and the outcomes of interest recorded as, yes indicating that it occurred, or no, indicating the opposite. Data were collected three times at every ANC visit to the health facility before delivery. The sample size was calculated using [12] based on the prevalence of preeclampsia in the region. Using the formulae $N = Z^2 * P (1 - P) / d2$, where N = sample size, Z = score for 95% Confidence Interval which is 1.96, P= Regional prevalence of preeclampsia, 32.9%, q=1-p (proportion of people without preeclampsia), d = Margin of error set at 5%, the sample size computed was N = 339. Using a loss to follow-up rate of 30% [13], and a non-response rate of 10% [14-16]. The total minimum sample size reached was 475. These numbers were proportionately assigned to all the seven Hospitals within the Eastern Region of Ghana. However, due to the loss to follow-up, a total of 420 were left for the final analysis.

Table 1. Prospective Cohort Study Follow-up Schedules

Prospective Cohort, n= 475	**Week 28**	**Week 32**	**Week 36**	**Week 38 to 40**
Stages of data collection	Baseline Assessment	Next Assessment	Next Assessment	Next Assessment

Stages of follow-up Assessment

Sampling

A two-stage lottery method probability sampling process was used. The first stage involved a simple random selection of seven Government Hospitals out of 17 in the Eastern Region. This was done by writing the names of all the Hospitals in the Region on pieces of paper and then mixed evenly, and seven were selected randomly out of the seventeen. In the participating Hospitals, a numbered list of ANC attendants with gestational ages $\geq$28 weeks from each Hospital was obtained from the ANC registers. The numbered list was captured on pieces of papers and dropped into a container, and properly mixed manually. Then, chits were randomly picked out of the container until the sample size was reached.

Table 2. Participating Districts and their Estimated Sample Sizes

Municipality/District	Expected Pregnancy	Estimation of Sample size	Sample Size
Birim Central	3632	$\frac{3632}{33155} \times 475$	52
New Juaben South	6275	$\frac{6275}{33155} \times 475$	90
West Akim	5454	$\frac{5454}{33155} \times 475$	78
Akwapim North	4891	$\frac{4891}{33155} \times 475$	70
Nsawam Adoagyiri	4389	$\frac{4389}{33155} \times 475$	63
Suhum	4523	$\frac{4523}{33155} \times 475$	65
Denkyembour	3991	$\frac{3991}{33155} \times 475$	57
Total	**33155**		**475**

These numbers were proportionately assigned to all the seven Municipalities and District Hospitals within the Eastern Region of Ghana as tabulated above.

24 Hour Dietary Recall Assessment

This method was used to collect data on dietary intake using open-ended questionnaire or template in the form of in-depth interviews. In this study, a repeated 24-hour dietary recall assessment was conducted. It involved in-depth interviews with the respondents where they were asked to recall the different foods and beverages they consumed within the 24 hours prior to the interview, for two weekdays and one weekend. When the recall was done, respondents were required to estimate the quantities of foods consumed using simple household handy measures. Estimated dietary consumption was converted into grams using the existing food conversion database. The weights in grams of the handy measures of the various foods eaten were entered into an excel sheet designed using the West African Food Composition (WAFCT) table to calculate the different nutrients contained in the food categories eaten by the pregnant women [17]. In situations where a specific food item was missing in the Ghana Food Database (GFD) software, we referred to the West African Food Composition (WAFCT) table [18]. Nutrient estimates from the dietary intakes were compared with the RDA. The different types of nutrients estimated from the individual level dietary intakes were compared with the standard RDA for pregnant women. The dietary intakes were categorized into

"Inadequate = <70%, coded '0'", "Adequate = >or=70, coded '1', and "Excess = >100% coded '2'. The percentages of each of these categories were computed, and their odds ratios were determined using logistic regression to determine the associations with PE-E. Averages of the repeated 24-hour recalls were exported into STATA for the analysis.

Results

Table 3. Comparison of Mean Daily Energy and Nutrient Intake among Pregnant Women and Recommended Dietary Allowance (RDA)

Nutrient Intake	RDA	Minimum	Maximum	Mean Intake	Std. Deviation
Energy (kcal)*	2419	416.4	5906.9	2033.3	746.8
Protein (g)**	60	10.9	197.9	59.2	25.9
Carbohydrates(g)**	175	76.4	1073.1	324.2	111.5
Dietary Fibre (g)**	25	8.4	91.1	27.1	9.6
Calcium (mg)**	1000	57.1	1873.7	400.2	208.2
Iron (mg)***	33	2.9	40.5	14.9	6.3
Magnesium (mg)**	450	94.8	1289.0	377.1	133.0
Phosphorus (mg)**	700	235.7	3942.5	1099.5	420.1
Potassium (mg)**	2,900	705.9	6968.6	2745.1	1036.5
Sodium (mg)**	2,300	739.8	13015.2	3456.8	1330.9
Zinc (mg)**	11	1.7	26.3	8.9	3.9
Manganese (mg)**	2	1.5	12.0	4.7	1.7
Vitamin C (mg)**	85	12.5	566.6	114.0	66.5
Vitamin B-6(mg)**	1.9	.5	5.6	1.9	.9
Folate (mcg) Total**	600	70.5	1687.6	461.0	250.4
Folic acid (mcg)**	600	.0	740.5	92.5	129.0
VitaminB-12 (mcg)**	2.6	.0	16.6	3.2	3.3
Vitamin A (IU)**	770	259.5	11293.6	2777.3	1701.2
Vitamin K (mcg)**	90	1.8	227.9	47.6	35.5

Source: **modified for pregnant women from Institute of Medicine 2006 [22, 23]. Dietary Reference Intakes: The Essential Guide to Nutrient Requirements. Washington, DC: The National Academies Press. https://doi.org/10.17226/11537. ***: Institute of Medicine (IOM) [22]. *Average of three trimesters -UK EARs [27].

Table 3 above displays the mean intakes of energy and nutrients with standard deviations. The average daily nutrient requirement for sodium was far higher than the recommended daily allowance of 2,300mg for pregnant women. The nutrient intakes that were above the RDA are carbohydrates, dietary fibre, phosphorus, manganese, vitamin C, vitamin-12, and vitamin A. The dietary intakes below the RDA are calcium, iron, magnesium, potassium, zinc, folate, folic acid, and vitamin k. Some of the dietary intakes were almost at par with the RDA, showing that the dietary intake by pregnant women in this study were almost at the standard level. The mean of Vitamin B6 is exactly the same as the recommended dietary intake in this study.

Table 4. Nutrient Adequacy Levels and Delivery Outcomes

Dietary Intake	%	Delivery Outcome			
		Normal	Haemorrhage	Preeclampsia/Eclampsia	P-value
Energy					0.364
Inadequate (<70%)	0	0	0	0	
Adequate (>or=70%)	0.4	1	0	1	
Excess (>100%)	93.9	335	22	61	
Protein					0.118
Inadequate (<70%)	29.3	108	3	12	
Adequate (>or=70%)	25.5	80	7	20	
Excess (>100%)	45.2	148	12	30	
Carbohydrates					0.694
Inadequate (<70%)	1.4	5	0	1	
Adequate (>or=70%)	2.6	8	0	3	
Excess (>100%)	95.9	323	22	58	
Dietary Fibre					0.829
Inadequate (<70%)	12.1	42	1	8	
Adequate (>or=70%)	32.4	110	7	19	
Excess (>100%)	55.5	184	14	35	
Calcium					0.018
Inadequate (<70%)	93.8	312	20	62	
Adequate (>or=70%)	4.3	18	0	0	
Excess (>100%)	1.9	6	2	0	
Iron					0.341
Inadequate (<70%)	78.6	258	18	54	
Adequate (>or=70%)	17.4	62	4	7	
Excess (>100%)	4.1	16	0	1	
Magnesium					0.952
Inadequate (<70%)	38.1	131	8	21	
Adequate (>or=70%)	37.6	125	8	25	
Excess (>100%)	24.3	80	6	16	
Phosphorus					0.078
Inadequate (<70%)	3.1	10	0	3	
Adequate (>or=70%)	13.1	51	0	4	
Excess (>100%)	83.8	275	22	55	
Potassium					0.586
Inadequate (<70%)	26.2	87	5	18	
Adequate (>or=70%)	35.9	120	6	25	
Excess (>100%)	37.9	129	11	19	
Zinc					0.335
Inadequate (<70%)	42.6	149	7	23	
Adequate (>or=70%)	30.9	98	7	25	
Excess (>100%)	26.4	89	8	14	
Manganese					0.707

Inadequate (<70%)	0.0	0	0	0	
Adequate (>or=70%)	2.9	10	0	2	
Excess (>100%)	97.1	326	22	60	
Vitamin C					0.031
Inadequate (<70%)	14.5	43	2	16	
Adequate (>or=70%)	22.1	79	2	12	
Excess (>100%)	63.3	214	18	34	
Folate					0.737
Inadequate (<70%)	55.0	182	14	35	
Adequate (>or=70%)	23.1	78	3	16	
Excess (>100%)	21.9	76	5	11	
Folic Acid					0.439
Inadequate (<70%)	95.7	322	20	60	
Adequate (>or=70%)	2.9	9	2	1	
Excess (>100%)	1.4	5	0	1	
Vitamin B12					0.705
Inadequate (<70%)	49.3	169	8	30	
Adequate (>or=70%)	9.1	29	2	7	
Excess (>100%)	41.7	138	12	25	
Vitamin A					0.530
Inadequate (<70%)	2.4	7	0	3	
Adequate (>or=70%)	2.1	7	0	2	
Excess (>100%)	95.5	322	22	57	
Vitamin K					0.481
Inadequate (<70%)	75.7	255	16	47	
Adequate (>or=70%)	12.1	43	1	7	
Excess (>100%)	12.1	38	5	8	
Sodium					0.082
Inadequate (<70%)	3.8	13	0	3	
Adequate (>or=70%)	13.1	51	0	4	
Excess (>100%)	83.1	272	22	55	

Note: Inadequate = (%RDA/I < 70%), Adequate = (%RDA/I >70%), Excess = (%RDA/I > 100%)

From table 4 above, it is observed that 25.5% of the pregnant women had adequate intake of protein, 2.6% had adequate intake of carbohydrates, 32.4% had adequate intake of dietary fibre, and 4.3% had adequate intake of calcium which was also statistically significant (P =0.018). Additionally, 17.4% had adequate intake of iron, 37.6% had adequate intake of magnesium, 13.1% had adequate intake of phosphorus, and 35.9% had adequate intake of potassium. However, 26.4% had an excess intake of zinc, 97.1% had excess intake of manganese, 63.3% had excess intake of vitamin C, 21.9% had excess intake of folate, 1.4% had excess intake of folic acid, 41.7% had excess of vitamin B12, 95.5% had excess of vitamin A, 12.1% had excess of vitamin K, and 83.1% had excess intake of sodium. In all the nutrients under study, calcium (P=0.018) and vitamin C (P=0.031) are statistically significant in relation to delivery outcomes.

Table 5. Logistic Regression showing the Association between Selected Categories of Dietary intake and the Development of PE-E and Haemorrhage

Preeclampsia/Eclampsia	COR	P-value	95% Confidence Interval
Protein	**Reference = <70 (Inadequate Intake)**		
Adequate (>or=70)	2.126	0.054	.986 -4.587
Excess (>100)	1.666	0.162	.815 -3.406
Magnesium	**Reference = <70 (Inadequate Intake)**		
Adequate (>or=70)	1.244	0.495	.665 -2.329
Excess (>100)	1.141	0.717	.558 -2.332
Zinc	**Reference = <70 (Inadequate Intake)**		
Adequate (>or=70)	1.615	0.128	.870 -2.996
Excess (>100)	.899	0.775	.436 -1.859
Vitamin C	**Reference = <70 (Inadequate Intake)**		
Adequate (>or=70)	.417	0.039	.181 -.958
Excess (>100)	.398	0.008	.202 -.784
Haemorrhage			
Protein	**Reference = <70 (Inadequate Intake)**		
Adequate (>or=70)	2.404	0.162	.703 -8.221
Excess (>100)	1.653	0.405	.507 -5.392
Calcium	**Reference = <70 (Inadequate Intake)**		
Adequate (>or=70)	1.161	0.888	.147 -9.189
Excess (>100)	6.579	0.027	1.244 -34.786
Folic Acid	**Reference = <70 (Inadequate Intake)**		
Adequate (>or=70)	1.736	0.606	.214 -14.121
Excess (>100)	3.820	0.231	.426 -34.256
Vitamin A	**Reference = <70 (Inadequate Intake)**		
Adequate (>or=70)	4.351	0.008	1.477 -12.814
Excess (>100)	2.263	0.449	.273 -18.769

Note: COR= Crude odds ratio

From Table 5, it is observed that vitamin C intake (adequate and excess), calcium intake (excess), and vitamin A intake (adequate) are all statistically significant at 95% confidence interval. The results show that pregnant women who had adequate intake and excess intake of vitamin C had reduced odds of developing PE-E by 41.7% and 39.8%, respectively, compared to those who had inadequate intake. Also, pregnant women who had adequate intake and excess intake of protein had increased odds of developing PE-E by 2.1 and 1.66 times, respectively, compared to those with inadequate intake. However, these were not statistically significant. Additionally, excess intake of calcium and adequate intake of vitamin A were both statistically significant. The results show that pregnant women who had an excess intake of calcium had 6.579 times the odds of developing haemorrhage compared to those who had inadequate intake. Again, pregnant women who had adequate intake of vitamin A had 4.351 times the odds of developing haemorrhage compared to those who had inadequate intake.

Table 6. Logistic Regression showing the Adjusted Odds Ratios between Adequacy of Dietary intake and the Occurrence of PE-E

Preeclampsia/Eclampsia	aOR	P-value	95% Confi. Interval
Protein	**Reference = Inadequate Intake**		
Adequate (>or=70)	1.559	0.226	.759 -3.200
Excess (>100)	1.141	0.699	.583 -2.233
Magnesium	**Reference = Inadequate Intake**		
Adequate (>or=70)	1.366	0.323	.736 -2.536
Excess (>100)	1.081	0.832	.527 -2.216
Zinc	**Reference = Inadequate Intake**		
Adequate (>or=70)	1.109	0.742	.597 -2.064
Excess (>100)	.826	0.588	.414 -1.649
Vitamin C	**Reference = Inadequate Intake**		
Adequate (>or=70)	.771	0.554	.326 -1.826
Excess (>100)	.746	0.433	.358 -1.552
Haemorrhage			
Protein	**Reference = Inadequate Intake**		
Adequate (>or=70)	2.443	0.158	.708 -8.427
Excess (>100)	1.413	0.576	.421 -4.749
Calcium	**Reference = Inadequate Intake**		
Adequate (>or=70)	0.959	0.969	0.119 - 7.741
Excess (>100)	7.623	0.023	1.321 -43.997
Folic Acid	**Reference = Inadequate Intake**		
Adequate (>or=70)	1 (empty)		
Excess (>100)	3.840	0.236	.414 -35.597
Vitamin A	**Reference = Inadequate Intake**		
Adequate (>or=70)	3.002	0.067	.924 -9.748
Excess (>100)	2.473	0.407	.290 -21.064

Variables adjusted for: Age, and gestational age, aOR= adjusted odds ratio

Table 6 shows the adjusted odds ratios of dietary intake and the occurrence of PE-E. After adjusting for age and gestational age, the results show that pregnant women who consumed adequate amounts of protein were 1.559 times the odds of developing PE-E compared to those who had inadequate intakes, and those who had excess intake of protein were 1.141 times the odds of developing PE-E compared to those with inadequate intake. However, the association was not statistically significant. However, excess intake of calcium and its association with the occurrence of haemorrhage was statistically significant. Pregnant women who had an excess intake of calcium were 7.623 times the odds of developing haemorrhage compared to those who had inadequate intake. Moreover, pregnant women who had an excess intake of folic acid were 3.84 times the odds of developing haemorrhage compared to those who had inadequate intake. However, this was not statistically significant.

Table 7. Multinomial Logistic Regression showing Association between the Predictor Variables and the Outcomes

Delivery Outcome	Coef.	P-value	95% Conf. Interval
Normal	**Reference = Normal**		
Preeclampsia/Eclampsia			
Energy kcal	-.002	0.088	-.005 .000
Protein g	.104	0.004	.033 .176
Carbohydrates g	-.009	0.184	-.021 .004
Dietary Fibre g	-.041	0.567	-.184 .101
Calcium mg	-.009	0.005	-.015 -.003
Iron mg	-.012	0.942	-.335 .311
Magnesium mg	.004	0.588	-.009 .017
Phosphorus mg	.003	0.148	-.001 .008
Potassium mg	-.000	0.856	-.001 .001
Sodium mg	.001	0.110	-.000 .001
Zinc mg	-.189	0.391	-.619 .242
Manganese mg	.656	0.003	.227 1.085
Vitamin C mg	.004	0.425	-.006 .014
Thiamine mg	1.734	0.359	-1.973 5.442
Riboflavin mg	-.349	0.822	-3.395 2.697
Niacin mg	-.121	0.097	-.264 .022
Vitamin B6	.324	0.742	-1.603 2.250
Folate mcg	-.007	0.014	-.012 -.001
Folic acid mcg	.012	0.034	.001 .023
Vitamin B12mcg	-.334	0.022	-.619 -.049
Vitamin AIU	-.000	0.795	-.001 .000

The statistically significant predictive variables in this multinomial logistic regression are protein (P= 0.004), calcium (P= 0.005), manganese (P= 0.003), folate (P=0.014), folic acid (P=0.034), and vitamin B12 (P=0.022). The results indicate that for every 1 unit increase in the amount of protein, manganese, and folic acid consumed among pregnant women, there is a corresponding 0.104, 0.656, and 0.012 times increase in the risk of developing PE-E compared to those who were normal. Conversely, for every 1 unit increase in the amount of calcium, folate, and vitaminB12 consumed among pregnant women, there is a corresponding -0.009, -0.007, and -0.334 times decrease in the risk of developing PE-E compared to those who were normal.

Discussion

Average nutrient intakes are determined to compare with the gold standard to determine the adequacy of nutrient intakes which may affect the nutritional status and pregnancy outcome of pregnant women. A study conducted in Ghana [19] found that vitamin B12 and carbohydrates had higher average scores than the RDA. This is consistent with the findings in this study where the nutrient intakes that were above the RDA are; carbohydrates, dietary fibre, phosphorus, manganese, vitamin C, vitaminB12, and vitamin A. This is consistent with the findings of this study [20] which is indicative of micronutrient adequacy. Nutrients classified below the RDA in this study are calcium, iron, magnesium, potassium, zinc, folate, folic acid, and vitamin k also showing signs of micronutrient inadequacy. This is in conformity with the findings of [21] where their study showed that the mean daily intake of calcium, iron and folate were below the RDA.

The findings here [19] showed that pregnant women had inadequate nutrient intakes of iron, folate, zinc, and calcium, which is in concord with the findings in this study. This is a true reflection of what pertains at the community level in the Eastern Region of Ghana because the majority of pregnant women who report to the Hospitals are mostly deficient of the above-mentioned nutrients, especially iron and folic acid. This may be due to inappropriate nutrient intakes such as drinking tea with iron-rich foods or inadequate intake of folate, zinc, and calcium-rich foods. Some of the dietary intakes were almost at par with the RDA, showing that the dietary intake by some pregnant women in this study were almost at the standard level. The mean of Vitamin B6 is exactly the same as the recommended dietary intake in this study. This shows that some of the individual nutrient intakes in this study were consistent with the RDA for pregnant women as documented by the Institute of Medicine [22], edited by Jennifer J. Otten, Jennifer Pitzi Hellwig, Linda D. Meyers. These findings are also consistent with the details shown [23], which clearly spells out the modified nutrient intakes for pregnant women. The results of this study show an average protein and carbohydrate consumption of 59.3g and 324.5g, respectively which are almost at the same value with the RDA of 60g and 175g respectively [23]. Also, the average protein intake of a study conducted in Ghana and reported by [24] is the same as what is reported in this study. This means the individual protein and carbohydrate requirements are met, and therefore, there would not be any imbalance that may affect foetal growth and development. According to [23], the energy needs of pregnant women increase to 452kcal in the third trimester. The mean dietary intake of vitamin B6 among pregnant women in this study is exactly what is required by the standard, 1.9mg/day each, in conformity with the RDA guidelines and cited by [23].

Study findings revealed that inadequate macronutrient and micronutrient intakes are rampant among pregnant women in the Caribbean due to inadequate intake of a variety of food [25-26]. The findings in this study indicate that 25.5% of the pregnant women had adequate intake of protein, 2.6% had adequate intake of carbohydrates, 32.4% had adequate intake of dietary fibre, and 4.3% had adequate intake of calcium which was also statistically significant (P =0.018).

This is in sharp contrast with the study conducted in developed countries that showed that pregnant adolescent girls had lower average intakes of energy, dietary fiber, and many important micronutrients compared to the RDA [27, 25]. Additionally, 17.4% had adequate intake of iron, 37.6% had adequate intake of magnesium, 13.1% had adequate intake of phosphorus, and 35.9% had adequate intake of potassium.

Adequate intakes of the micronutrients above signify positive progress in maternal health because micronutrient requirements increase during pregnancy to improve physiologic functions and neonatal growth. Therefore, deficiencies in pregnancy can lead to bad pregnancy outcomes, thus worsening the risk of maternal and neonatal health [28]. However, 26.4% of the pregnant women had an excess intake of zinc, 97.1% had an excess intake of manganese, 63.3% had an excess intake of vitamin C, 21.9% had an excess intake of folate, 1.4% had an excess intake of folic acid, 41.7% had an excess of vitamin B12, 95.5% had an excess of vitamin A, 12.1% had an excess of vitamin K, and 83.1% had an excess intake of sodium. Excess intake of micronutrients among pregnant women may also lead to toxicity of those particular nutrients, which may affect the health of the mother and the developing foetus. The majority of pregnant women in this study had adequate consumption of phosphorus far above the RDA, but inadequate intake of calcium, excess intake of sodium, and manganese which is in consonance with the findings of [29]. Adequate intake of a variety of diets is important to augment and replenish the deficient vitamins and minerals due to inadequate intake of fruits and vegetables. Additionally, overcooking of vegetables denatures the nutrients, thus reducing the amount available for normal human functions, which may lead to increasing blood homocysteine levels. Inadequate nutrient intake of the vitamin B complex (folic acid, vitamins B12 and B6), which does not auger well for homocysteine metabolism, can lead to hyper-homocysteinemia in over 90% of cases [30]. This can be a risk factor for preeclampsia [30].

The findings of the study show that vitamin C intake (adequate and excess), calcium intake (excess), and vitamin A intake (adequate) are all statistically significant at 95% confidence interval. This is in agreement with the findings of [31, 32]. According to the study findings [31], explain that calcium intake reduces the risk of developing pre-eclampsia by 55%, and it also protects against maternal morbidity and mortality. This explains the importance of dietary intake, including macro and micronutrients, for the proper maintenance of body cells, growth, and development in pregnancy as espoused by [21, 33]. According to [34], calcium intake has some benefits for pregnant women with inadequate dietary intake. This is in contrast with the findings in this study.

The findings reveal that pregnant women who had both adequate and excess intake of vitamin C had reduced odds of developing PE-E by 41.7% and 39.8%, respectively, compared to those who had inadequate intake. This is consistent with the findings of [35], where the study found that macronutrients (e.g, carbohydrates), micronutrients (vitamins and minerals), and dietary fibre intake were associated with the development of PE-E. Vitamin C helps to boost the body`s immune system and promotes iron absorption [23]. Therefore, this immune-boosting mechanism and iron absorption ability may contribute to the protective effect observed in this study.

Calcium needs in pregnancy are very important for normal physiological functions and for the growth and development of the foetus. The study shows that pregnant women who had an excess intake of calcium had 6.579 times the odds of developing haemorrhage compared to those who had inadequate intake. Pregnant women who had adequate intake of vitamin A in an unadjusted odds ratio were 4.351 times the odds of developing haemorrhage compared to those who had inadequate intake. However, data from the mean individual level nutrient intake in this study show excess vitamin A intake which is far above the RDA. Vitamin A is important for cell differentiation and proliferation in addition to the maturation of the spine, heart, eyes, and ears.

However, excess consumption above 10,000 IU per day is linked to cranial-facial (face, palate, ears) and heart-related birth abnormalities [23]. This may be contributing to the observation made in this study. The statistically significant predictive variables in the multinomial logistic regression are protein ($P= 0.004$), calcium ($P= 0.005$), manganese ($P= 0.003$), folate ($P=0.014$), folic acid ($P=0.034$), and vitamin B12 ($P=0.022$). The study shows that for every 1 unit increase in the amount of protein, manganese, and folic acid consumed among pregnant women, there is a corresponding 0.104, 0.656, and 0.012 times increase in the risk of developing PE-E compared to those who were normal. Conversely, for every 1 unit increase in the amount of calcium, folate, and vitamin B12 consumed among pregnant women, there is a corresponding -0.009, -0.007, and -0.334 times decrease respectively in the risk of developing PE-E compared to those who were normal. This is in line with the findings [35], which concluded in their study that individual-level dietary intake has an effect on overall pregnancy outcome [35]. This is also consistent with the study [36], where several articles [37-38] were cited to indicate that nutrient intake of calcium and other inadequate nutrient intakes may lead to PE-E. WHO recommends a daily calcium supplementation of 1.5 g–2.0g oral elemental calcium to augment what is deficient in the body for pregnant women to reduce the risk of preeclampsia. Caregivers at the ANC clinics are encouraged to adequately counsel pregnant women on dietary intake of calcium-rich locally available food towards achieving the desired objective [39].

Conclusion

The findings of this study show that majority of pregnant women in this study had adequate consumption of phosphorus far above the RDA, coupled with inadequate intake of calcium, excess intake of sodium, and manganese. The average nutrient intake for carbohydrates in this study is higher than the RDA. The mean dietary intake of vitamin B6 among pregnant women in this study is exactly what is required by the standard, 1.9mg/day. Calcium and vitamin C showed statistically significant associations with PE-E and haemorrhage. A few of the minerals and vitamins they consume are inadequate amounts comparable to the RDA. The findings show that pregnant women who consumed adequate and excess amounts of vitamin C reduced their odds of developing PE-E by 41.7% and 39.8%, respectively. Also, there was a statistically significant association between the intake of calcium and vitamin A and haemorrhage.

The results show that pregnant women who had excess intake of calcium were 6.579 times the odds of developing haemorrhage compared to those who had inadequate intake. Again, pregnant women who had adequate intake of vitamin A were 4.351 times the odds of developing haemorrhage compared to those who had inadequate intake.

Ethical Consideration

Ethical approval was given by the ethics review committee of the Ghana Health Service (GHS-ERC: Number, 007/05/21). Pregnant women who participated in the study signed consent forms before taking part in the study. Confidentiality and privacy of the data collection were assured, and anonymity was maintained throughout the study. Also, approval was obtained from the Eastern Regional Health Directorate and all the participating Hospitals before the data collection.

Consent for Publication

Inapplicable.

Availability of Data and Materials

All the data associated with this work is available from the corresponding author on reasonable request.

Competing Interests

None was declared.

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The authors bore the cost of funding this study.

Authors' Contributions

JAA conceived the study and designed the study together with AA, AO, and IS. JAA implemented the study and conducted data collection. JAA and IS analyzed the data, and JAA wrote the first draft. All authors proofread and edited the manuscript. AA, AO, and MW and FKA critically revised the draft for important intellectual content. All authors read and approved the final manuscript.

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