보건학석사 학위논문

Influence of Maternal Dietary Diversity on the Risk of Low Birth Weight of Neonates in the Cape Coast Metropolis of Ghana

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저체중아 출생 위험에 미치는 영향

2017년 8월

서울대학교 보건대학원
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Dan Yedu Quansah의 석사학위논문을 인준함

2017년 7월

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Abstract

Influence of Maternal Dietary Diversity on the Risk of Low Birth Weight of Neonates in the Cape Coast Metropolis of Ghana

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Epidemiological studies have suggested that adequate diet during pregnancy may have beneficial effects on fetal growth, development and neonatal birth outcomes including low birth weight (LBW). However, few studies have investigated the relationship between dietary diversity and birth outcomes in Ghana. Therefore, this study was conducted to investigate the association between maternal dietary diversity and the risk of LBW in the Cape Coast metropolis. The subjects were 420 mothers who received Antenatal care (ANC) and delivered at the Cape Coast Metropolitan Hospital. A food frequency questionnaire was used to collect dietary information on the frequency of consumption of food items per week during pregnancy. In reference to the FAO women's Dietary Diversity Score (DDS), the subjects were categorized into low, medium or high DDS. Primary outcome was LBW, defined as weight at birth less than 2 500g.

The prevalence of LBW was 43.8%, which was higher in the low DDS group (47.8%) than high DDS group (11.4%) ($p<0.0001$). Mothers in the low DDS group had lower frequencies of the intakes of grains, meat, eggs, and fruits than those in the medium and high DDS groups. After adjusting for potential confounding variables, the risk of LBW in the low DDS group (OR= 4.29 95% CI, 1.24-4.08) was four times higher than in the high DDS group. Three dietary patterns namely "western", "traditional" and "healthy" which explained 58.23% of variability were identified. After adjusting for potential confounding variables, the subjects in the highest quartile of healthy and traditional dietary pattern score had significantly lower LBW risk (healthy: OR= 0.23 95% CI, 0.40-0.90, P trend <0.0001; traditional: OR= 0.14 95% CI, 0.06-0.35, P trend <0.0001 than those in the lower quartiles of dietary pattern score. The results of this study reinforce the significance of adequate nutrition during pregnancy. Counselling and educating mothers on the most appropriate nutritional practices during pregnancy are important to prevent LBW in the study area.

Keywords: Dietary diversity score, Antenatal care, Incidence, Dietary patterns, Nutrition, Pregnancy, Low birth weight, Cape Coast metropolis, Ghana

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CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

WHO: World Health Organization

LBW: Low birth weight

MDD: Minimum dietary diversity

DDS: Dietary diversity score

FAO: Food and Agriculture Organization

GSS: Ghana Statistical Service

ANC: Antenatal care

1. Introduction

The World Health Organization (WHO) defines low birth weight (LBW) as an infant weight at birth less than 2 500g (5.5 pounds) (World Health Organization, 1992). LBW is the consequence of pre-term birth and/or intrauterine growth retardation (IUGR) which is associated with inhibited growth and cognitive development (Kramer, 1989; Barker, 1992). Infants weighing less than 2 500g have 20 times higher risk of death than their heavier counterparts (Kramer, 1989). Research on developmental origins and disease outcomes also suggests that LBW infants have a higher risk of developing hypertension in adult life than their heavier counterparts (Stewart and Rogerson, 1995).

LBW is associated with many risk factors including socioeconomic characteristics, mothers' nutritional status before and during pregnancy, maternal anthropometry, and health markers (Lee *et al.,* 1991; Karim and Mascie-Taylor, 1997; Osrin, 2000; Taylor and Minich, 2004). Interactions between maternal socio-economic characteristics and nutrition during pregnancy are also known to influence LBW (Valero de Bernabéa *et al.,* 2004). According to the WHO, poor maternal nutritional status during pregnancy confers greater risk for LBW in developing countries (WHO, 2002; WHO Technical Consultation, 2004). In economically deprived populations, multiple nutrient deficiencies from poor maternal diet have been associated with higher risks of delivering an infant with LBW (Fall *et al.,* 2003).

Nutrient adequacy and/or overall diet quality during pregnancy is directly associated with neonatal birth weight (Fikree, 1994).

Adequate nutrition before and during pregnancy contributes to rich nutrient reserves needed for fetal growth (Landman, 1989; Singh and Jain, 2009). It is also known that adequate nutrition during pregnancy positively influence birth weight by providing maternal nutrient reserves that can serve as nutritional stores during the period of pregnancy (Kant, 2004; Fowles, 2005). However, these findings have not been clearly demonstrated in developing countries, such as Ghana.

The Dietary Diversity (DD) for women of reproductive age known as food group dietary diversity could be a useful indicator to assess multiple nutrient deficiencies and the risk of LBW in developing countries, especially in countries where valid food composition tables and dietary assessment tools have not been developed. Food group dietary diversity referred in this study as Dietary Diversity Score (DDS) is the number of different food groups consumed in a day or over a specified period of time (Ruel, 2003). It is an indicator of whether mothers have consumed at least five out of the ten defined food groups over a period of time (FAO and FHI, 2016). DDS is an important indicator of micronutrient adequacy which is relatively simple and suitable for large cross-sectional surveys (FAO and FHI, 2016).

The promotion of diverse diet during pregnancy is known as one of the many approaches that can improve micro-nutrients, high diet quality and moderate consumption of low nutrient density foods associated with chronic disease and to some extent intrauterine growth retardation (Christian and Stewart, 2010; George *et al.*, 2014; FAO and FHI, 2016).

Previous studies (Doyle *et al.,* 1992; Ferland and O'Brien, 2003) indicated that maternal dietary practices, adequate nutritional composition and increased food diversity, have beneficial effects on fetal growth, development and birth outcomes including birth weight and apgar score. In a recent prospective cohort study of Ethiopian mothers, the attainment of ≥ 4 DDS during pregnancy was inversely associated with risk of maternal anemia, LBW, and pre-term birth (Zerfu *et al.,* 2016), an understanding of which could guide nutritional interventions during pregnancy.

Generally, nutritional status of Ghanaian women and children has been poor. Although the level of thinness among women slightly decreased from 9% in 2003 to 6% in 2014, undernutrition still remains a major concern (GSS and GHS, 2015) along with a high (estimated 11%) prevalence of LBW (GSS, 2011). However, this issue has not received much needed recognition (Fosu *et al.,* 2013). Few studies have focused on the relationship between maternal nutrition, dietary diversity and birth weight in this setting. One of such studies focused on predominantly farming communities in the northern region of Ghana (Saaka, 2013). This population have different socio-economic, health status, diet and cultural makeup from the population in urbanized Southern Ghana (GSS, 2015). Thus, the objective of this study was to investigate the association between maternal dietary diversity and dietary patterns on the risk of LBW in Cape Coast Metropolis, one of the major urban centers of Southern Ghana.

2. Methods

2.1 *Study area*

The study was conducted in Cape Coast Regional Hospital, Ghana. Cape Coast is the capital of the central region of Ghana. The Cape Coast metropolis is bounded to the west by the Komenda/Edina/Eguafo/Abrem district, on the east by the Abura/Asebu/Kwamankese district, on the north by the Twifu/Hemang/Lower Denkyira district and the Gulf of Guinea to the south. The Metropolis covers an area of 122 square kilometers and is the smallest metropolis in the country. Health Services in the metropolis is provided by both government and private institutions, and are structured along the three tier system of the Primary Health Care strategy.

2.2 *Study design and participants*

The study subjects were recruited from January through to April 2014 among mothers who were between the ages of 17 years and older, attended ANC, answered to dietary questionnaire on food intake during pregnancy, delivered and were attending postnatal clinic at the Cape Coast Metropolitan hospital. Mothers who had stillbirths and babies with gross congenital malformations were excluded from the study. The data reflects the birth data of the Cape Coast Metropolitan hospital in the 2014 gestation period and assumed representative of the metropolis birth record. Overall 420 mothers were included in the final analysis. The study protocol was approved by the University of Cape Coast Institutional Review Board, and informed consent was obtained from all participants.

2.3 *Outcome variable*

The main outcome of the study was LBW. In accordance with WHO standards, infants with birth weight less than 2 500g were classified as LBW (WHO, 1992) infants.

2.4 *Socio-demographic characteristics*

A structured questionnaire with information on sociodemographic, lifestyle, and health characteristics was administered to participants in one of the following two ways. A trained interviewer administered the questionnaire to mothers who could not read or write, whereas questionnaires to literate mothers were self-administered. To ensure a serene environment free of distractions, all interviews were conducted in the office of the midwife after mothers' postnatal appointment. Educational level was divided into four categories: no formal education, primary and/or Junior High School (JHS) (grade 1-9), Senior High School (SHS) (grade 10-12) and tertiary education (diploma or university degree and above). Monthly income was quantified as self-reported income by study participants, and consisted of three categories: ≤ GH¢ 300, GH¢ 301-500 and GH¢ more than 500. The lowest income level (GH¢ 300) was twice the national minimum wage of GH¢ 162.00 ($1= GH¢ 3.84) at the time of the study. Pre-pregnancy body mass index (BMI) was subdivided into 4 categories: underweight (<18.50 kg/m^2), normal (18.50-24.99 kg/m^2), overweight (25.00-29.99 kg/m^2) and obese (≥30 kg/m^2) based on WHO BMI classification (Rao *et al.,* 2001). ANC which meant hospital appointments during pregnancy was divided into three subgroups: 1-4 times, 5-8 times and more than 8 times.

2.5 *Anthropometric measurements*

Maternal height and weight were obtained from mothers' ANC records. Mother's height was measured with a stadiometer and rounded to the nearest 0.1 cm during the first ANC appointment. Mothers' weight was measured at the first ANC appointment and during the last ANC prior to delivery. The Tanita HD-351 Scale was used for weight measurement and was rounded to the nearest 0.05 kg. Mothers' gestation weight gain was determined by subtracting weight at first ANC from the weight at last ANC prior to delivery. Neonatal birth weight was also obtained from mothers' antenatal records. This value was recorded by the hospital delivery team within 24 hours after delivery.

2.6 *Food frequency questionnaire*

A food frequency questionnaire was developed using a qualitative dietary assessment of communities surrounding the University of Cape Coast, where participants were asked to name all foods and drinks consumed during the past 24 hours. A draft food list was prepared from this data and then adjusted to accommodate the most common foods eaten among the people of the metropolis in consultation with the metropolis nutritionists. The resulting food frequency questionnaire contained 17 food items including cereals, milk and dairy products, fats and oils, legumes, tubers, meats, eggs, fruits, fish, and vegetables. Beverages and sweets were excluded, as the study population did not commonly consume them. Frequency responses included: ≥2 times/day, once/day, 2-4 times/week,, occasionally, and not at all. Frequency responses were adopted because of the lack of consensus on food portion sizes in Ghana. Food frequency questionnaire was developed based on this process because of the lack of regional or national data on common foods consumed in the country.

2.7 *Maternal dietary diversity score*

Maternal DDS, which is defined as the number of food group consuming out of the ten defined food groups during the gestation period, is used as a proxy indicator for diet quality in this study. The food items on the food frequency questionnaire were aggregated into ten food groups in accordance with the FAO standards of calculating minimum DDS for women of reproductive age. The 10 resulting food groups were grains (bread, maize, sorghum, rice), beans (all kinds of beans, other legume products), dairy products (powdered and liquid forms of milk, cheese, yoghurt), meat (poultry products, fish, pork, chicken, goat, guinea fowl), egg (chicken, duck, guinea fowl), green leafy vegetables (broccoli, kontomire, carrot greens, chili, lettuce, okra greens), fruits rich in vitamin A (pumpkin, pawpaw, mango, apricot, melon, peaches, tomato), other vegetables (mushroom, onion, tomato, peas, green pepper, eggplant, cabbage), other fruits (apple, banana, avocado, coconut flesh, guava, orange, pear, watermelon, tangerine) and nuts and seeds (groundnut or peanuts, almond, cashew, sesame seed). Table 3 shows a detailed description of the food groups and their main sources of food items. Each food group had a score of 1 or 0 if a subject had consumed at least one of the food items that was classified as a source of that particular food group or not. A mother was assigned low, medium or high DDS group if she consumed 5 or less food groups (DDS $\leq$ 5), between 6 to eight food groups (DDS 6-8), and 8 or more food groups (DDS $\geq$8) respectively.

Recent studies (Rao *et al.,* 2001; Moore and Davies, 2004) have validated this method as an efficient way of determining dietary diversity, because the regular consumption of major food sources leads to nutrient adequacy and ultimately influence neonatal birth outcomes such as birth weight.

2.8 *Statistical analysis*

All statistical analyses were carried out using SPSS software version 22 (IBM Corp. Released, 2011). The prevalence of LBW according to socio-demographic and health characteristics were described using frequency and percentages. The differences of socio-demographic and health characteristics of subjects according to DDS and neonatal birth weight sub-groups were determined using chi-square test. We performed a regression analysis to determine the extent to which LBW was influenced by DDS. Socio-demographic, lifestyle, and health characteristics were included in the multivariate analysis as potential confounders. In model 1, variables including age, education, employment, marital status, and monthly income were controlled. In model 2 we adjusted for covariates in model 1 as well as birth-order, parity and ANC attendance. Model 3 additionally adjusted for smoking, alcohol intake, and supplement intake. Factor analysis was conducted to determine maternal dietary patterns. We used varimax rotation to ensure that the distribution of scores were centered on 0 with standard deviation of 1 for easy interpretation. Variance was based on rotated sum of squared loadings with Keiser Normalization using Principal axis factoring extraction method. Factors were obtained by the help of scree plot that explained variance for each factor. We observed no intersection of loading across dietary patterns.

Factor loadings had a magnitude greater than 0.3. Kaiser-Meyer-Olkin measure of sample adequacy which is a test of assumption required for factor analysis was performed and all assumptions were met before the final analysis were conducted. The quartiles of factor score of each dietary pattern was saved as a regression variable and further used in regression analysis to determine the risk of low birth weight according to the quartiles of dietary pattern score after adjusting for potential confounding variables. In model 1, variables including age, education, employment, marital status, and monthly income were controlled. In model 2, we adjusted for covariates in model 1 as well as birth-order parity and ANC attendance. Model 3 was additionally adjusted for smoking, alcohol intake, and supplement intake. Odds ratios and 95% confidence intervals were determined, and statistical significance were accepted at $P < 0.05$.

3 Results

3.1 *Socio-demographic characteristics of study participants by birth outcome*

Baseline characteristics of subjects are presented in Table 1. The prevalence of LBW among the study subjects was 43.8%. The mean age (± standard deviation) of subjects was 26.7 ± 5.7 years with a range of 17 to 45 years. A large percentage of the subjects had some form of education (83.0%), were employed (68.8%), married (66.2%), and had low monthly income (51.2%). Majority (48.6%) of the subjects had a normal BMI (18.5 24.99 kg/m^2), and were more likely to gain less than the recommended 12 kg of weight gain during pregnancy (76.4%). The prevalence of LBW decreased with an increasing birth order (P <0.001) and parity (P <0.001). Single (P = 0.005) unemployed (P <0.001) and mothers who gained <12kg during pregnancy (P <0.05) had the highest prevalence of LBW than those who were married and employed.

3.2 *Health and lifestyle characteristics of mothers and LBW*

Mothers who had no anemia, and never smoked during pregnancy were likely to deliver infants with normal birth weight. Although ANC attendance and alcohol intake had no statistical significance on infants birth weight, subjects who took no alcohol and attended ANC > 5 times during pregnancy were more likely to deliver infants who were not LBW. Details are shown in table 2.

3.3 *Food group intake, dietary diversity score and birth weight*

Table 4 shows a detailed description of the relationship between food group intake and neonatal birth weight in the study. Generally, mothers who delivered normal birth weight infants had higher frequency of the intakes of all the ten food groups except diary than those who delivered LBW infants. All the study subjects consumed green leafy vegetables. There were significant differences between the consumption of beans (P =0.001), eggs (P <0.05), and fruits (P =0.001) and neonatal birth weight. Dietary diversity score showed significant differences with infant birth weight in this study (P <0.0001). Majority (52.8%) of our study participants had a medium DDS whereas about 34.5% had low DDS. Only about 13% of the respondents had high dietary diversity. Mothers who had low DDS had significantly higher prevalence of LBW than those in the high DDS category. (figure 2).

3.4 *Maternal and infant characteristics according to DDS*

Figure 4 indicates the distribution of neonatal birth weight categories according to sex. Boys had the highest prevalence (54.2%) of LBW. Infants whose mothers were in the low dietary diversity group had significantly lower birth order (P <0.05), birth weight (P <0.0001), and apgar score (P<0.05) than those whose mothers were in the medium and high diversity sub-groups. Neonatal birth weight and apgar score significantly increased with increasing DDS. Details of this is presented in table 5.

3.5 *Influence of dietary diversity score on the incidence of low birth weight*

Table 6 shows a detailed description of the risks (OR, 95% CI) of LBW according to dietary diversity score. Participants with lower diversity score had significantly higher likelihood of delivering infant with LBW compared to those who had higher diversity score. A significant association between low dietary diversity score (OR= 2.35 95% CI, 1.23-4.47) and LBW was observed. When socio-demographic characteristics including age, education, employment, marital status and monthly income were adjusted in model 1, the association between low dietary diversity score and LBW remained significant (OR= 1.99 95% CI, 1.02-3.90). When further covariates (smoking, alcohol intake and supplement intake) were adjusted in model 3 the risk of LBW in the low dietary diversity group was four times higher than those who had high diversity score (OR= 4.29 95% CI, 1.24-4.08)

3.6 *Maternal dietary patterns during pregnancy*

Three significant dietary factors, that best explained the dietary behavior of the study subjects during the period of pregnancy, were identified. These three best explanatory factors were labelled as "western", "traditional" and "healthy" patterns. All of 17 food items that were included for analysis had loading factors greater than 0.3 for at least one of the three factors. Food items such as meat, poultry products, organ meat (liver, kidney), egg and pork constituted the "western" dietary pattern whereas maize, fish, shell fish, sorghum, rice, bread, milk and other vegetables made up the "traditional" dietary patterns. The "healthy" or otherwise known as "prudent pattern" was made up of green leaves, fruits, pumpkins and other fruits. The factor loading of each food item is shown in table 7. The percentage of variance explained for "western", "traditional" and "healthy" patterns were 19.78%, 12.65% and 12.30% respectively with 58.23% of accumulated variability. The eigenvalues of "western", "traditional" and "healthy" patterns were 3.36, 2.15 and 2.09 respectively.

3.7 Influence of *dietary patterns on the incidence of low birth weight*

The odds ratio (OR) and 95% CI of the risk of LBW according to the quartiles (Q) of dietary pattern score are presented in table 8. The subjects in the highest quartile of healthy and traditional dietary pattern scores had significantly lower LBW risk (healthy pattern: OR= 0.45 95% CI, 0.56-0.87, P trend <0.0001; traditional: OR= 0.18 95% CI, 0.08-0.40, P trend <0.0001) than those in the lower quartiles of dietary pattern score after adjusting for age, education, employment, marital status and monthly income. In model 3 where smoking, alcohol and supplement intakes were further adjusted, healthy and traditional dietary patterns (healthy: OR= 0.23 95% CI, 0.40-0.90, P trend <0.0001; traditional: OR= 0.14 95% CI, 0.06-0.35, P trend <0.0001) were still associated with a decreased risk of LBW. There were no associations between western dietary pattern and the risk of LBW in all the regression models.

[Table 1]. Maternal socio-demographic characteristics according to neonatal birth weight of the study participants

Variables	Frequency (N)	Percent (%)	Birth weight Low (N, %)	Birth weight Normal (N, %)	*P*-value
Age, years					
<20	16	3.8	6 (37.5)	10 (62.5)	<0.0001
20-30	322	76.7	162 (50.3)	160 (49.7)	
>30	82	19.5	16 (19.5)	66 (80.5)	
Educational level*					
No formal	68	16.2	41 (60.3)	27 (39.7)	<0.0001
Primary/JHS	157	37.4	69 (43.9)	88 (56.1)	
SHS	67	16.0	16 (23.9)	51 (76.1)	
Tertiary	128	30.5	58 (45.3)	70 (54.7)	
Employment					
Yes	289	68.8	114 (39.4)	175 (60.6)	0.005
No	131	31.2	70 (53.4)	61 (46.6)	
Marital status					
Single	142	33.8	82 (57.7)	60 (42.3)	<0.0001
Married	278	66.2	102 (36.7)	176 (63.3)	
Monthly income†					
≤300	215	51.2	109 (50.7)	106 (49.3)	<0.0001
301- 500	83	19.8	47 (56.6)	36 (43.4)	
≥500	116	27.6	28 (24.1)	88 (75.9)	
Birth order					
1	236	56.2	124 (52.5)	112 (47.5)	<0.0001
2	141	33.6	47 (33.3)	94 (66.7)	
≥4	43	10.2	13 (30.2)	30 (69.8)	
Parity					
1	239	57.9	124 (51.9)	115 (48.1)	<0.0001
2	106	25.2	25 (23.6)	81 (76.4)	
≥3	75	17.9	35 (46.7)	40 (53.3)	
Pre pregnancy BMI (kg/m^2)‡					
Underweight (<18.50)	18	4.3	12 (66.7)	6 (33.3)	0.086
Normal (18.5-24.99)	204	48.6	85 (41.7)	119 (58.3)	
Overweight (25.0-29.9)	119	28.3	47 (39.5)	72 (60.5)	
Obese (>30)	79	18.8	40 (50.6)	39 (49.4)	
Gestational weight gain (Kg)					
<12	321	76.4	125 (45.2)	176 (54.8)	0.022
>12	89	21.2	29 (32.6)	60 (67.4)	

*JHS meant subjects with educational level from grade 1-9 called the junior high school, SHS meant education level from grade 10-12 which is called the senior high school and Tertiary meant subject with a diploma or university degree and above.

†Income earned in one month and consisted of ≤ GH¢ 300, GH¢ 301-500 and GH¢ 500+.

‡Pre-preganancy BMI meant body mass index before pregnancy..

P-value derived from chi-square test

[Table 2]. Maternal health and lifestyle characteristics according to birth weight of infants

Variables	Frequency (N)	Percent (%)	Birth weight		*P*-value
			Low (N, %)	Normal (N, %)	
ANC attendance*					
1-4	24	5.9	6 (25.0)	18 (75.0)	0.096
5-8	245	60.0	117 (47.8)	128 (52.2)	
≥8	139	34.1	61 (43.9)	78 (56.1)	
Supplement intake†					
Yes	143	34.0	67 (46.9)	76 (53.1)	0.212
No	277	66.0	117 (42.2)	160 (57.8)	
Smoking‡					
Yes	32	7.6	20 (62.5)	12 (37.5)	0.021
No	388	92.4	164 (42.3)	244 (57.7)	
Alcohol intake§					
Yes	44	10.7	19 (43.2)	25 (56.8)	0.536
No	368	89.3	157 (42.7)	211 (57.3)	
Anemia					
Yes	69	16.4	17 (24.6)	52 (75.4)	<0.0001
No	351	83.6	167 (47.6)	184 (52.4)	
Malaria in pregnancy					
Yes	132	31.4	50 (37.9)	82 (62.1)	0.057
No	285	67.9	134 (47.0)	151 (53.0)	

*ANC attendance meant to attend anti-natal clinic during the gestation period
†Supplement intake "yes" meant took dietary supplement
‡Smoking: "yes", smoked >100 cigarettes during the period of pregnancy
§Alcohol intake "yes" ", more than once a month over the pregnancy period
P-value are derived from chi-square test

[Table 3]. Individual food items that contributed to food groups

Food group	Food items*
Grains	Bread, maize, sorghum, rice
Beans	Beans (all kinds), other legume products
Dairy	Milk (powdered and liquids), cheese, yoghurt
Meat	Poultry products, fish, pork, chicken, goat, guinea fowl
Egg	Eggs (chicken, duck, guinea fowl)
Green leafy vegetables	Broccoli, kontomire, carrot greens, chili, lettuce, okra greens
Fruits (vitamin A rich)	Pumpkin, pawpaw, mango, apricot, melon, peaches, tomato
Other vegetables	Mushroom, onion, tomato, peas, green pepper, eggplant, cabbage
Other fruits	Apple, banana, avocado, coconut flesh, guava, orange, pear, watermelon, tangerine
Nuts and seeds	Groundnut or peanuts, almond, cashew, sesame seed

*Individual food items that were aggregated into ten food groups used in calculating food group diversity

[Table 4]. Percentage of subjects who consumed each food group and DDS according to neonatal birth weight

Food group*	Birth weight Low (N, %) (n=184)	 Normal (N, %) (n=236)	*P*-value
Grains	168 (43.8)	216 (56.3)	0.536
Beans	54 (33.8)	106 (66.3)	<0.001
Dairy	19 (51.4)	18 (48.6)	0.213
Meat	182 (43.5)	236 (56.5)	0.191
Egg	58 (35.4)	106 (64.6)	0.003
Green leafy vegetables†	184 (43.8)	236 (56.2)	-
Fruits (vitamin A rich)	181 (44.4)	227 (55.6)	0.150
Other vegetables	73 (35.3)	134 (67.7)	<0.001
Other fruits	136 (40.0)	204 (60.0)	0.001
Nuts and seeds	175 (44.2)	221 955.8)	0.336
DDS‡			
Low (n=145)	88 (60.7)	57 (39.3)	<0.001
Medium (n=222)	75 (33.8)	147 (66.2)	
High (n=53)	21 (39.6)	32 (60.4)	

*Food groups from aggregated individual food items

†The intake of green leafy vegetables was constant i.e. consumed by all subjects in the study

‡ DDS meant Dietary diversity score; is the score indicating whether or not mothers consumed at least five out of ten defined food groups the previous day or night. Low meant DDS $\leq$ 5, Medium meant DDS 6-8 and High meant DDS $\geq$8.

P-value are derived from chi-square test

[Table 5]. Characteristics of pregnancy outcomes according to dietary diversity score

Variable	Dietary diversity score (DDS)* Low Mean (SD)	Medium Mean (SD)	High Mean (SD)	P-value
Pre-pregnancy weight (kg)	65.00 (2.90)	64.51 (3.17)	64.29 (2.20)	0.995
Pre-pregnancy BMI†	26.18 (0.80)	26.53 (0.87)	26.42 (1.53)	0.957
Birth order	1.43 (0.05)	1.64 (0.04)	2.67 (0.11)	0.002
Birthweight (g)‡	2611.63 (56.69)	2937.11 (46.41)	3000.00 (91.75)	<0.001
Apgar score‖	5.86 (0.06)	6.17 (0.08)	6.38 (0.15)	0.012

*Means of maternal and infant characteristics according to dietary diversity score

†Maternal pre-pregnancy body mass index

‡Neonatal birth weight in grams (g)

‖Apgar score of neonate

P-value are derived from ANOVA test

[Table 6]. Odds ratios (OR) and 95% CI of the risk of low birth weight according to dietary diversity score

Dietary diversity score	Co-eff (β)	OR (95%, CI)	P-value
Crude*			
Low	0.855	2.35 (1.23-4.47)	0.009
Medium	-0.252	0.77 (0.42-1.44)	0.424
High	Ref	1.00	
Model 1†			
Low	0.692	1.99 (1.02-3.90)	0.043
Medium	-0.252	0.77 (0.41-1.47)	0.442
High	Ref	1.00	
Model 2‡			
Low	0.761	2.14 (1.07-4.27)	0.031
Medium	-0.136	0.87 (0.45-1.69)	0.687
High	Ref	1.00	
Model 3|			
Low	1.457	4.29 (1.24-4.08)	0.021
Medium	-0.081	0.92 (0.28-2.96)	0.892
High	Ref	1.00	

*Crude meant uni-variate unadjusted regression estimates

†Model 1: Adjusted for socio-demographic characteristics including age, education, employment, marital status and monthly income

‡Model 2: Model 1 + birth-order of infant, parity of infant and number of ante-natal clinic (ANC) attendance

|Model 3: Model 2 + smoking, alcohol intake and supplement intake

[Table 7]. Loading factors from factor analysis using varimax rotation

	Factor loading		
	Western	Traditional	Healthy or prudent
Meat	0.931		
Poultry products	0.927		
Organ meat (liver, kidney)	0.583		
Egg	0.711		
Pork	0.612		
Maize		0.621	
Shell fish		0.569	
Sorghum		0.518	
Rice		0.510	
Fish		0.453	
Bread		0.423	
Milk		0.321	
Other vegetables		0.311	
Green leaves			0.819
Fruits			0.675
Pumpkins			0.505
other fruits			0.486
Eigenvalues	3.36	2.15	2.09
% of variance explained	19.78	12.65	12.30
% of variance accumulated	19.78	45.93	58.23

Kaiser-Meyer-Olkin Measure of Sampling Adequacy =0.660, Bartlett's Test of Sphericity. Chi-Square =2254.851, P = <0.0001

[Table 8]. Odds ratio (OR) and 95% CI of the risk of low birth weight according to the quartile (Q) of dietary pattern score

Dietary pattern	Q1	Q2		Q3		Q4		*P* for trend
		OR	95% CI	OR	95% CI	OR	95% CI	
Healthy								
Crude*	1	0.64	0.55-0.84	0.47	0.65-0.82	0.33	0.32-0.91	<0.0001
Model 1†	1	0.60	0.62-0.80	0.57	0.53-0.94	0.45	0.56-0.87	<0.0001
Model 2‡	1	0.44	0.52-0.93	0.33	0.42-0.81	0.48	0.64-0.72	<0.0001
Model 3∥	1	0.33	0.43-0.79	0.42	0.61-0.94	0.23	0.40-0.90	<0.0001
Traditional								
Crude	1	0.30	0.17-0.56	0.46	0.26-0.81	0.26	0.14-0.47	0.0020
Model 1	1	0.16	0.07-0.36	0.34	0.16-0.70	0.18	0.08-0.40	<0.0001
Model 2	1	0.14	0.06-0.33	0.31	0.14-0.70	0.15	0.06-0.37	<0.0001
Model 3	1	0.13	0.05-0.31	0.3	0.13-0.68	0.14	0.06-0.35	<0.0001

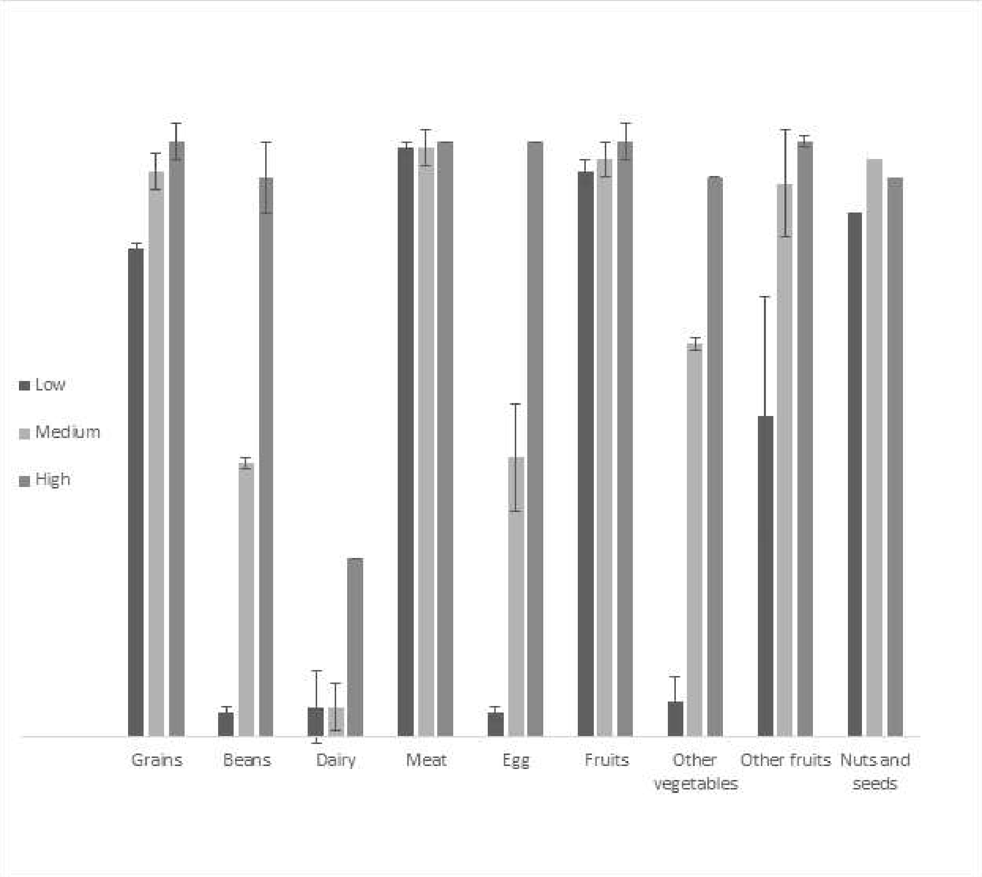
Western								
Crude	1	0.71	0.39-1.29	2.41	1.36-4.26	1.71	0.97-3.00	0.5310
Model 1	1	0.79	0.35-1.76	1.69	0.73-3.88	1.13	0.51-2.48	0.2270
Model 2	1	0.77	0.32-1.86	1.38	0.57-3.32	1.31	0.55-3.08	0.1560
Model 3	1	0.75	0.30-1.84	1.48	0.60-3.60	1.73	0.68-4.37	0.1580

*Crude meant uni-variate unadjusted regression estimates

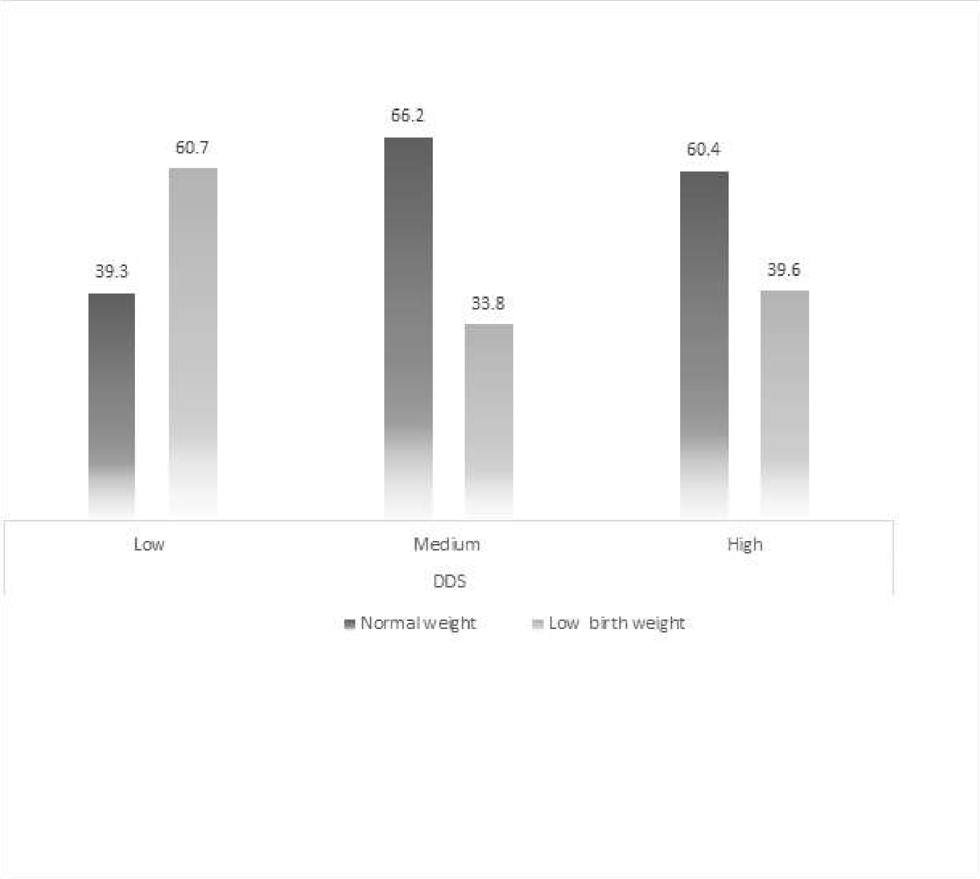
† Model 1: Adjusted for socio-demographic characteristics including age, education, employment, marital status and monthly income

‡ Model 2: Model 1 + birth-order of infant, parity of infant and number of antenatal care (ANC) attendance

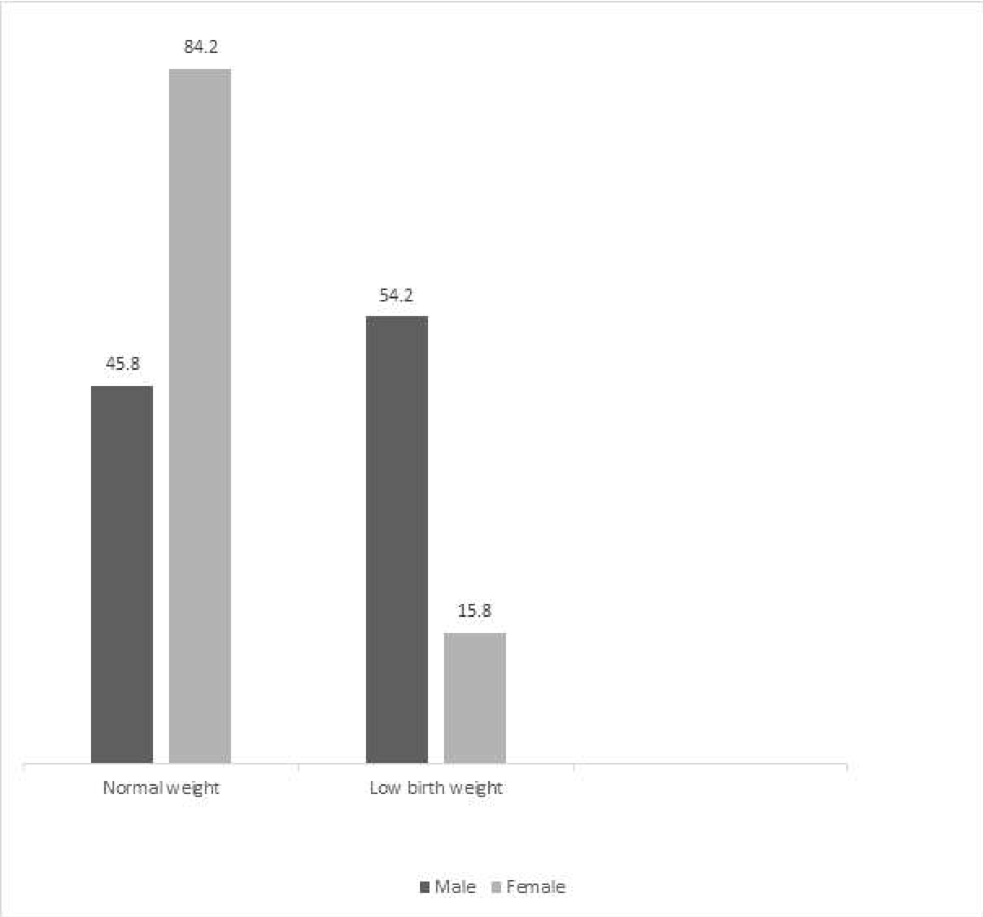
| Model 3: Model 2 + smoking, alcohol intake and supplement intake



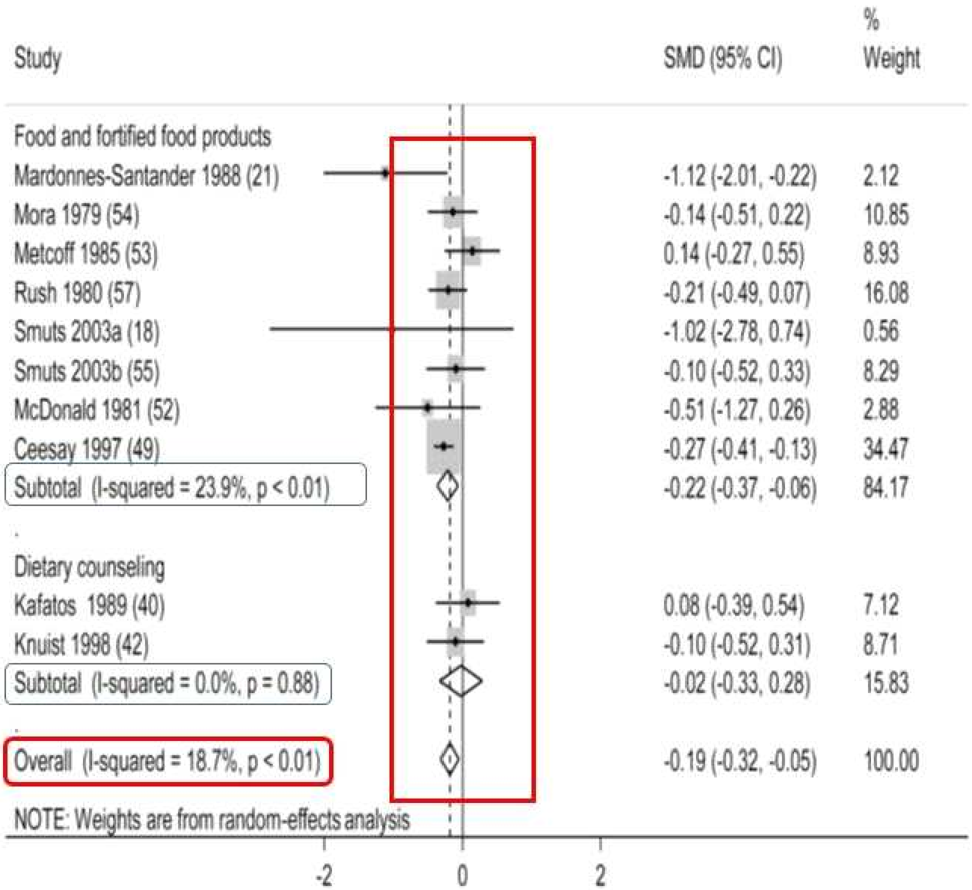
[Figure 1]. Food group consumption of pregnant women according to dietary diversity score. Dark shaded bars indicate low diversity (DDS ≤5), grey shaded bars indicate medium diversity (DDS 6–8) and dark grey bars indicate high diversity (DDS ≥8) with error bars on top of each food group.



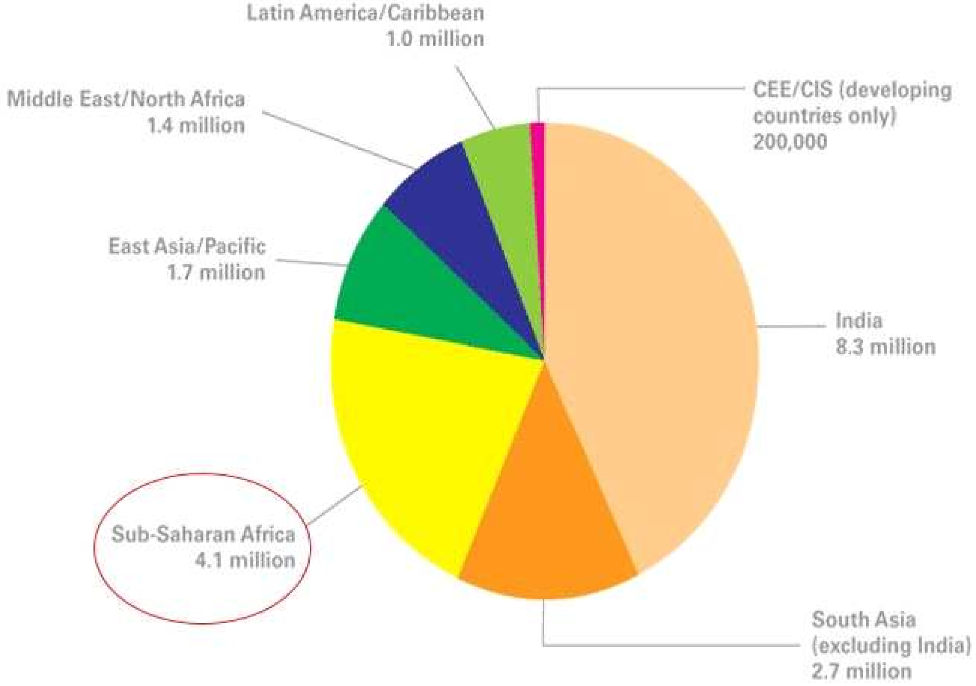
[Figure 2]. Prevalence of low birth weight according to dietary diversity score of mothers. The dark shaded bars indicate low birth weight (<2.5kg) and light shaded bars indicate normal birth weight (>2.5kg).



[Figure 3]. Neonatal birth weight categories according neonate's sex. Light shaded bars indicate girls and dark shaded bars indicate boys.



[Figure 4]. Example of systematic review on dietary interventions and birth outcomes (Gresham *et al.,* 2014)



[Figure 5]. Global prevalence of low birth weight; progress for children 2007 (UNICEF, 2007)

[Figure 6]. Map of Study area (Cape Coast metropolis, Ghana)

4.1 Discussion

This study sought to investigate the association between maternal dietary diversity and dietary patterns on the risk of LBW in the Cape-Coast metropolis. A high prevalence (43.8%) of LBW was observed in the study area. A significant association between low dietary diversity score and LBW was observed. Three dietary patterns namely healthy, traditional and western patterns were identified among the study participants and the healthy and traditional dietary patterns were inversely associated with LBW.

High prevalence of LBW has been found in both developed and developing countries (Knudsen *et al.,* 2008; Fosu e*t al.,* 2013; Saaka, 2013; Senbanjo and Olayiwola, 2013). According to a UNICEF report, Asia had the highest prevalence of LBW followed by Sub-Saharan Africa. Even though south Asia had an estimated 2.7 million LBW infants, India alone had a whopping 8.3 million estimate in 2007. Over 4.1 million infants in Sub-Saharan African are born with inadequate weight (Unicef, 2007). This shows the severity of LBW along with its long and short term effects.

Epidemiologic studies in both developed and developing nations further confirms the high prevalence of LBW earlier reported by UNICEF. In India, nearly 20% of newborns are LBW (Bharati *et al.*, 2011), that of Nigeria is around 11.5% (Onalo and Olateju, 2013; Oladeinde *et al.*, 2015). The prevalence of LBW in this study is higher than the Ghana national prevalence of 10% and the prevalence for Africa (14.3%) and Western Africa (15.4%) (GDHS, 2014). The prevalence of LBW found in this study is inconsistent with recent studies that have reported the prevalence of LBW in the Cape Coast metropolis as 14.3% and 7.7% (Afriyie *et al.*, 2016; Prah *et al.*, 2016).

The differences in these studies can be attributed to differences in study designs, sample size, and years between the studies.

Previous studies have shown that the variety of foods eaten during pregnancy was associated with birth outcomes (Andersen *et al.*, 2003; Kolte, Sharma and Vali, 2009; Saaka, 2013; Sharma and Mishra, 2014; Cetin and Laoreti, 2015; Abubakari and Jahn, 2016; Zerfu e*t al.,* 2016; Knudsen e*t al.,* 2008; Senbanjo and Olayiwola, 2013). High DDS diet during pregnancy are known to contain several essential nutrients that are important in the growth and development of the fetus (Kitajima and Oka, 2001).

In this study, mothers who had low DDS had higher risks of LBW than those who had high diversity scores. The consumption of fewer food groups could result in nutrient deficiencies of essential nutrients that are during pregnancy for growth and development of the infant. The findings of other studies have shown that DDS is an independent predictor of neonatal birth weight (Saaka, 2013; Ali e*t al.,* 2014; Abubakari and Jahn, 2016), a finding which is consistent with this study. Although DDS may serve as a good indicator for measuring maternal diet variety and quality (FAO and FHI, 2016) in socio-economically disadvantaged regions, it should however be noted that the measurement of usual intakes and quantity of food consumed can give a better indication of the determinants of nutritional status (Ali e*t al.,* 2014) during pregnancy.

According to Zerfu and colleagues, (Zerfu e*t al.,* 2016), women who had inadequate DDS had an increased likelihood of delivering infants with LBW (ARR: 2.06; 95% CI: 1.03, 4.11) compared to those with adequate DDS. In another study, maternal DDS was inversely associated with the incidence of LBW (Adjusted OR = 0.43, 95% CI =

0.22–0.85, p = 0.014). These results are consistent with the findings of this study. We found a significant association between dietary diversity score (OR= 2.35 95% CI, 1.23–4.47) and LBW. After adjusting for covariates the risk of LBW in the low dietary diversity group was four times higher than those in the high diversity score (OR= 4.29 95% CI, 1.24–4.08) group.

Evidence from multiple micro-nutrients trials showed that iron and folic acid supplement may be negatively or positively associated with LBW (Adu-Afarwuah *et al.*, 2015; Ba and Za, 2016). The impact of multiple nutrient supplementation includes resistance to infections during pregnancy, improved nutritional status and improved birth outcomes (Ba and Za, 2016). It was not surprising that the prevalence of LBW was higher among those in the low DDS category because mothers consumed fewer food groups (≤5) than those in the higher diversity category. Subjects with high dietary diversity had higher frequency of the intakes of grains, meat, egg and fruits compared with those with low and medium diversity scores. Balanced nutrition during pregnancy may favor gestation weight gain (Lagiou and Tamimi, 2004) and improved birth outcomes such as birth weight.

Besides DDS, this study investigated the association between maternal dietary patterns and LBW. Many studies that have investigated the association between nutrition during pregnancy and birth outcomes mostly considered the effect of single nutrients and or food group (Jackson et al., 2011; Islam et al., 2010; Hooshmand et al., 2011). These approaches are known to have limitations (Binkley et al., 2009; Farrell et al., 2009). Even though it is useful to isolate the impact of these specific nutrients, it is insufficient to account for the complex behavior of food consumption and nutrient interactions during pregnancy (Hu, 2002; Loy and Jan, 2013). Therefore, methods that identify dietary patterns rather than single nutrient or food group are more useful for identifying associations between nutrition and potential disease risk. In addition to assessing individual nutrients, dietary patterns provides a more comprehensive understanding of dietary behaviors (Hu, 2002) during pregnancy.

Although several studies (Shin and Joung, 2013; Shin, Sung and Joung, 2015; Shin *et al.*, 2017) have investigated the role of dietary patterns in disease risks as well as dietary patterns and the risk of LBW in developed countries (Thompson *et al.*, 2010; Kjøllesdal and Ottesen, 2014; Chen *et al.*, 2016), only one study has examined the relationship between dietary patterns and LBW (Abubakari and Jahn, 2016) in developing countries such as Ghana due to the problematic nature of measuring nutrient intakes. These studies have shown a number of dietary patterns. Thompson and colleagues identified three dietary patterns namely; "traditional' "fusion" and "junk" diets. Mothers who had higher 'traditional' pattern scores in early pregnancy were less likely to deliver LBW infants (Thompson *et al.*, 2010). Coelho *et al.,* (Coelho *et al.*, 2015) showed a positive association between birth weight and "snack' dietary pattern rather than "traditional", "prudent" and "western" patterns. A study conducted by Abubakari and Jahn (Abubakari and Jahn, 2016) indicated that both "Health conscious" and "non-Health conscious" dietary patterns offered protective effect for LBW among northern Ghanaian women. In another study (Wolff *et al.,* 1995) dietary patterns from nutrient dense and protein rich foods were associated with higher birth weight whereas a traditional diet pattern which contained fats and oil, high-fat meats and sugar were associated with LBW. A South African study which identified four dietary patterns; 'animal-based', 'stapled-based', 'recommended diet', 'egg-and breakfast-cereals' and 'legumes-and-vegetables (Annan *et al.,* 2015) are similar to those identified in this study. In this study, the highest quartile of healthy (OR= 0.23 95% CI, 0.40-0.90, P trend <0.0001) and traditional (OR= 0.14 95% CI, 0.06-0.35, P trend <0.0001) dietary pattern scores were associated with lower risks of delivering an infant with LBW. The western pattern showed no association with LBW. Results from other studies indicates that healthier dietary patterns are associated with lower odds of LBW as observed in this study.

The present study has several limitations which need to be considered when interpreting the findings. First, the lack of data on commonly consumed foods and their typical portion sizes makes it difficult to estimate dietary intakes and diet quality. Second, dietary diversity was based on frequency responses of participants and may not represent true intakes. Third, the use of FFQ may also result in recall bias although we did probe and provided cues to aid mothers to recall. The study also relied on secondary data from participants hospital records during pregnancy. Therefore errors in measurements, reading and recordings of these data may influence the results. Fourth, it is worthy to state that dietary patterns are not chosen in advance and that the posteriori method of assessing dietary patterns may have some weakness. The lack of established cut-offs for additional percentage of variance explained in factor analysis for the determination of factors and which foods should be considered relevant in each pattern (Thompson *et al.*, 2010; Abubakari and Jahn, 2016) can also influence the study result. Despite these limitations, the study results are consistent with other studies such as the one conducted by Clausen and colleagues (Clausen et al., 2005) which used a similar questionnaire to asses dietary diversity and dietary patterns.

4.2 Conclusion

We found a 43.8% prevalence of LBW in the Cape Coast metropolis. Low maternal dietary diversity score was associated with LBW. The likelihood of delivering an infant with LBW was four times higher among mothers who had lower dietary diversity score than those who had high diversity scores. We also identified three dietary patterns among pregnant women in the cape coast metropolis, healthy. traditional and western dietary patterns. The subjects in the higher quartiles of healthy and traditional dietary patterns scores were associated with a lower likelihood of delivering an infant with LBW. The results of this study reinforces the significance of adequate nutrition during pregnancy. The epidemiological importance of this study lies in the counselling and education of mothers on the most appropriate nutritional practices and food intakes before and during pregnancy.

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KOREAN ABSTRACT

가나 케이프코스트 지역 산모의 식사 다양성이 저체중아 출생 위험에 미치는 영향

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산모의 영양 상태와 식사의 다양성은 태아의 성장과 저체중아 출생 예방에 효과가 있다고 여러 역학 연구를 통해 입증되어 왔다. 그러나 가나에서는 산모의 식사 다양성과 신생아 건강 간의 연관성을 분석한 연구가 드문 실정이다. 따라서 본 단면 연구는 가나 케이프코스트에 거주하는 산모의 식사 다양성 점수 (dietary diversity score; DDS)와 저체중아 출생 위험의 연관성을 분석하고자 하였다. 케이프코스트 병원에서 산전 관리를 받고 아기를 출산한 총 420명의 산모를 대상으로 임신 기간 동안의 식품섭취빈도조사를 시행하였다. 유엔식량농업기구 (FAO)에서 발표한 여성의 DDS를 참고하여 대상자들의 DDS를 낮음, 보통, 높음의 세 단계로 구분하였다. 저체중아는 출생 시 체중이 2,500 g 이하인 신생아로 정의하였다. 대상자의 43.8%가 저체중아를 출산했으며, DDS가 낮은 산모에게서 저체중아 출생률이 유의하게 높았다 ($p < 0.0001$). DDS가 낮은 산모들은 곡류, 육류, 달걀, 과일의 섭취량이 다른 산모들에 비해 낮았다. 교란변수를 보정했을 때, DDS가 낮은 군의 저체중아 출생 위험은 높은

군보다 4배 높았다(OR= 4.29 95% CI, 1.24-4.08). 대상자들에게서 58.23%의 변이를 설명할 수 있는 western, traditional, healthy의 세 가지 식사 패턴을 확인하였다. 공변량 보정 후 Healthy와 (OR= 0.23, 95% CI, 0.40-0.90, P trend <0.001) Traditional (OR= 0.14, 95% CI, 0.06-0.35, P trend <0.001) 식사 패턴에서 LBW 예방 효과가 나타났다. 이와 같은 결과를 통해 임신 중 영양 상태를 적절히 관리하는 것이 중요하다고 할 수 있다. 해당 지역에서 저체중아 출생을 예방하기 위하여 임신 전과 임신 도중의 적절한 영양 관리와 식품 섭취에 대하여 산모들을 교육하는 것이 중요할 것이다.

주요어: 식사 다양성 점수, 산전 관리, 유병률, 식사 패턴, 영양, 임신, 저체중아, 케이프코스트, 가나

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