Dietary Diversity Score during Pregnancy is Associated with Neonatal Low Apgar Score: A Hospital-Based Cross-Sectional Study

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Abstract: *Background*: Apgar score is an established index of neonatal well-being and development. Nutrition during pregnancy is an accepted risk factor for neonatal low Apgar score.

Objective: To investigate the association between dietary diversity score and low Apgar score.

Methods: This was a hospital based cross-sectional study. The study participants were 420 mothers who delivered and were attending the postnatal clinic at the Cape Coast Metropolitan Hospital. Mothers' dietary information during pregnancy was assessed with a food frequency questionnaire. In reference to the FAOs women's Dietary Diversity Score (DDS), the subjects were categorized into low, medium or high DDS. The primary outcome was Apgar score. Apgar scores < 5 were classified as low.

Results: The mean age (± standard deviation, SD) of subjects was 26.7 ± 5.7 years with a range of 17 to 45 years. The prevalence of low Apgar score among the study population was 16.9%. Majority of the study participants had a low DDS in relation to low Apgar score whereas 7.5% had high DDS. After adjusting for potential confounding factors, the odds of low Apgar score in the low DDS group was three times higher than those who had high DDS (Adjusted odds ratio, AOR= 3.10, 95% confidence interval, CI=1.23-4.48).

Conclusion: Dietary diversity score during pregnancy was associated with a low Apgar score in the study area. The results of this study reinforce the significance of adequate nutrition during pregnancy in the study area.

Keywords: Dietary diversity score**,** Apgar score, Pregnancy, Cape Coast Metropolitan Hospital, Neonate.

INTRODUCTION

Ever since the Apgar score was developed by Virginia Apgar [1, 2], it has been accepted as an index for assessing the immediate health status of an infant after birth. The knowledge of Apgar score also serves as a guide for a rapid response to resuscitation should the need arise [3]. Apgar score is widely accepted as the standard and established measure or an indicator of a neonates' immediate postnatal health [3]. The Apgar score which is a quick test performed on a neonate at 1 and 5 minutes after birth comprises of five components namely; color, heart rate, reflexes, muscle tone, and respiration, each of which is given a score of 0, 1, or 2 [1,3-5]. Even though the Apgar score is reported at one and five minutes after birth, this index is repeated at 5 minutes interval until 20 minutes for an infant with a score of less than 7 [4,6].

According to Li *et al*. [7], the low Apgar score is associated with high neonatal and post-neonatal mortality rates in the United States. The Center for disease control (CDC) reports that more than 23,000 infant deaths are associated with maternal complications of pregnancy, disorders associated with preterm birth, low birth weight and low Apgar score [8]. Recently, the United Nations Inter-agency Group for Child Mortality Estimation (UN IGME) indicated that newborn deaths contribute to about 46% of under 5 mortality rates [9].

Although the Apgar score cannot be appropriately used to predict and/or determine an individual's adverse and neurologic outcome, it is an indicator of an underlying neonatal disease or health. The American Academy of Pediatrics (APP) stipulates that, "a 5-

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minute Apgar score of 7–10 generally indicates a healthy infant, a score of 4–6 as moderately abnormal, and a score of 0–3 as nonspecific indication of illness, and may be one of the first indications of encephalopathy” [4].

Epidemiologic studies have also associated low Apgar scores with the prevalence of neurologic disability and low cognitive function [10], cerebral palsy [11], seizures, epilepsy and mental retardation [12]. Higher prevalence of low Apgar score has been reported for developing countries [13, 14].

Factors such as adequate nutrition during pregnancy, health care availability and maternal socio-demographic characteristics are known to influence Apgar score [10, 15-19]. Whereas studies have mainly reported on the association between socioeconomic position, maternal obstetrical factors, health care availability and Apgar score [14,20-26], very few studies have looked at the relationship between nutrition during pregnancy and Apgar score [21,27,28], even though adequate nutrition during pregnancy has been established as a consequence of favorable birth outcomes such as higher Apgar score and appropriate birth weight. This study therefore investigated the association between dietary diversity score and low Apgar score in the Cape Coast Metropolitan Hospital of Ghana. We hypothesized that higher dietary diversity score during pregnancy is associated with higher Apgar score.

METHODS

Study Area

This study was conducted at the Metropolitan Hospital in Cape Coast, Ghana. Cape Coast is the capital of the central region of Ghana. The Cape Coast Metropolis is bounded on the south by the Gulf of Guinea, west by the Komenda/Edina/Eguafo/Abrem District, east by the Abura/Asebu/Kwamankese District and north by the Twifu/Hemang/Lower Denkyira District. The Metropolis covers an area of 122 square kilometers and is the smallest metropolis in the country. The total fertility rate (TFR) for the metropolis was 2.2 births per 1000 women in 2010 and it was the lowest in the region. The general fertility rate (GFR) is 59.2 births per 1000 women aged 15-49 years and the crude birth rate (CBR) is 17.9 per 1000 population [29,30]. Health Services in the metropolis are provided by both government and private institutions, and are structured along the three-tier system of the Primary Health Care strategy.

Study Design and Participants

This was a hospital based retrospective cross-sectional study. The study subjects were recruited from January through to April 2014. Mothers who were 17 years and older, delivered and were attending (6-8 weeks) postnatal clinic at the Cape Coast Metropolitan Hospital were eligible for inclusion. Mothers who had stillbirths and babies with gross congenital malformations were excluded from the study. Overall, 420 mothers were systematically sampled based on their postnatal appointment list with the facility midwife.

A structured questionnaire with information on socio-demographic, lifestyle, and health characteristics was administered to the 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. The study protocol was approved by the University of Cape Coast Institutional Review Board and informed consent was obtained from all participants.

Outcome Variable

The main outcome of the study was Apgar score, which was classified as ‘low’ when an infant’s mean Apgar score was less than 5 (at 1 and 5 minutes after birth) or ‘high’ when an infant’s Apgar score was greater than 5.

Neonatal Apgar score were retrospectively obtained from mothers’ birth records. This value was recorded by the hospital delivery team (doctors, midwives and supporting staff) immediately after delivery. The Apgar test was performed at one and five minutes after birth. Apgar scores were determined by scoring rates including respiration or crying, reflexes or irritability, pulse or heart rate, skin color of body and muscle tone. A measure of 0, 1, or 2 for each scoring category was given with the best possible total score equaling 10. We classified Apgar score below five as a low and scores above five as high in line with literature [3, 5].

Maternal Dietary Diversity Score

Dietary information during pregnancy was obtained retrospectively with food frequency questionnaire which concentrated on food eaten during the third trimester of pregnancy. A food frequency questionnaire which contained 17 food items including cereals, milk and dairy products, fats and oils, legumes, tubers, meats, eggs, fruits, fish, and vegetables was used to access dietary information from study participants. These food items were adjusted to accommodate the most common foods eaten among the people of the metropolis in consultation with the metropolis nutritionist. Beverages such as coffee, tea 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'.

Maternal DDS, which is defined as the number of food group consumed out of the ten defined food groups during pregnancy, was used as a proxy indicator for diet diversity in this study. The food items on the food frequency questionnaire were aggregated into ten food groups in accordance with the FAOs standards of calculating minimum DDS for women of reproductive age [31]. 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). In developing the DDS, each food group was assigned a score of 1 if a subject had consumed at least one of the food items listed in that particular food group or 0 if not. Mothers were then classified into a low, medium or high DDS group if they consumed 5 or less food groups (DDS ≤ 5), between 6 to eight food groups (DDS 6-8), and 8 or more food groups (DDS ≥8), respectively. Recent studies [32, 33] have validated this method as an efficient way of determining dietary diversity, because the regular consumption of major food sources leads to nutrient variety and adequacy which is essential for maternal health, and fetal growth and development.

Anthropometric Measurements

Maternal height and weight were obtained from mothers' Antenatal clinic (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 again during the last ANC prior to delivery. A Tanita HD-351 Scale was used for weight measurement and was rounded to the nearest 0.05 kg. Mothers' weight gain during pregnancy was determined by subtracting weight at first ANC from the weight at last ANC prior to delivery. 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 [34] whereas pre-pregnancy height was subdivided into 100-149cm, 150-18cm and >180cm.

Measurement of other Covariates

The information on other covariates, such as mother's education and household income, was obtained with a structured questionnaire. 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 household income was quantified as self-reported income by study participants, and classified into 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. Other covariates such as marital status (married or single), smoking ("yes" or "no"), alcohol intake ("yes" or "no"), and supplement intake ("yes" or "no") were adjusted as potential confounding variables in the regression models.

Statistical Analysis

All statistical analyses were carried out using SPSS software version 22 [35]. The prevalence of low Apgar score according to socio-demographic and health characteristics were described using frequency and percentages. The association of socio-demographic and health characteristics of subjects with DDS and neonatal Apgar score categories were first determined using chi-square test. We performed a logistic regression analysis to determine the extent of association between DDS with low Apgar score. Socio-demographic, lifestyle, and health characteristics were adjusted for in the multivariable analysis. Odds ratios (OR) and 95% confidence intervals (CI) were estimated from the logistic regression.

Table 1: General Characteristics of Study Participants According to Neonatal Apgar Score (N=420)

Variables	Apgar score		*P*-value
	Low (<5) (n=71) N (%)	High (>5) (n=349) N (%)	
Age (mean)	27.72	26.46	0.90
Education*			
No formal	19(28)	49(72)	<0.001
Primary/JHS	35(22)	122(78)	
SHS	13(10)	115(90)	
Tertiary	4(6)	63(94)	
Occupation			
Hairdresser/ seamstress	19(26)	54(74)	0.054
Fishmonger/ caterer	23(18)	102(82)	
Office worker	0(0)	42(100)	
Housewife/ unemployed	23(33)	47(67)	
Student	3(5)	58(95)	
Other	3(6)	46(94)	
Marital status			
Single	52(36)	90(63)	<0.001
Married	9(4)	239(96)	
Co-habiting	10(33)	20(67)	
Monthly income			
<GHC 300	45(21)	170(79)	0.061
GHC 301- 500	16(19)	67(81)	
GHC 501 – 700	10(29)	24(71)	
>GHC 700	0(0)	82(100)	
Neonatal characteristics			
Sex			
Male	27 (23)	89 (77)	0.014
Female	2 (5)	36 (95)	
Birth weight			
<2500g	68 (37)	116 (63)	0.001
2500 – 4000g	0 (0)	188 (100)	
>4000g	3 (6)	45 (94)	

*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.
Results are presented as percentages unless otherwise stated.
P-value were derived from chi-square test.

RESULTS

Background Characteristics of Study Participants by Birth Outcome

Table **1** shows the baseline characteristics of subjects involved in this study. The mean age (± standard deviation, SD) of subjects was 26.7 ± 5.7 years with a range of 17 to 45 years. The prevalence of low Apgar score among the study population was 16.9%. The prevalence of low Apgar score was higher in males (23%) than in females (5%) (P<0.014).

The highest proportion of respondents with low Apgar score were reported among those with no formal education (28%), were unemployed/housewife (33%), and were unmarried (36%).

All infants with birth weight between 2500 and 4000g had Apgar score of >5. About 37% of neonates who had low birth weight had low Apgar score (P<0.001) (Table **2**). Mothers who smoked and took to alcohol drinking during pregnancy had the highest percentage of neonates with low Apgar score (31% and 44% respectively).

Association between DDS and Low Apgar Score

Table **3** shows a detailed description of the relationship between food group intake, DDS and

Table 2: Anthropometry, Supplement Intake and Lifestyle of Mothers during Pregnancy According to Neonatal Apgar Score

Variables	Apgar score		*P*-value
	Low (<5) (n=71) N (%)	High (>5) (n=349) N (%)	
Pre-pregnancy BMI (kg/m^2) (Mean) *	26.46	26.36	0.946
Weight gain (12kg)			
>12	4(13)	27(87)	0.648
<12	19(16)	98(84)	
Regular intake of supplement			
Yes	19(18)	84(82)	0.923
No	8(18)	37(82)	
Smoking during pregnancy			
Yes	10(31)	22(69)	0.024
No	61(16)	327(84)	
Alcohol intake during pregnancy			
Yes	8(44)	10(55)	0.003
No	21(15)	115(85)	

*Pre-pregnancy BMI meant body mass index before pregnancy.
P-value were derived from chi-square test.
All analyses are presented as percentages unless otherwise stated.

Table 3: The Distribution of Subjects who Consumed each Food Group and Diversity Score According to Apgar Score

Food group*(yes)	Apgar score		*P*-value
	Low (N, %) (n=71)	Normal (N, %) (n=349)	
Grains	66 (17.2)	318 (82.8)	0.409
Beans	26 (16.3)	134 (83.8)	0.444
Dairy	- (-)	37 (100)	<0.001
Meat	69 (16.5)	349 (83.5)	0.028
Egg	24 (14.6)	140 (85.4)	0.195
Green leafy vegetables†	71 (16.9)	349 (83.1)	-
Fruits (vitamin A rich)	71 (17.4)	337 (82.6)	0.105
Other vegetables	22 (10.6)	185 (89.4)	<0.001
Other fruits	47 (13.8)	293 (86.2)	<0.001
Nuts and seeds	65 (16.4)	331 (83.6)	0.203
DDS‡			
Low (n=145)	36 (24.8)	109 (75.2)	0.004
Medium (n=222)	31 (14.0)	191 (86.0)	
High (n=53)	4 (7.5)	49 (92.5)	

*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; Low meant DDS ≤ 5, Medium meant DDS 6-8 and High meant DDS ≥8.
P-value were derived from chi-square test.

neonatal Apgar score in the study. Generally, mothers who delivered infants with normal Apgar scores consumed more food groups. Majority of mothers who delivered infants with normal Apgar scores had higher consumption of each of the 10 food groups (except for grains, and fruits rich in vitamin A) compared to mothers who delivered infants with low Apgar score. All subjects consumed green leafy vegetables.

Table 4: Odds Ratios (AOR) and 95% CI of Low Apgar Score Risk According to DDS

Dietary diversity score	AOR (95%, CI)	P-value
Model 1*		
Low	4.04 (1.36-4.99)	0.012
Medium	1.98 (0.67-5.89)	0.216
High	1.00	
Model 2†		
Low	3.53 (1.11-4.15)	0.031
Medium	1.60 (0.50-5.03)	0.421
High	1.00	
Model 3‡		
Low	3.91 (1.16-5.17)	0.031
Medium	1.96 (0.58-6.57)	0.687
High	1.00	
Model 4|		
Low	3.10 (1.23-4.48)	0.021
Medium	1.07 (0.93-1.25)	0.403
High	1.00	

*Model 1 is the Crude unadjusted regression estimates.
†Model 2: Adjusted for socio-demographic characteristics including age (continuous), education, marital status and monthly income.
‡Model 3: Adjusted for variables in model 2 + birth-order of infant, parity of infant and number of ante-natal clinic (ANC) attendance.
|Model 4: Adjusted for variables in model 3 + smoking, alcohol intake and supplement intake.

None of the mothers who delivered infants with low Apgar scores consumed dairy products. There were significant relationships between the consumption of diary (P <0.001), meat (P =0.028), other vegetables (P <0.001) and other fruits (P <0.001) with neonatal Apgar score. Majority (24.8%) of our study participants had a low DDS in relation with Apgar score whereas about 7.5% had high DDS. About 14.0% of the respondents had medium dietary diversity in relation with neonatal Apgar score. DDS showed significant association with infant Apgar score in this study (P <0.004).

Table **4** presents the ORs and 95% CIs for the association of low Apgar score with DDS. Participants with lower DDS had significant higher odds of delivering infant with low Apgar score compared to those who had higher diversity score. After adjusting for potential confounders, the odds of low Apgar score in the low DDS group was about three times higher than those who had high DDS (AOR= 3.10, 95% CI, 1.23-4.48).

DISCUSSION

This hospital based cross-sectional study investigated the association between dietary diversity score and the risk of low Apgar score. We observed a 16.9% prevalence of low Apgar score in the study area. We found a statistically significant association between low dietary diversity score and low Apgar score.

Previous studies have shown that the diversity and /or variety of foods consumed during pregnancy are associated with birth outcomes such as birth weight [36-40] and Apgar score [21, 28,41]. The consumption of high diverse diet during pregnancy provides several essential nutrients that are important for the growth and development of the fetus [42]. In this study, mothers who had low dietary diversity score had higher odds of low Apgar score than those who had high diversity scores. The consumption of fewer food groups could result in deficiencies of some essential nutrients that are needed during pregnancy for growth and development of the fetus. Since Apgar score is associated with birth weight [21,41,43], it is plausible that, an infant with a low birth weight due to poor nutrition during pregnancy becomes more likely to have a low Apgar score. It was however not surprising when infants with moderate and higher birth weight had the lowest prevalence of low Apgar score (0% and 6% respectively) compared with infants with lower birth weight in this study. After adjusting for potential covariates, the risk of low Apgar score in the low dietary diversity group was three times higher than those in the high diversity score group in this study.

Results from other studies as well as those of our study supports the hypothesis that adequate diet during pregnancy could be an independent predictor of neonatal birth outcomes such as Apgar score and birth weight in developing countries such as in Ghana [44,45]. Our results is however inconsistent with the results of a systematic review and meta-analysis conducted by Gresham and colleagues which indicated that, dietary intervention during pregnancy has no effect on Apgar score, and perinatal mortality [28] but rather consistent with their conclusion that dietary interventions focused on micronutrient intake favorably influence birth weight.

As stated earlier, the more a mother consumes foods from diverse food groups, the greater the possibility of obtaining essential nutrients needed for fetal growth and development. Therefore, the higher the dietary diversity scores of a mother, the greater the possibility of consuming several diets and obtaining essential nutrients for fetal development and the higher the possibility of delivering an infant with favorable birth outcomes including higher Apgar score. Epidemiological studies further reveal that anemia which is a consequence of poor nutrition during pregnancy increases the risk of low Apgar scores [21,27]. A study conducted by Ahmad and Kalsoom concluded on a linear relationship between maternal anemia and low Apgar score [21]. Also, mothers with low hemoglobin which is an indicator of anemia status during pregnancy showed lower infant Apgar score among a Korean population [27].

LIMITATIONS

There are some limitations to be considered in this study. First, dietary diversity score based on frequency responses cannot represent true food intakes. Although dietary diversity score may serve as a good indicator for measuring maternal diet variety and quality [31] 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 during pregnancy.

Second, the use of a food frequency questionnaire may also result in recall bias although we did probe and provided cues to aid mothers to recall foods eaten during pregnancy. Misclassification of dietary diversity status is thus possible in the study. The direction of bias is, however, unclear. While the categorization of Apgar score into low and high categories may result in a limitation, this does not change the fact that DDS influenced Apgar score in this study.

Third, the study also relied on secondary data from participant's hospital records during pregnancy including Apgar scores and thus errors in measurements, readings and recordings of these data may influence the results. Misclassification of outcomes is thus also possible in the study. However, the potential outcome misclassification is likely to be non-differential with the direction of bias towards the null. This is because Apgar score was measured and recorded by health staff independent of our study. Finally, maternal infections such as HIV, syphilis, anemia, malaria and reproductive tract infections [46, 47] are likely to influence the outcome of this study even though we adjusted for several maternal risk factors associated with low Apgar scores in our multivariable analysis. We however believe that antenatal care appointments that included treatment of maternal infections as well as the prevention of malaria and anemia during pregnancy minimized the effects of these infections.

CONCLUSION

We found that the prevalence of low Apgar score in the Cape Coast metropolitan hospital was 16.9% and low maternal dietary diversity score was significantly associated with low Apgar score. The odds of delivering an infant with low Apgar score was three times higher among mothers who had low dietary diversity score than those who had high diversity scores. The results of this study reinforce the significance of adequate nutrition during pregnancy in the study area.

COMPETING INTERESTS

The authors declare that they have no competing interests.

FUNDING

None.

DATA AVAILABILITY

Data available on written request.

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