European Journal of Nutrition & Food Safety

11(1): 1-13, 2019; Article no.EJNFS.2019.001
ISSN: 2347-5641

Maternal Anthropometry and Dietary Diversity Associated with Birth Weight in Maternity Hospitals in Abidjan (Côte d'Ivoire)

Stéphane Claver Vanié[1*], Grodji Albarin Gbogouri[1], Angèle Edjème-Aké[2,3] and Allico Joseph Djaman[3,4]

[1]Laboratory of Nutrition and Food Safety, Nangui Abrogoua University, Abidjan, Côte d'Ivoire.
[2]Laboratory of Biochemistry, Félix Houphouet-Boigny University, Abidjan, Côte d'Ivoire.
[3]Department of Clinical and Fundamental Biochemistry, Pasteur Institute of Côte d'Ivoire (IPCI), Côte d'Ivoire.
[4]Laboratory of Pharmacodynamics and Biochemistry, Felix Houphouet-Boigny University, Abidjan, Côte d'Ivoire.

Authors' contributions

This work was carried out in collaboration among all authors. Author SCV designed the study, wrote the protocol, managed the literature searches and wrote the first draft of the manuscript. Author AEA contribute of methods and results approval and revised the manuscript. Author GAG participated in data supervision, clark, approved the methodology, discussion writing and manuscript preparation. All authors read and approved the final manuscript submitted for publication.

Article Information

DOI: 10.9734/EJNFS/2019/v11i130123
Editor(s):
(1) Dr. Michael Lokuruka, Department of Food Science and Nutrition, School of Agriculture and Biotechnology, Karatina University, Karatina, Kenya.
Reviewers:
(1) Nikolaos Antonakopoulos, University of Athens, Greece.
(2) Byron Baron, University of Malta, Malta.
Complete Peer review History: http://www.sdiarticle4.com/review-history/51482

Original Research Article

Received 10 July 2019
Accepted 19 September 2019
Published 04 November 2019

ABSTRACT

Aims: Birth weight is a powerful predictor of infant growth and survival and depends on the fetal growth environment, which is influenced by maternal nutritional status. However, the association between maternal anthropometric and nutritional factors and birth weight is not well characterized in Côte d'Ivoire. The objective of this study was to determine the maternal anthropometric and nutritional characteristics associated with birth weight.
Study Design: This was a retrospective study.

**Corresponding author: Email: stephvanie2016@gmail.com, clavervaniest@yahoo.fr;*

Place and Duration of Study: This study was done in maternity hospitals of three municipalities in Abidjan, Côte d'Ivoire, from 1st October to 30 November 2018.
Methodology: It consisted in collecting birth data from 146 newborns born from a monofetal pregnancy, whose mothers aged 20 to 42 had participated in a previous survey. Also, the relationship between birth weight, maternal anthropometry and maternal nutrition factors has been studied. Univariate, bivariate and multivariate data analysis was done using SPSS version 25 software.
Results: The results indicate mean birth weight of 3118.48±515.39 g and 7.6% and 5.5% respectively of low and excessive birth weight. In a multivariate linear regression, the mean birth weight of newborns of women with medium and high dietary diversity score was higher than those newborn of women with low dietary diversity score (AOR=0.386, 95% confidence interval (CI): 0.072-0.699; p=0.017 and AOR=0.233, 95% CI: 0.016-0.450; p=0.036). Similarly, women with gestational weight gain greater than 7 kg and high stature (>1.55 cm) gave birth to heavier children (AOR=0.551, 95% CI: 0.346-0.756; p=0.000 and AOR=0.633, 95% CI: 0.207-1.059; p=0.004, respectively).
Conclusion: Although it revealed the presence of low and excess birth weight, this study has shown that maternal anthropometry and dietary diversity score were associated with birth weight of the baby.

Keywords: Pregnancy; maternal anthropometry; dietary diversity; birth weight; Abidjan.

1. INTRODUCTION

Adequate maternal nutrition during the period from conception to birth is considered as an important determinant for the harmonious development of pregnancy and fetal growth and child health [1-3]. Infant birth weight is a powerful predictor of infant growth and survival. It depends on the fetal growth environment such as nutritional status and maternal prenatal nutrition factors [2,4] which therefore influence the anthropometry of the newborn.

Many maternal and fetal complications due to inadequate nutrition during pregnancy have been noted, including intrauterine growth retardation, premature delivery, fetal malformations and low birth weight [5]. Current research pointed out that the first 1000 days of life (up to two years of life) are crucial for the prevention of illness in adulthood [6]. According to Schmidt et al. [7] a delay in child growth is due to inadequate maternal dietary intake rather than exposure to postnatal environmental factors. Hence the importance of dietary diversification and micronutrient intakes as recommended by international dietary guidelines [8,9].

The use of the women dietary diversity score (WDDS) as a tool for assessing maternal dietary intake and its relationship to pregnancy outcomes has been explored by several authors [10-13] but with divergent results. Indeed, as modifiable risk factors, the study of eating habits often associated with increased risks of adverse outcomes of pregnancy [14,15], can be integrated into pregnant women health care.

In addition, fetal growth and birth weight are also influenced by maternal weight, height, body mass index (BMI) and total gestational weight gain [16-20]. From these anthropometric measurements, BMI during pregnancy and gestational weight gain have been identified as the most important determinants of birth weight [19,20].

In Côte d'Ivoire, several studies on nutrition and anthropometry have focused on schoolchildren, non-pregnant women of childbearing age and students [21-23], but not on newborn birth weight. According to the literature, pregnancies in this country are associated with adverse outcomes such as low birth weight (LBW) with a prevalence of 13% in Abidjan and 14% at the national level [24]. However, the association between birth weight, maternal anthropometric and nutritional factors is not well characterized in Côte d'Ivoire, and in particular in Abidjan. Therefore, this study was designed to study the effect of maternal anthropometric and nutritional characteristics on the birth weight of the newborn.

2. MATERIALS AND METHODS

2.1 Conceptual Framework of Study

This study was designed to examine the relationship between maternal characteristics in

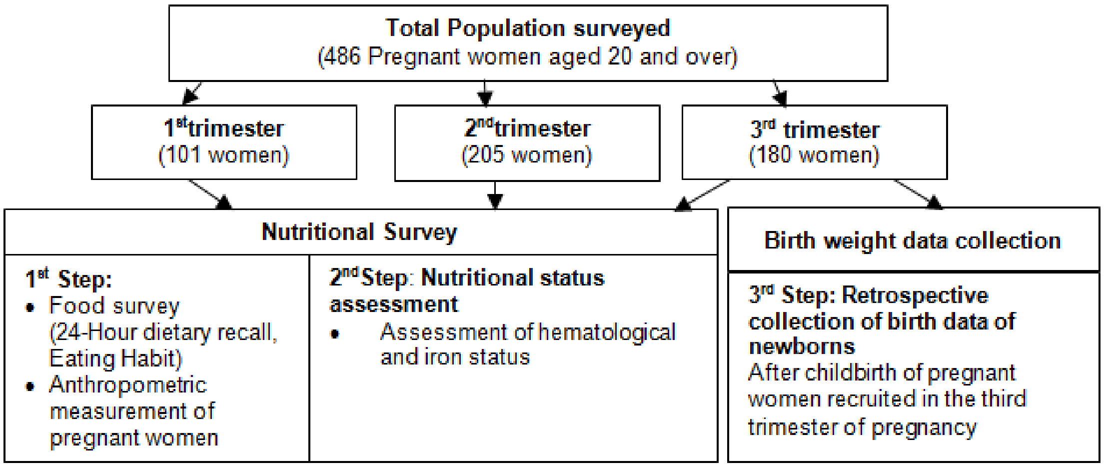

Fig. 1. Conceptual framework for retrospective study of newborn birth data of pregnant women collected in the 3rd trimester of pregnancy

pregnant women in the 3rd trimester of pregnancy (who participated in a previous nutritional survey) and the birth weight of their newborns. The conceptual framework of the study is shown in Fig. 1.

2.2 Study Area and Population

This study was carried out in maternity hospitals of the municipalities of Yopougon, Abobo and Cocody in city of Abidjan. These are the maternity hospitals of the General Hospital of Yopougon Attié, the Urban Health Centers with Community Base (CSUCOM in french) of Abobo-Té and Anono Riviera-2. The study population consisted of 146 mother-child couples whose birth and delivery data were collected.

2.3 Study Design and Period

This was a retrospective study that took place from October 1st to November 30, 2018. It involved the collection of birth data for newborns and the pregnancy delivery of women by consulting birth records.

2.4 Selection of Samples and Inclusion Criteria

All newborn birth data available in the birth registers of the maternity units selected in the previous study were included. These were newborns, born alive by the vaginal route or cesarean section, from a monofetal pregnancy of pregnant women in the previous nutritional survey. Those whose baby data were not available were contacted by telephone. A total of 146 newborns made up the study population. Therefore, a sampling method was not used for the size and selection of the study population.

2.5 Data Collection and Study Variables

Newborn birth data and maternal characteristics at birth were collected retrospectively. The nutritional survey that preceded this study collected socio-demographic, obstetrical and prenatal characteristics, as well as the eating habits and biological analyses of pregnant women. Details are described below.

2.5.1 Socio-demographic and economic characteristics

The economic situation of the household as measured by the well-being index is based on the non-monetary approach to household poverty developed by Garenne and Hohmann [25]. Principal Component Analysis (PCA) was used to select the variables to be included in the index calculation. The well-being quintile obtained was later classified as a well-being tercile (low, medium and high).

2.5.2 Dietary diversity assessment

The measurement of dietary diversity is defined as the consumption or not of 9 food groups in the 24 hours before the survey. Using the information collected during the 24-hour recall, women's dietary diversity scores (DDS) were calculated based on FAO guidelines [26]. These nine food groups are starchy foods, dark green leafy vegetables, meat and fish, other vegetables and fruits, vegetables and fruits rich in vitamin A, organ meats, milk and dairy products, eggs, legumes, nuts and seeds. The classification of dietary diversity into tercile has been obtained from these food groups. A scale has been established for this distribution: low (1-3), medium (4-5) and high (4-9) [27].

2.5.3 Blood samples collection and analysis

For each of the enrolled women, a blood sample by venipuncture at the fold of the elbow in a tube without anticoagulant and an EDTA tube of 5 ml each was taken on an empty stomach. Hematological parameters were measured immediately on samples collected from EDTA tubes by the Sysmex XN-1000™ hematological analyzer. The samples contained in the dry tubes were centrifuged at 3000 rpm for 5 min and the aliquoted serum was stored at -20°C for the determination of biochemical parameters of the iron status on the Cobas C 311 automaton (*Roche*^{R}). All biological analysis were performed at the Clinical Biochemistry and Hematology Unit of the Institut Pasteur of Côte d'Ivoire (IPCI).

Anemia has been defined according to WHO criteria as a hemoglobin level below 11 g/dL in pregnant women. As for Iron deficiency, it has been established for ferritin values lower than 20 µg/l with or without inflammatory status. Similarly, in the presence of an inflammatory status, iron deficiency is found for ferritin values between 20 and 100 µg/l. While ferritin values above 100 µg/l suggest a normal iron status irrespective of the inflammatory status.

2.5.4 Maternal anthropometry and gestational weight gain

The weight, height of the mother and Mid-Upper Arm Circumference (MUAC) were recorded from the examination of the pregnancy follow-up diary and antenatal care (ANC) visit. Gestational weight gain is calculated by subtracting the weight before pregnancy or, failing that, at the beginning of pregnancy from the weight at the end of pregnancy (usually measured just before childbirth). The total number of ANC, term and delivery mode were also collected.

2.5.5 Anthropometric characteristics of the newborn

The weight, height and circumference of the head were recorded by consulting the birth records in the maternity facilities. However, only birth weight was used as pregnancy outcome in this study.

2.6 Statistical Analysis

Qualitative and quantitative data analysis was performed using the SPSS statistical software package (version 25.0; SPSS Inc, Chicago, USA). The continuous variables were expressed as mean and standard deviation. The chi-square test was used to compare the proportion of categorical variables. The maternal characteristics were the independent variables and the birth weight of the newborn as an outcome of pregnancy was a continuous dependent variable. The association between the continuous dependent variable and each of the explanatory variables (continuous or categorical) was studied in a univariate and multivariate linear regression model. This model took into account potential confounding factors and calculated odds ratios (ORs) and 95% confidence intervals (CIs). The independent variables at $p < 0.20$ were then entered into the multivariate linear regression model by the stepwise method. The effect of certain maternal characteristics on birth weight of the newborn, significant at the $p < 0.05$ threshold, was retained. The Kolmogorov-Smirnov test was used to assess the normality of the dependent variable.

3. RESULTS AND DISCUSSION

3.1 Characteristics of Pregnant Women in the 3rd Trimester of Pregnancy

Maternal characteristics included socio-demographic, economic, obstetric factors and prenatal monitoring, as well as dietary habits of women in the third trimester of pregnancy. The age of study participants ranged from 20 to 42 years with mean age of 28.44±5.88 years and 39.7% of participants in the 25 to 30 year age group. 42.1% of pregnant women were from the Akan ethnic group, 40.4% from secondary school and 44.7% from income-generating activities compared to 36% being housewives. More than two-thirds of women lived in couples (72.4%) with only 25 women, or 17.2%, who were legally married. The mean household size was 4.27±2.09 persons per household.

About 38% of pregnant women belong to households with a low well-being index. Among the surveys, 56 women, or 38.4% were first born (Primipara). More than three-quarters of women, 77.8% had inter-pregnancies interval greater than 24 months. About 60% of pregnant women had completed their first antenatal care (ANC) visit before the end of the first trimester of pregnancy. Up to the time of delivery, 75.9% of women received at least 4 ANC according to the recommendations of the Health Authorities of Côte d'Ivoire (Table 1).

More than two-thirds of pregnant women, or 80.8%, took at least all three meals per day with a mean of 3.27±0.9 meals per day. Only 47.6% took a snack as an additional meal per day. Clay consumption or Pica was found in 21.2% of pregnant women, while 31.5% of pregnant women consumed alcoholic beverages. No woman used tobacco during pregnancy.

Table 1. Description of the characteristics of women in the 3rd trimester of pregnancy in maternity hospitals of three municipalities of Abidjan

Variables	Frequency	Percent/Mean±sd
Age group		28.44±5.88 years
20-25 years	42	28.8
25-30 years	58	39.7
>30 years	46	31.5
Ethnic groups		
Akan	61	42.1
Krou	29	20
Mandé	14	9.6
Gour	14	9.7
Other nationalities	27	18.6
Marital status		
Concubine	52	35.9
Single person	39	26.9
Traditional marriage	28	19.3
Legal marriage	25	17.2
Education level of mother		
None	24	16.4
Primary	19	13.0
Secondary	59	40,4
Superior	44	30.1
Occupation of women		
Trader and hairdresser	59	44.7
Employee (Public or Private)	26	19.7
Housewife	47	35.6
Household size		4.47±2.37 persons
1-4 persons	70	47.9
5-6 persons	52	35.6
7 persons and over	24	16.4
Wealth-being index		
Low	55	37.7
Medium	37	26.0
High	53	36.3
Obstetrical history and prenatal care		
Inter-pregnancy interval		55.13±37.17 months
<24 months	20	22.2
≥24 months	70	77.8
Parity		2.24±1.05
Primipara	56	38.4
Parity 2	46	31.5
Parity 3	21	14.4
At least 4	23	15.8
Beginning of the first Antenatal Care (ANC)		
≤ 12 weeks of pregnancy	86	59.3
>12 weeks of pregnancy	59	40.7

Variables	Frequency	Percent/Mean±sd
Total number of Antenatal Care (ANC)		
<4	35	24.1
≥4	110	75.9
Iron/folate supplementation		
Yes	114	78.1
No	32	21.9
Antimalarial prophylaxis (IPTp)		
Yes	43	29.5
No	103	70.5
Dietary habits		
Frequency of meals		3.27±0.9 meal per day
<3	28	19.2
=3	53	36.3
>3	65	44.5
Consumption of clay sand (Pica)		
Yes	31	21.2
No	115	78.8
Usual consumption of alcohol in current pregnancy		
Yes	46	31.5
No	100	68.5

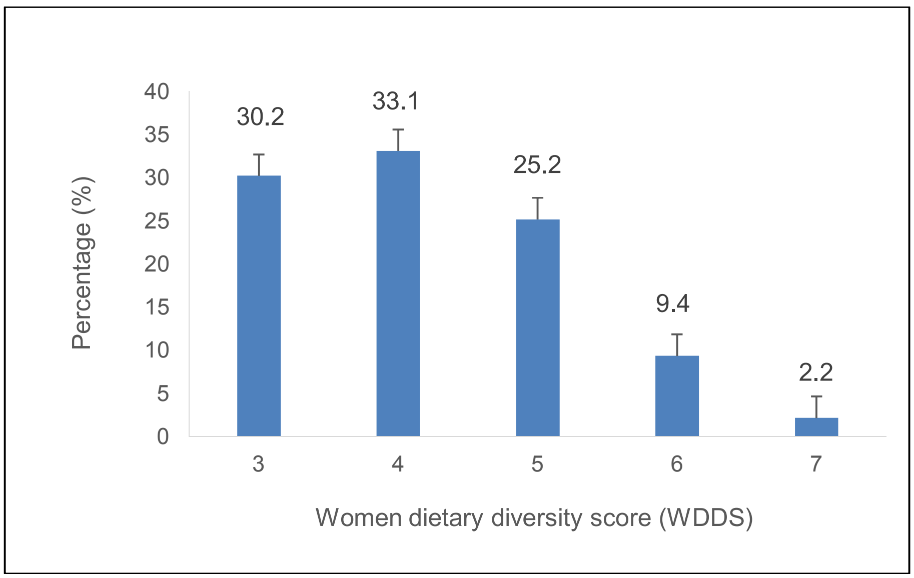

Fig. 2. Distribution of women by women dietary diversity score

3.2 Food Consumption of Women in the 3rd Trimester of Pregnancy

3.2.1 Distribution of pregnant women by dietary diversity score

Based on 9 food groups, the mean dietary diversity score was 4.20±1.04. The majority of women (69.8%) consumed at least four food groups in the last 24 hours prior to the study. The distribution of the dietary diversity score among pregnant women in the third trimester of pregnancy is shown in Fig. 2. Women in the average dietary diversity score (4-5 food groups) were the most represented with a proportion of 58.3% against 30.2% and 11.6% respectively for the low (≤3 food groups) and high dietary diversity score (≥6 food groups).

3.2.2 Dietary profile of women based on 9 food groups

The food consumption profile allowed us to know what pregnant women consumed in each food diversity category. About 30.2% of women were in the category of inadequate diversity compared to 69.8% for the category of adequate diversity (Table 2). The diets of women in the inadequate and adequate dietary diversity category consisted of starches, meat and fish, and other fruits and vegetables, but those in the adequate diversity category consumed in addition, milk, eggs, fruits rich in vitamins A and dark leafy greens (Table 2).

3.3 Anthropometry, Hematological and Iron Status of Pregnant Women in the 3rd Trimester of Pregnancy

The mean value of hemoglobin in the third trimester of pregnancy was 11.02±1.26 g/dl. Anemia in pregnancy, as defined by WHO, was found in 47.3% of pregnant women. This anemia was mild and moderate in 58.2% and 41.8% of women, respectively, and there were no cases of severe anemia. More than half (58.2%) of pregnant women had an iron deficiency in the third trimester of pregnancy. Gestational weight gain was higher (>7 kg) in 67.1% of women with an average of 7.06±1.51 kg, while height was greater than 1.55m in 91.8% of women. Similarly, the majority of pregnant women (84.9%) had a MUAC greater than or equal to 21 cm (Table 3).

3.4 Anthropometric Characteristics of Newborns and Term of Birth

Table 4 shows that 84 newborns (57.9%) were boys. From the total, 11 (7.6%) weighed < 2500 g, 127 (86.9%) weighed 2500 to 3999 g and 8 (5.5%) weighed 4000 g. The mean weight was 3118.48g±515.39g. The gender-based distribution of newborns shows that boys weighed an average of 194 g more than girls

Table 2. Comparison of food consumption profiles* by dietary diversity category to pregnant women in the 3rd trimester of pregnancy

Dietary diversity category	
Inadequate (< 4 Food groups) N (%)	**Adequate (≥ 4 Food groups) N (%)**
44 (30.2%)	102 (69.8%)
Starches	Starches
Other fruit and vegetables	Other fruit and vegetables
Meat and fish	Meat and fish
	Dark green leaf vegetables
	Fruits and vegetables rich in vitamin A
	Eggs
	Milk and dairy products

** For a food group to be included in the dietary profile of a category of women, more than 50% of these women must have consumed that food group*

Table 3. Nutritional status in the 3rd trimester of pregnancy and maternal anthropometry

Variables	Category	Frequency	Percent/Mean±Sd
Anemia			11.02±1.26 g/dl
	Yes	69	47.3
	No	77	52.7
Severity of anemia	Mild (10 – 10.9 g/dL)	85	58.2
	Moderate (7– 9.9 g/dL)	61	41.8
Iron deficiency	No	38	41.8
	Yes	53	58.2
Height			1.63±0.06 m
	≤1.55 m	12	8.2
	>1.55 m	134	91.8
Maternal MUAC in pregnancy			26.97±3.56 cm
	< 21 cm	22	15.1
	≥ 21 cm	124	84.9
Gestational weight gain (GWG)			7.06±1.51 kg
	GWG ≤ 7 kg	48	32.9
	GWG > 7 kg	98	67.1

Table 4. Anthropometrics characteristics of newborn

Variables	Total (N (%))	Girls (N (%))	Boys (N (%))
		61(42.1%)	84 (57.9%)
Mean Birth weight	3118.48±515.39 g	3006.23±565.66 g	3200±462.12 g
P-value			0.021
Birth weight			
Low Birth weight (< 2500 g)	11 (7.6%)	9 (81.8%)	2 (18.2%)
Normal Birth Weight (2500 – 3999 g)	129 (86.9%)	49 (38.9%)	77 (61.1%)
Excessive Birth weight (≥ 4000 g)	8 (5.5%)	3 (37.5%)	5 (62.5%)
p-value			0.025
Delivery			
Preterm (<37 week of pregnancy)	4 (2.7%)	3 (66.7%)	1 (33.3%)
Term (≥37 week of pregnancy)	142 (97.3%)	59 (41.5%)	83 (58.5%)
P-value		0.383	

Table 5. Multivariate linear regression analysis of maternal characteristics associated with mean of birth weight in three maternities in the city of Abidjan

	β	T	P-value	95% CI	Tolerance	VIF
(Constant)	1.924	9.07	0.000	1.50 - 2.35		
Gestational weight gain						
≤7 kg	Ref.					
>7 kg	0.551	5.37	0.000	0.35 - 0.77	0.72	1.39
Mother's height						
≤1.55 m	Ref.					
>1.55 m	.633	2.97	0.004	0.21 - 1.06	0.95	1.06
Education level						
None	Ref.					
Primary	-					
Secondary	-					
Higher	0.174	1.89	0.064	- 0.01 - 0.36	0.94	1.06
Well-being index						
Low	Ref.					
Medium	0.124	1.30	0.198	- 0.07 - 0.32	0.96	1.040
High	-					
Alcohol consumption						
Yes	- 0.137	- 1.55	0.127	- 0.315 - 0.04	0.99	1.01
Never	Ref.					
Dietary diversity score						
Low	Ref.					
Medium	0.386	2.46	0.017	0.072 - 0.70	0.68	1.47
High	0.233	2.15	0.036	0.016 - 0.45	0.59	1.69

(P=0.021). The results showed the highest proportion of low birth weight among girls (81.8%) compared to boys, who had the highest proportions of normal weight (61.1%) and excess weight (61.5%) at birth. There was a significant difference by gender (P=0.025). Among these newborns, 142 (97.3%) were born at term of pregnancy (≥37 weeks of pregnancy) compared to 4 (2.7%) premature (<37 weeks of pregnancy).

3.5 Multivariate Linear Regression Analysis of Maternal Characteristics Associated with Birth Weight

Table 5 shows that gestational weight gain, maternal height and dietary diversity score were associated with birth weight after adjusting for level of education, well-being index and alcohol consumption in a multivariate linear regression.

These results show that women with gestational weight gain over 7 kg and tall (>1.55 m) gave birth to heavier children compared to children of other women with AOR (95%CI) of 0.551, respectively [95%CI: 0.346-0.756] and 0.633 [95%CI: 0.207-1.059]. On the other hand, there was no significant difference in the mean birth weight for women with higher or no level of education. Likewise, the average well-being index and alcohol consumption were also not significant determinants of birth weight (P>0.05). It is also clear from this table that women with medium dietary diversity score (4-5 food groups) and high dietary diversity score (≥6 food groups) gave birth to newborn with a mean birth weight greater than those of women with a low dietary diversity score (Table 5).

3.6 Discussion

The objective of this study was to determine the maternal anthropometric and nutritional characteristics associated with birth weight of newborns in maternity hospitals of three municipalities of Abidjan.

The results showed the existence of the cycle of maternal-infant malnutrition reflected by LBW and excess birth weight in the same type of population. These results indicate 7.6% and 5.5% respectively of LBW and excess birth weight. Similar results have been reported in other countries in Africa within the same population type [11,13,28].

For LBW, the results of this study are similar to those of Onubogu et al. [28] in Nigeria, but much lower than 13% and 14% LBW, respectively mentioned in Abidjan and at national level [26]. In Africa, on the other hand, LBW prevalence ranges from 14 to 28%, almost two to three times higher than our results [11,29,30]. The reason why the prevalence of LBW is low in this study might be due on the one hand to the age of mothers. In fact, the authors' studies treated all women of childbearing age between 15 and 49 years, unlike ours, which only included women aged 20 and over. However, a maternal age of less than 20 years has been proved in the etiology of LBW [31-34]. These authors showed that the risk of giving birth to a LBW child is higher among women under the age of 20 years compared to other adult women. On the other hand, LBW may be due to other pregnancy-related factors. These include poor nutrition, spacing of births, lifestyles (smoking and alcohol use), inadequate prenatal care, overweight, obesity and poverty [31,33,34]. Moreover, according to Gonzalez-Cossio et al. [35] maternal malnutrition and reduced inter-pregnancy intervals, lead to a decrease in physical resources during a new pregnancy, perpetuating the cycle of mother-child malnutrition. This is not the case for more than three quarters of the women in this study where 77.8% and 84.9% respectively observed an interval between pregnancy of at least two years and presented a better nutritional status (PB≥21 cm) despite the diagnosis of anemia and iron deficiency at the end of pregnancy.

The prevalence of excess birth weight in this study is 5.5% comparable those of Ezeugwu et al. [36]. Excess birth weight in this study could be explained by maternal anthropometry before and during pregnancy as well as gestational weight gain. In addition, several studies have shown that excess birth weight is primarily associated with excess maternal weight before pregnancy, excess gestational weight gain, gestational diabetes and multiparity [11,37,38]. This could be consistent with the characteristics of women in this study with the exception of gestational diabetes. On the other hand, the prevalence of excess birth weight ranging from 7 to 14.8% higher than ours, were found in other countries in Africa [11,13,28,39].

The mean birth weight of newborns (3118.48±515.39 g) in this study, is higher than those found in Burkina Faso, Ethiopia and Ghana, which were 2914 g, 2600 g and 2669 g respectively [29,30,33]. A positive association was found in a multivariate linear regression between some maternal anthropometry characteristics, dietary diversity and birth weight after adjusting for the educational level of mother, well-being index and alcohol consumption during pregnancy. Women with medium and higher dietary diversity score gave birth to heavier babies compared to women with low dietary diversity score (P=0.017 and P=0.036, respectively). This could be explained by the fact that women of adequate dietary diversity (≥4 food groups) also consumed nutrient-rich foods, such as milk and dairy products, eggs, fruits and vegetables. These results are in line with those of Saaka [10] and Zerfu et al. [12] which showed that the dietary diversity score has a positive impact on birth weight. Thus, inadequate dietary diversity has been associated with a high risk of premature delivery and low birth weight [12].

In addition, lack of dietary diversity is strongly associated with inadequate intake and risks of essential micronutrient deficiencies [40]. Such insufficient nutrient intake during pregnancy would result in irreversible damage to the fetus that can compromise survival and subsequent health. As a result, a low dietary diversity score has been identified as a major determinant of adverse pregnancy outcomes [40]. Indeed, the mean number of food groups consumed in this study was 4.2, and almost 70% of them had consumed foods from at least four food groups (Table 2). This is in accordance with those reported by Kouassi et al. [22] during the food vulnerability survey in Abidjan. This could be due to the fact that most of the study participants (about 65%) were engaged in an activity that allowed them to earn money, which would then allow them to purchase a greater variety of food. Indeed, low purchasing power limits the consumption of certain food groups such as fruits, vegetables and animal source food [41]. Similarly, the level of education of women in this study could affect their knowledge and practices regarding dietary diversity. This finding is also supported by the study by Aliwo et al. [42] which showed that the probability of adequate dietary diversification was twice as high among educated pregnant women as that of those who had no formal education. One could then say that education contributes to the knowledge of the importance of a diversified diet. In short, nutritional status including maternal nutrition strongly influences birth weight [10,12,13]. Therefore, the challenge for the health authorities of these public health facilities is to develop strategies that would improve access to information on dietary diversification during antenatal care (ANC) visit for women of reproductive age, particularly pregnant women. Contrary to these results, Poon et al. [43] found no relationship between birth weight and maternal diet.

It is clear from Table 5 that gestational weight gain and maternal height were the major maternal factors significantly associated with birth weight. Indeed, women of high stature (> 1.55 m) had babies with a significantly higher birth weight (P=0.004) than women of small stature (≤1.55 m). Studies by Morrison et al. [16] and Tabrizi and Saraswathi [17] have previously found a strong correlation between mother height and birth weight of newborn. It is the same for gestational weight gain. Mothers with high gestational weight gain (>7 kg) gave birth to children with higher birth weight (P=0.000) compared to children of mothers with low gestational weight gain (≤7 kg). Similar results have been reported in many studies [18,19]. This could be explained by the positive correlation (r=0.356; P=0.002, results not shown) between the gestational weight gain of the women in this study and the dietary diversity score, which would have helped the newborn to gain more weight.

The well-being index in this study had no significant influence on baby weight at birth as in the work of Tabrizi and Saraswathi [17] in Iran and Atuahene et al. [44] in Ghana. Nevertheless, results contrary to ours have been observed elsewhere [12,13].

Women's level of education was also not a direct predictor of birth weight. These results are consistent with those of other authors [33, 17,44] who found that educational attainment did not have a significant effect on birth weight.

5. CONCLUSION

At the end of this study, which established the effect of anthropometric and maternal nutrition characteristics on birth weight of the newborn. It appears that low and excessive birth weight (7.6% and 5.5%, respectively) were prevalent among newborns of adult women (20 - 42 years) who gave birth in maternity hospitals of the three municipalities of Abidjan, thus indicating the presence of the mother-child malnutrition cycle. In addition, gestational weight gain, maternal height and dietary diversity score had a positive effect on newborn birth weight.

These results suggest that expanded preventive actions in maternal nutrition and body weight management during pregnancy are needed, particularly in the study areas. Further follow-up studies should be conducted from the beginning of pregnancy to delivery.

CONSENT

As per international standard, patient's written consent has been collected and preserved by the author(s).

ETHICAL APPROVAL

Ethical approval was given by the local Ethics committee (N/Ref:126-18/MSHP/CNESVS-km).

ACKNOWLEDGEMENTS

We would like to thank the heads and personnel of the different maternity hospitals as well as all the women for their collaboration in the implementation of this study. We sincerely thank all the collaborators of the Clinical Biochemistry and Hematology Unit of the Pasteur Institute of Côte d'Ivoire (IPCI).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Pellaë M. Poids et grossesse: importance du statut nutritionnel antérieur. La lettre de l'Institut Danone. 2001;55:6. Fench.
2. Guoyao W, Fuller WB, Timothy AC, Cynthia JM, Thomas ES. Maternal nutrition and fetal development. J Nutr. 2004;134 (9):2169-72.
DOI: 10.1093/jn/134.9.2169
3. Brenseke B, Prater MR, Bahamonde J, Gutierrez JC. Current thoughts on maternal nutrition and fetal programming of the metabolic syndrome. Journal of Pregnancy. 2013;13.
[Article ID 368461]
Available:https://doi.org/10.1155/2013/368461.
4. Sharma M, Mishra S. Effects of maternal health and nutrition on birth weight of infant. International Journal of Science and Research (IJSR). 2014;3(6):855-858.
[Paper ID: 02014116]
5. Cetin I, Laoreti A. The importance of maternal nutrition for health. Journal of Pediatric and Neonatal Individualized Medicine. 2015;4(2):e040220.
DOI: 10.7363/040220
6. Adair LS. Long-term consequences of nutrition and growth in early childhood and possible preventive interventions. Nestlé Nutr Inst Workshop Ser. 2014;78:111–120.
DOI: 10.1159/000354949
7. Schmidt MK, Muslimatun S, West CE, Schultink W, Gross R, Hautvast JGAJ. Nutritional status and linear growth of Indonesian infants in West Java are determined more by prenatal environment than by postnatal factors. The Journal of Nutrition. 2002;132(8):2202-2207.
Available:https://doi.org/10.1093/jn/132.8.2202
8. Mora JO, Nestel PS. Improving prenatal nutrition in developing countries: Strategies, prospects and challenges. Am J Clin Nutr. 2000;71(5Suppl):1353S-63S.
DOI: 10.1093/ajcn/71.5.1353s
9. Ramlal RT, Tembo M, King CC, Ellington S, Soko A, Chigwenembe M, et al. Dietary patterns and maternal anthropometry in HIV-infected, pregnant Malawian women. Nutrients. 2015;7(1):584-94.
DOI: 10.3390/nu7010584.
10. Saaka M. Maternal Dietary Diversity and Infant Outcome of Pregnant Women in Northern Ghana International Journal of Child Health and Nutrition. 2012;1:148-156.
DOI: 10.6000/1929-4247.2012.01.02.6
11. Abubakari A, Jahn A. Maternal dietary patterns and practices and birth weight in Northern Ghana. PLoS ONE. 2016; 11(9):e0162285.
DOI:10.1371/journal.pone.0162285.
12. Zerfu TA, Umeta M and Baye K. Dietary diversity during pregnancy is associated with reduced risk of maternal anemia, preterm delivery, and low birth weight in a prospective cohort study in rural Ethiopia. Am J Clin Nutr. 2016;103(6):1482-8.
DOI: 10.3945/ajcn.115.116798
13. Goshu H, Teshome MS, Abate KH. Maternal dietary and nutritional characteristics as predictor of newborn birth weight in Jimma Town, Southwest Ethiopia. J. Public Health Epidemiol. 2018;10(5):155-164.
Available:https://doi.org/10.5897/JPHE2017.0977
14. Abu-Saad, Fraser D. Maternal nutrition and birth outcomes. Epidemiol. Rev. 2010;32: 5–25
15. Khan AI. Effects of pre- and postnatal nutrition interventions on child growth and body composition: The minima trial in rural Bangladesh. Glob Health Action. 2013;6: 22476.
DOI: 10.3402/gha.v6i0.22476
16. Morrison J, Williams GM, Najman JM, Andersen MJ. The influence of paternal height and weight on birth-weight. Aust N Z J Obstet Gynaecol. 1991;31:114-6.
Available:https://doi.org/10.1111/j.1479-828X.1991.tb01795.x
17. Tabrizi MF, Saraswathi G. Maternal anthropometric measurements and other factors: Relation with birth weight of

neonates. Nutr Res Pract. 2012;6(2):132-7.
DOI: 10.4162/nrp.2012.6.2.132

18. Gala UM, Godhia ML, Nandanwar YS. Effect of maternal nutritional status on birth outcome. International Journal of Advanced Nutritional and Health Science. 2016;4(2):226-233.
[Article ID Med-316]
19. Tela FG, Bezabih AM, Adhanu AK. Effect of pregnancy weight gain on infant birth weight among mothers attending antenatal care from private clinics in Mekelle City, Northern Ethiopia: A facility based follow-up study. PLoS One. 2019;14(3): e0212424.
DOI: 10.1371/journal.pone.0212424
20. Woldeamanuel GG, Geta TG, Mohammed TP, Shuba MB, Bafa TA. Effect of nutritional status of pregnant women on birth weight of newborns at Butajira Referral Hospital, Butajira, Ethiopia. SAGE Open Med. 2019;7:2050312119827096.
DOI: 10.1177/2050312119827096
21. Kouassi KF, Beugré J-B, Aké-Tano O, Aké O, Yeo A, Sonan NK, et al. Comportements alimentaires et etat nutritionnel dans un groupe d'enfants scolarisés en Côte d'Ivoire. Biom. Hum. Et Anthropol. 2010;28(3-4):85 – 93. French
22. Kouassi B, N'Goran P, Tapé C, Anon B, Foto M, Assi Y, et al. Enquête sur la vulnérabilité alimentaire en milieu urbain: Cas de la ville d'Abidjan. Rapport final du Ministère de l'agriculture et du Ministère de la santé et de la lutte contre le SIDA (Côte d'Ivoire). 2013 ;57. French.
23. Gbogouri GA, Vanié SC, Atchibri AL, Brou K. Anthropometric profile and dietary habits of students of Nangui Abrogoua University in Côte d'Ivoire, A Pilot Cross-Sectional Study. International Journal of Food and Nutritional Sciences. 2017; 6(3).
24. MSLS/INS, ICF International. Ministère de la Santé et de la Lutte Contre le Sida (MSLS), Institut National de la Statistique (INS) et ICF International. Enquête Démographique et de Santé et à Indicateurs Multiples de Côte d'Ivoire 2011-2012: Rapport de synthèse. 2013, Calverton, Maryland, USA: MSLS, INS et ICF International. French.
25. Garenne M, Hohmann SA. Wealth index to screen high-risk families: Application to Morocco. J Health Popul Nutr. 2003;21(3): 235-42.
[PMID: 14717569]
26. FAO. Guidelines for measuring household and individual dietary diversity Rome, Italy: Food and Agriculture Organization of the United Nations; 2011.
27. Kennedy G, Razes M, Ballard T, Dop MC. Measurement of dietary diversity for monitoring the impact of food based approaches. International Symposium on Food and Nutrition Security; 2010, Rome Italy.
(Accessed 10 November 2016)
Available: http://www.ipcinfo.org
28. Onubogu CU, Egbuonu I, Ugochukwu EF, Nwabueze AS, Ugochukwu O. The influence of maternal anthropometric characteristics on the birth size of term singleton South-East Nigerian newborn infants. Niger J Clin Pract. 2017;20:852-9.
DOI: 10.4103/njcp.njcp_308_16
29. Nikiéma L, Vocouma A, Sondo B, Martin-Prével Y. Déterminants nutritionnels de l'anémie chez la femme enceinte et issue de la grossesse en milieu urbain au Burkina Faso. Science et technique, Sciences de la santé. 2010;33(1):2. French.
30. Metgud CS, Niak VA and Mallapur MD. Effect of maternal nutrition on birth weight of newborn: a community based study. The Journal Family Welfare. 2012;58(2):35–39.
31. Nzaji KM, Museka JK, Kangulu IB, Kibibi AA, Numbi OL. Influence de l'âge et de la parité de la mère sur le poids de naissance (cas du centre de santé Shungu en RDC. Health Sci Dis. 2014;15(2):4.
32. Luhete PK, Mukuku O, Kayamba PKM. Etude du faible poids de naissance associé à l'âge maternel et la parité dans une population couple mère-enfant suivi à Lubumbashi. The Pan African Medical Journal, 2015;20:246. French.
DOI:10.11604/pamj.2015.20.246.5169.
33. Manyeh AK, Kukula V, Odonkor G, Ekey RA, Adjei A, Narh-Bana S, et al. Socioeconomic and demographic determinants of birthweight in southern rural Ghana: Evidence from Dodowa health and demographic surveillance system. BMC Pregnancy Childbirth. 2016; 16(1):160.
DOI: 10.1186/s12884-016-0956-2
34. Endalamaw A, Engeda EH, Ekubagewargies DT, Belay GM and Tefera MA. Low birth weight and its associated

factors in Ethiopia: A systematic review and metaanalysis. Ital J Pediatr. 2018;44 (1):141.
DOI:10.1186/s13052-018-0586-6
35. Gonzalez-Cossio T, Habicht JP, Rasmussen KM, Delgado HL. Impact of food supplementation during lactation on infant breast-milk intake and on the proportion of infants exclusively breast-fed. The Journal of Nutrition. 1998;128(10): 1692-1702.
36. Ezeugwu HU, Ikeakor LC, Egbuji C. Fetal macrosomia: Obstetrics outcomes of 311 cases in UNTH, Enugu, Nigeria. Niger J Clin Pract. 2011;14(3):322-6.
DOI: 10.4103/1119-3077.86777
37. Olmos PR, Borzone GR, Olmos RI, Valencia CN, Bravo FA, Hodgson MI, et al. Gestational diabetes and pre-pregnancy overweight: possible factors involved in newborn macrosomia. J Obstet Gynaecol Res. 2012;38(1): 208-14.
DOI: 10.1111/j.1447-0756.2011.01681.x
38. Santos EM, Amorim LP, Costa OL, Oliveira N, Guimarães AC. Profile of gestational and metabolic risk in the prenatal care service of a public maternity in the Brazilian Northeast. Rev Bras Ginecol Obstet. 2012;34(3):102-6.
[PMID: 22488492]
39. Denguezli W, Faleh R, Hajjaji A, Saidani Z, Letaier M, Haddad A, et al. Alimentation maternelle et poids fœtal: Rôle des oligo-éléments et vitamines. Journal de Gynécologie Obstétricale et Biologie de la Reproduction. 2007;36(5):473-478.
DOI: 10.1016/j.jgyn.2007.03.006
40. Savy M, Martin-Prevel Y, Sawadogo P, Kameli Y, Delpeuch F. Use of variety/diversity scores for diet quality measurements: Relation with nutritional status of women in a rural area in Burkina Faso. Eur J Clin Nutr. 2005;59(5): 703-16.
DOI: 10.1038/sj.ejcn.1602135
41. Dachner N, Ricciuto L, Kirkpatrick SI, Tarasuk V. Food purchasing and food insecurity among low-income families in Toronto. Can J Diet Pract Res. 2010 Fall; 71(3):e50-6.
DOI: 10.3148/71.3.2010.127
42. Aliwo S, Fentie M, Awoke T, Gizaw Z. Dietary diversity practice and associated factors among pregnant women in North East Ethiopia. BMC Res Notes. 2019; 12(1):123.
DOI:10.1186/s13104-019-4159-6
43. Poon AK, Yeung E, Boghossian N, Albert PS, Zhang C. Maternal dietary patterns during third trimester in association with birth weight characteristics and early infant growth. Scientifica. 2013;7.
https://doi.org/10.1155/2013/786409
44. Atuahene M, Mensah D, Adjuik M. A cross-sectional study of determinants of birth weight of neonates in the Greater Accra region of Ghana. Matern Health Neonatol Perinatol. 2015;1:23.
DOI:10.1186/s40748-015-0023-4

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/51482