Maternal Dietary Diversity and Infant Outcome of Pregnant Women in Northern Ghana

Mahama Saaka*

University for Development Studies, School of Medicine and Health Sciences, P.O. Box 1883, Tamale, Ghana

Abstract: *Objective*: Little is known regarding the role of maternal dietary diversity score (DDS) in predicting poor outcomes of pregnancy including preterm delivery, and low birth weight (LBW). The main aim of this study was to explore the relationship between dietary diversity scores of urban Ghanaian women and infant weight at birth.

Methods: This analytical cross-sectional study comprised 524 pregnant women who delivered singleton babies. A Structured questionnaire was used to collect data on socio-demographic variables (e.g. educational status, age, maternal occupation, household wealth index), obstetric history (for example, gravidity, gestational weight gain), dietary intake, malarial infection and Sulphadoxine pyrimethamine (SP) uptake, blood pressure (BP), haemoglobin concentration (Hb), anthropometric measurements (e.g. weight of mother and new born baby).

Results: This study showed that maternal dietary diversity as measured by individual dietary diversity score scores (IDDS) was a significant independent predictor for mean birth weight and LBW. Analysis of covariance (ANCOVA) showed there was a significant difference in adjusted mean birth weight between women on low and high diversified diets , $F (1, 415) = 8.935$, $p = 0.003$. The results further showed that maternal IDDS was negatively associated with the incidence of LBW (Adjusted OR = 0.43, 95% CI = 0.22–0.85, $p = 0.014$).

Conclusion: In nutritional deprived populations, maternal diet in the third trimester appears to be an important determinant of LBW and that DDS can serve as useful predictive indicator of maternal nutrition during pregnancy and the likelihood of delivering LBW babies.

Keywords: Pregnancy, Ghana, dietary diversity, preterm delivery, low birth weight.

INTRODUCTION

Background

Maternal nutrition appears to play a crucial role in influencing foetal growth and birth outcomes growth [1, 2], but the evidence is far from consistent [3]. Although a strong positive relationship between adequate maternal nutrition and birth outcomes has been clearly demonstrated in experimental animal studies, the relationship is much less consistent in humans perhaps, due to a number of factors including methods previously used to assess maternal nutritional status and confounding variables such as socioeconomic status (SES).

Furthermore, most of the studies that investigated the association between maternal nutrition and birth outcomes have approached the issue by assessing the effect of single nutrients in isolation [3]. A major limitation of this approach is the fact that multiple nutrient deficiencies are more likely to occur than single deficiencies especially in socio-economically deprived populations [4]. An indicator that can capture multiple nutrient deficiencies will best measure the overall adequacy of nutrient intake in these settings. Admittedly, quantitative assessment of dietary food intake has always been a difficult one. This is more so in populations where food is eaten from a common pot, and individual intake is not easily quantified [5].

Available scientific evidence suggests that dietary diversity scores can be a measure of micronutrient diet adequacy of women [6, 7]. Dietary diversity is defined as the number of different foods or groups of food consumed over a period of time, most often in a day or in a week [8]. The concept of dietary diversity score (DDS) in diet quality assessment has been tried in a number places among some population groups [9, 10]. This approach places emphasis on non-quantitative assessment of actual food consumption. Dietary diversity score (DDS) is relatively quite simple to apply and it has been shown to reflect micronutrient intake [10]. There have been three large multi-country validation studies and several smaller studies which have provided scientific evidence for use of dietary diversity scores as a measure of household food security and/or micronutrient adequacy of diets of women of reproductive age [7]. A validation study carried out in a West-African country was able to show that the dietary diversity of an index individual (especially, a woman) was related to a much more comprehensive measure of household nutrient adequacy [11].

*Address corresponding to this author at the University for Development Studies, School of Medicine and Health Sciences, P.O. Box 1883, Tamale, Ghana; Tel: 233-0207061136; E-mail: mmsaaka@gmail.com

E-ISSN: 1929-4247/12

Problem Statement

Adequate dietary intake during pregnancy is an important factor that can affect birth outcome. Dietary diversity scores have been shown to be valid proxy indicators for dietary energy availability at household level and micronutrient adequacy of diets of individuals. As to whether DDS can serve as a reliable indicator of dietary quality that can predict functional outcomes such as preterm delivery, low birth weight (LBW), and intra-uterine growth restriction (IUGR) has received little attention and therefore merits further research especially in developing countries such as Ghana, where measurement of nutrient intakes is problematic. This present study therefore investigated the association of maternal dietary diversity and infant weight at birth in a nutritionally deprived population.

Objectives of the Study

The main aim was to explore the relationship between dietary adequacies, as measured by individual dietary diversity score (IDDS) and infant weight at birth. The specific objectives were to:

1) Determine the prevalence of LBW and preterm delivery in the study sample.

2) Measure nutrient intake using dietary diversity scores (DDS) and to investigate its association to infant weight at birth and LBW.

3) Identify the determinants of food diversity scores among pregnant Ghanaian women.

Significance of the Study

The prevalence of low birth weight is regarded as an index that reflects the level of general and of maternal health and nutrition in particular. The identification of factors that underlay the persistent high percentage of LBW and the initiation of remedial measures to combat it are issues that must receive attention. It is anticipated that this study will provide additional information on the interrelationship between maternal dietary diversity and pregnancy outcomes. The results of the study may also help give a clearer picture of the relationship between maternal DDS and low birth weight in economically developing/low-income populations.

Ethical Clearance

Permission for the study was obtained from authorities of Tamale Teaching Hospital. Ethical clearance was also sought and obtained from the School of Medicine and Health Sciences (SMHS) Ethics Committee, UDS. Each study participant after being briefed and offered the opportunity to ask questions about the study, was provided with individual informed written consent form to sign or thumbprint.

SUBJECTS AND METHODS

Study Area

The study was conducted at the maternity and antenatal units of the Tamale Teaching Hospital. The hospital was chosen because it is the main hospital and serves as major referral centre in Northern Ghana.

Study Design and Participants

This analytical cross sectional study comprised 524 pregnant women who delivered term singleton babies in the Tamale Teaching Hospital in Ghana. The study sample was systematically extracted from the ANC attendance registers which provided the sampling frame.

Data Collection

The data were collected from 1st January through 30th June 2011. Structured questionnaire was used to collect data on socio-demographic variables (e.g. educational status, age, maternal occupation, household wealth index), obstetric history (for example, gravidity, gestational weight gain), dietary intake, malarial infection and Sulphadoxine pyrimethamine (SP) uptake, blood pressure (BP), haemoglobin concentration (Hb), anthropometric measurements (e.g. weight of mother and new born baby).

Uptake of SP tablets was supervised by nurses at ante-natal clinics and recorded in the maternal health records booklet provided to each pregnant woman.

Dietary Assessment

The nutrient adequacy of diet during pregnancy was assessed based on dietary diversity scores. Study participants were interviewed in late pregnancy between 34-36 weeks gestation by the Investigator. The data were collected using a modified version of the FAO dietary diversity questionnaire [12]. The FAO dietary diversity questionnaires is a 12-item scale designed to assess the variety of the diet by summing the number of food groups eaten by household members or individuals in the 24 hours prior to the interview. It is especially suitable in developing countries. The 12 major food groups inquired about are cereals, tubers, vegetables, fruits, meat, fish, eggs, legumes, milk and milk products, fats and oils, sugar and sweets, beverages. We excluded beverages because this food group was not commonly consumed in the study population. This tool can be administered at either the household or individual level. The reference period can either be the previous day or week [13, 14]. At the household level, dietary diversity score is a measure of access to food, (e.g. of households' capacity to access costly food groups). At the individual level, dietary diversity scores (DDS) provide simple, validated measures of dietary quality or nutrient adequacy [15].

In this study, maternal individual dietary diversity score (IDDS) was derived on the basis of the number of food groups consumed from a 24-hour food frequency questionnaire and included 11 food groups. Based on the consumption from a particular food category, as recalled for the past 24 hours, a score of 1 was assigned and tallied to give the DDS, with a maximum possible score of 11. A score of 0 was assigned to a food category if not consumed in the past 24 hours.

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

Assessment of Maternal Height, Weight and Gestational Weight Gain

Maternal height was measured on the participant's first visit to the antenatal clinic. Height was measured to the nearest 0.1 cm. The Seca 767 digital adult scale was used to weigh participants to the nearest 0.05 kg. Gestational weight gain was determined by the difference in maternal weight in early pregnancy (5-10 weeks) gestation and late pregnancy (34-36 weeks).

Estimation of Gestational Age

Accurate estimation of gestational age is a fundamental issue that is essential in the validity and interpretation of anthropometric outcome measures such as birth weight and maternal weight gain during pregnancy [16]. Gestational age at recruitment of participants was assessed on their first visit to the antenatal clinic. In view of recall bias associated with last menstrual period (LMP) approach, gestational age of new born was confirmed by use of biometric measurements of the foetus (that is, ultrasound scanning). The dates for the assessment of gestational age at recruitment and at delivery were all recorded in the maternal health records booklet. The length of gestation was subsequently calculated in completed weeks from the recorded data.

Assessment of Infant Birth Outcomes

Babies delivered in the hospital were weighed naked within two hours of delivery. All babies were weighed by trained midwives on a standard baby weighing scale, to the nearest 1.0 g. Mode of delivery was noted from hospital records. Infants with birth weight < 2500 grams were considered as low birth weight and with birth weight ≥ 2500 grams as normal.

Both preterm (gestational age < 37 weeks), and full-term (gestational age of 37 weeks or higher), deliveries were included in this study.

Diagnosis of Anaemia

Two assessments were made at recruitment and 34-36 weeks of gestation. Haemoglobin concentrations were measured by the cyanmethemoglobin method. Anaemia was defined as haemoglobin concentrations less than 11.0 g/dl.

Diagnosis of Malarial Infection

Peripheral blood parasitemia was assessed through microscopic examination of thin and thick blood smears. Malaria parasite and leucocyte counts were made on the same microscopic fields and a minimum of 200 leucocytes were counted in each blood sample. Malaria infection was defined as the presence of asexual forms of *P. falciparum* parasites (trophozoites, schizonts) in a thick Giemsa-stained blood film [17].

Determination of Educational Level

The educational level was based on the highest level attained according to the Ghanaian System where primary education consist of six years of formal education, the Junior High School (JHS) is nine years, Senior High School (SHS) is 13 years. An individual with tertiary level education spends at least 17 years acquiring formal education. The educational levels were categorized into low and high. Low represented women who had no formal education and those up to Junior Secondary School. High education represented women who completed at least SHS.

Determination of Household Economic Status

A household wealth index based on household assets and housing quality was used as a proxy indicator for socio-economic status (SES) of households. An absolute measure of household wealth (wealth index) used in this study is based on an earlier concept developed by Garenne & Hohmann [18], whereby the sum of dummy variables created from information collected on housing quality (floor, walls, and roof material), availability of water and type of toilet facility, and ownership of household durable goods and livestock (e.g. bicycle, television, radio, motorcycle, sewing machine, telephone, cars, refrigerator, mattress, bed). These facilities or durable goods are often regarded as modern goods that have been shown to reflect household wealth. A household of zero index score for example means that household had not a single modern good. The scores were thus added up to give the proxy household wealth index. The index varied from 0-18. Households that had a wealth index score of 13 and below were classified as having a low wealth index score and those that had a wealth index score of 14 and above were classified as having a high wealth index score.

The main aim of creating the index was to categorize households into SES groupings in order that we could factor in socio-economic status in multiple regression analysis

Data Processing and Analysis

Data collected for the study was analyzed using the Predictive Analytical Software (PASW) formerly known as Statistical Package for Social Sciences (SPSS).

Analysis of covariance (ANCOVA) was used to measure the differences in means and also to control for confounding factors. Chi square test was used to study the significance of difference between proportions. Independent variables found to be significant at the 0.1 level based upon the results of the bivariate tests, were entered as potential variables included in the logistic and linear regression models. Multiple logistic regression models were applied to investigate the predictors of LBW whilst multiple linear regression analysis was used to identify the determinants of mean birth weight. Statistical difference was considered significant if the p-value was <0.05 and 95% confidence intervals (CI) were calculated for all main outcome measures that met the normality and homogeneity assumption criteria. IDDS were categorized into low ($\leq$ 7 food-groups) and high diversified group ($\geq$ 8 food-groups).

RESULTS

Socio-Demographic Characteristics of the Sample

Most of the participants, 87.6 % (459/524) were married whilst the rest were either single or living with their partners. A total of 18.6 % (97) of the study participants reported they were not in any gainful employment. With respect to education, 32.3% of the participants have had no form of formal education at all whereas 11.8% of the sampled populations have had formal education up to the tertiary level. A total of 287

Table 1: Socio-Demographic Characteristics of the Sample

Characteristic	Mean	SD
Maternal Age (years)	26.7	5.2
Hb Concentrations (g/dl)	10.8	1.3
Height (cm)	160.0	6.7
Weight (Kg) at recruitment	60.4	9.4
Gestational Age at recruitment (weeks)	13.7	2.9
Diastolic Blood Pressure (mmHg)	58.9	10.4
Systolic Blood Pressure (mmHg)	103.0	12.8
% of Primigravidae	32.3 (169/524)	
% of Secundigravidae	30.0 (157/524)	
% of Multigravidae	37.7 (197/524)	

out of the total 524 women sampled representing 54.8% were within the age range of 21-30 years. The mean age was 26.7±5.2 (Table **1**).

Dietary Diversity and Food Group Frequency Consumption

In late pregnancy, the minimum dietary diversity (that is, proportion of women who receive foods from 8 or more food groups in seven days was 85.5 %. The mean DDS-11 was 9.1±1.4.

The mean food group frequency of consumption (past 7 days) was 15.0±2.8. The minimum and maximum of the food group frequency of consumption index scores were 6.0 and 22 respectively.

Pregnancy Outcomes

The mean gestational age (in weeks) of the study participants was 38.4 ± 2.6. A significant proportion 92.6 % (485/524) of the participants delivered at full term, whilst 7.4 % (39) delivered before their 37th week making them preterm. Out of 524 deliveries, 50.6 % (265) were females. The mean birth weight was 2,845±0.5 g. The incidence of LBW was 17.0 % (89/524).

Relationship between Maternal Dietary Diversity and Birth Weight

In adjusted regression model (ANCOVA), there was a significant difference in adjusted mean birth weight between women on low and high diversified diets, $F(1, 415) = 8.935$, $p = 0.003$. The adjusted mean birth weight in the high diversified Group was 197.0 g higher than in the group that was on low diversified diets (2,867 g versus 2,670 g). Mean birth weight was adjusted for maternal age, length of gestation, educational level, gender of baby, gestational weight gain, uptake of SP, frequency of ANC attendance, and anaemia during pregnancy.

The results of this study also showed that maternal IDDS was associated with reduced risk of LBW (Adjusted OR = 0.43, 95% CI = 0.22–0.85, *p* = 0.014). The covariates controlled for were SP uptake, preterm delivery, gender of infant and household wealth index.

Determinants of Mean Birth Weight

A statistical model was developed to assess the relationship between infant weight at birth and potential determinants. Using multivariate linear regression analysis (Stepwise) method, some important determinants were identified. Variables found to be significant at the 0.1 level were entered into the model (that is, malarial infection, candidiasis, household wealth index, type of occupation, length of gestation, anaemia during pregnancy, gravidity, maternal height, educational level, mode of delivery, marital status, age, ethnicity, SP intake, gender of infant, gestational weight gain, maternal IDDS, maternal food group frequency of consumption index).

The main independent determinants of infant weight at birth in the adjusted linear multiple regression model were malarial infection, uptake of SP, anaemia during pregnancy, gestational weight gain, length of gestation,

Table 2: Determinants of Birth Weight

Model	Standardized Coefficients	T	Sig.	95% Confidence Interval for B	
	Beta			Lower Bound	Upper Bound
(Constant)		3.08	0.002	0.39	1.76
Number of SP doses	0.14	3.07	0.002	0.02	0.10
Anaemia during pregnancy	-0.16	-3.72	<0.001	-0.24	-0.08
Gender of infant	-0.16	-3.68	<0.001	-0.24	-0.07
Length of gestation	0.14	3.19	0.002	0.01	0.04
Weight of mother in the first trimester of pregnancy (Kg)	0.13	2.95	0.003	0.002	0.012
Gestational wt gain	0.19	4.21	<0.001	0.009	0.025
DDS Classification	0.12	2.70	0.007	0.05	0.31
Educational level	0.09	2.07	0.039	0.003	0.12

maternal age, educational level, maternal dietary diversity score, gender of infant (Table **2**). The set of predictors accounted for 33.0 % of the variance in birth weight (Adjusted $R^2 = 0.331$).

Considering the beta coefficients, female babies had birth weights 0.161 standardized units lower than their male counterparts. In the same light, growth restricted babies were lighter by 0.395 units. Longer gestation was associated with heavier babies; a week increase in gestation was associated with of 0.141 standard units increase in birth weight. Babies of women on high diversified diet were heavier than those of low diversified diet by 0.117 units. On the average, women who received three doses of SP delivered babies who were heavier by 0.136 standard units, compared to those who did not receive any SP during pregnancy. Women who were anaemic during pregnancy delivered babies who were 0.162 standard units lighter than those who were not anaemic. Gestational weight gain was the strongest determinant of mean birth weight (Table **2**).

Determinants of LBW

The incidence of LBW was more common in younger (11-20 years), compared to the older (41-50 years) mothers (chi-square = 9.697, p = 0.021). LBW was also common in the low-income group and those with little or no education.

The important independent variables in the adjusted logistic regression model were maternal dietary diversity score, uptake of SP, preterm delivery, gender of baby and household's wealth.

Women who were on low dietary diversified diet were 2.3 times increased risk of delivery LBW babies compared to those on high dietary diversified scores (Adjusted OR: 2.3, CI: 1.18 - 4.78, p = 0.014). Preterm delivery and poor family wealth were the most important determinants of LBW. Women from households whose wealth index was classified as high who receives financial support had 71.0 % protection against LBW, compared to those from households of low financial support (Table **3**).

Determinants of DDS

Using the stepwise selection procedure in multiple regression analysis, household wealth index classification and frequent ANC attendance were the only significant independent predictors of maternal DDS.

Women of high household wealth index had a mean DDS that was significantly different from those in low household wealth index (9.2 versus 8.7) [F (*1, 508)* = 9.941, p = 0 .002].

Similarly, the food group consumption frequency index was higher in women from households of high wealth index, compared with women of low household wealth index 15.4 versus 14.1) [F (*1,* 508) = 15.465, p = 0 .001].

DISCUSSION

In the present study, there was statistically significant positive association between maternal DDS and infant weight at birth. There was however, no discernible relationship between maternal dietary diversity score and preterm delivery.

Previous studies that investigated actual nutrient intakes found no significant association with pregnancy

Table 3: Determinants of LBW

	B	S.E.	Wald	Sig.	Exp(B)	95.0% C.I.for EXP(B)	
						Lower	Upper
Household Wealth	-1.26	0.30	17.02	<0.001	0.29	0.16	0.52
SP uptake	-0.39	0.11	11.86	0.001	0.68	0.54	0.85
Gender of infant	-0.61	0.28	4.77	0.029	0.54	0.31	0.94
IDDS	0.84	0.35	5.99	0.014	2.33	1.18	4.57
Preterm	1.52	0.40	14.33	<0.001	4.59	2.09	10.10
Anaemia	-0.99	0.38	6.97	0.008	0.37	0.18	0.77
Constant	0.85	0.49	3.01	0.083	2.33		

outcomes [19-24]. Contrarily to these studies, significant association between nutrient intake and mean birth weight, LBW and preterm delivery among low socio-economic groups in East London, United Kingdom and the US have been reported [25, 26] .

Other studies have revealed that maternal dietary composition has an effect on foetal growth [27, 28]. Furthermore, multi-micronutrient supplements mostly in low-income/ developing-country populations significantly reduced risk of LBW and increased birth weight in comparison with placebo or iron-folic acid supplements alone [29, 30].

As pointed out by Worthington-Roberts and Klerman [24], the inconsistent results on maternal diet and pregnancy outcome may be due to difficulty in assessing accurate dietary intake and little variation in average daily nutrient intake among women in many populations studied. It is expected that maternal diet should have an effect on pregnancy outcomes especially in situations where women are undernourished before and/or during pregnancy. In this study sample, maternal diet during pregnancy of some women was poor.

The major influence regulating foetal growth is the supply of nutrients to the foetus [31]. It important to emphasize that during pregnancy foetal supply is affected by not only what the mother eats but also the mechanism of nutrients transfer to and across the placenta. Furthermore, nutrient supply to the foetus depends also on the mother's body composition, size and total store of nutrients.

In this study, dietary assessment was undertaken in the third trimester of pregnancy. In a study in Australia, maternal dietary composition in late pregnancy was largely unrelated to birth size of the baby; although there was an indication that high carbohydrate intake was linked to neonatal thinness [28].

By virtue of the fact that nutritional requirements of the developing foetus is time dependent, effects of nutritional deprivation on foetal growth could vary with the time of pregnancy. Therefore the effect of maternal diet on the foetus in early pregnancy may not be the same as with late pregnancy. Embryonic growth depends initially on simple molecules such as pyruvate, and thus being influenced more by amino acid concentrations [32]. Glucose becomes a major fuel later in gestation [33]. It is however, not clear the exact role some critical micronutrients which are provided by diversified diet might be playing at each stage of gestation. One cannot therefore be certain that nutrition requirements of the foetus, especially micronutrients are tied to any particular trimester of pregnancy.

The true relationship between maternal diet and pregnancy outcome appears to be confounded by socio-economic differentials. Kramer *et al*. [34] maintained that elimination of the higher risks of IUGR and preterm birth among the poor appears impossible without eliminating poverty itself. This highlights the critical role socioeconomic disparities play in pregnancy outcome. It was clear from the present study that household wealth index was a major determinant of maternal dietary diversity and also a strong independent determinant of birth weight. Maternal DDS was sufficiently higher in women of high socio-economic class, compared to women of low socio-economic class. Similar studies conducted in developing countries have demonstrated that a DDS is associated with socio-economic status. This association existed irrespective of the number of food groups from which the DDS was calculated. In the Ghanaian study, eleven food groups were used in an urban setting. In Mali and Burkina Faso, household DDS estimated from nine food groups was found to be associated with socio-economic status of household [9, 35]. Hoddinott and Yohannes [6] also reported that a DDS calculated from a list of 12 food groups was associated with household income. Frequent ANC attendance was strongly associated with maternal dietary diversity. This may be attributed to the nutrition education given to pregnant women at ANC sessions.

Findings of the present study suggest maternal diet is of great importance in deprived environments. This is consistent with the conclusion of a recent review of studies that maternal nutrition plays a crucial role in influencing fetal growth and birth outcomes [3] particularly among developing/low-income populations.

Individual dietary diversity score IDD serves as a proxy of the nutrient (mainly micronutrient) adequacy of the diet of an individual. The association between maternal dietary intake as measured by IDDS and infant weight at birth has rarely been investigated especially in developing countries where measurement of nutrient intakes is problematic. This study may perhaps be one of the few that has explored the relationship of IDDS and pregnancy outcomes.

CONCLUSION

In nutritional deprived populations, maternal diet appears to be an important determinant of LBW and that DDS can serve as useful predictive indicator of maternal nutrition during pregnancy and the likelihood of delivering LBW babies but not preterm delivery. Dietary diversity score was positively and significantly associated with infant weight at birth.

LIMITATION OF THE STUDY

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

The study also relied on secondary data about participants recorded by health professionals during the pregnancy. Therefore any error in measurements, readings or recordings of these parameters and indices will reflect in the results. However with the level of professionalism of health workers in the institutions involved in the study, this is expected to be minimal.

ACKNOWLEDGEMENT

The author gratefully acknowledges the women who participated in the study, the midwives and administrative staff of the Tamale Teaching Hospital who made the study possible.

REFERENCES

[1] World Health Organization. Report of the advisory group meeting on maternal nutrition and low birth weight. Geneva: WHO 2002.

[2] World Health Organization. Promoting optimal fetal development: report of a technical consultation. Geneva: WHO 2006.

[3] Abu-Saad K, Fraser D. Maternal Nutrition and Birth Outcomes. Epidemiol Rev 10; 32: 32: 5-25.

[4] Fall CH, Yajnik CS, Rao S, *et al.* Micronutrients and fetal growth. J Nutr 2003; 133(5 suppl 2): 1747S-56S.

[5] Hudson G. Food intake in a west African village. Estimation of food intake from a shared bowl. Br J Nutr 1995; 73(4): 551-69. http://dx.doi.org/10.1079/BJN19950058

[6] Hoddinott J, Yohannes Y. Dietary Diversity as a Household Food Security Indicator. FANTA Project. Washington, DC: Academy for Educational Development 2002. http://dx.doi.org/10.3945/jn.110.123414

[7] Arimond M, Wiesmann D, Becquey E*, et al.* Simple food group diversity indicators predict micronutrient adequacy of women's diets in 5 diverse, resource-poor settings. J Nutr 2010; 140(11): 2059S-69S.

[8] Ruel MT. Is dietary diversity an indicator of food security or dietary quality? A review of measurement issues and research needs. FCND Discussion Paper no 140 Washington, DC: IFPRI 2002.

[9] Hatloy A, Hallund J, Diarra MM*, et al.* Food variety, socioeconomic status and nutritional status in urban and rural areas in Koutiala (Mali). Public Health Nutr 2000; 3(1): 57-65. http://dx.doi.org/10.1017/S1368980000000628

[10] Arimond M, Ruel MT. Progress in Developing an Infant and Child Feeding Index: An Example using the Ethiopia Demographic and Health Survey 2000. Washington, DC: International Food Policy Research Institute 2002.

[11] Becquey E, Martin-Prevel Y, Traissac P, *et al.* The household food insecurity access scale and an index-member dietary diversity score contribute valid and complementary information on household food insecurity in an urban West-African setting. J Nutr 2010; 140(12): 2233-40. http://dx.doi.org/10.3945/jn.110.125716

[12] FAO. Guidelines for Measuring Household and Individual Dietary Diversity, Rome-Italy: FAO/Nutrition and Consumer Protection Division 2007; pp. 5-31.

[13] FAO. Guidelines for measuring household and individual dietary diversity Rome, Italy: Food and Agriculture Organization of the United Nations 2011.

[14] World Food Programme (WFP). Comprehensive Food Security & Vulnerability Analysis Guidelines Rome, Italy: United Nations World Food Programme 2009.

[15] Kennedy G, Ballard T, Dop MC. Guidelines for Measuring Household and Individual Dietary Diversity Rome, Italy: FAO, Nutrition and Consumer Protection Division 2011.

[16] WHO. Physical status: the use and interpretation of anthropometry. Report of WHO Expert Committee. WHO Technical Report Series, no 854. Geneva: World Health Organization 1995.

[17] World Health Organization. Basic Laboratory Techniques. Geneva, Switzerland: World Health Organization 1982.

[18] Garenne M, Hohmann S. A wealth index to screen high risk families: application to Morocco. J Health Population Nutr 2003; 21(3): 235-42.

[19] Johnson AA, Knight EM, Edwards CH, *et al.* Dietary intakes, anthropometric measurements and pregnancy outcomes. J Nutr 1994; 24(6 Suppl): 936S-42S.

[20] Mathews F, Yudkin P, Neil A. Influence of maternal nutrition on outcome of pregnancy: prospective cohort study. BMJ 1999; 319(7206): 339-43. http://dx.doi.org/10.1136/bmj.319.7206.339

[21] Rosso P, Ed. Nutrition and Metabolism in Pregnancy: Mother and Fetus. New York, NY: Oxford University Press Inc. 1990.

[22] Scholl TO, Hediger ML, Khoo C*, et al.* Maternal weight gain, diet and infant birth weight: Correlations during adolescent pregnancy. J Clin Epidemiol 1991; 44: 423-8. http://dx.doi.org/10.1016/0895-4356(91)90081-J

[23] Susser M. Maternal weight gain, infant birth weight, and diet: causal sequences. Am J Clin Nutr 1991; 53: 1384-96.

[24] Worthington-Roberts BS, Klerman LV. Maternal nutrition. In: Merkatz IR, Thompson JE, Mullen P*, et al.*, Eds. *New Perspectives on Prenatal Care*. New York, New York: Elsevier Science Publishing Co. Inc. 1990; pp. 235-71.

[25] Scholl TO, Hediger ML, Bendich A*, et al.* Use of multivitamin/ mineral prenatal supplements: influence on the outcome of pregnancy. Am J Epidemiol 1997; 146(2): 134-41. http://dx.doi.org/10.1093/oxfordjournals.aje.a009244

[26] Doyle W, Wynn AHA, Crawford MA*, et al.* Nutritional counseling and supplementation in the second and third trimester of pregnancy, a study in a London population. J Nutr Med 1992; 3(3-4): 249-56. http://dx.doi.org/10.3109/13590849208997980

[27] Ferland S, Turgeon O'Brien H. Maternal dietary intake and pregnancy outcome. J Reproduc Med 2003; 48(2): 86-94.

[28] Moore VM, Davies MJ, Willson KJ, *et al.* Dietary Composition of Pregnant Women Is Related to Size of the Baby at Birth. J Nutr 2004; 134: 1820-6.

[29] Shah PS, Ohlsson A. Knowledge Synthesis Group on Determinants of Low Birth Weight and Preterm Births. Effects of prenatal multimicronutrient supplementation on pregnancy outcomes: a meta-analysis. CMAJ 2009; 180(12): E99-E108. http://dx.doi.org/10.1503/cmaj.081777

[30] Harder T, Rodekamp E, Schellong K, *et al.* Birth weight and subsequent risk of type 2 diabetes: a meta-analysis. Am J Epidemiol 2007; 165: 849-57. http://dx.doi.org/10.1093/aje/kwk071

[31] Barker D. The malnourished baby and infant. Br Med Bull 2001; 60: 69-88. http://dx.doi.org/10.1093/bmb/60.1.69

[32] Martin PM, Sutherland AE, Van Winkle LJ. Amino acid transport regulates blastocyst implantation. Biol Reprod 2003; 69: 1101-8. http://dx.doi.org/10.1095/biolreprod.103.018010

[33] Harding JE. The nutritional basis of the fetal origins of adult disease. Int J Epidemiol 2001; 30: 15-23. http://dx.doi.org/10.1093/ije/30.1.15

[34] Kramer MS, Séguin L, Lydon J, *et al.* Socio-economic disparities in pregnancy outcome: why do the poor fare so poorly? Paediatr Perinat Epidemiol 2000; 14(3): 194-10. http://dx.doi.org/10.1046/j.1365-3016.2000.00266.x

[35] Savy M, Martin-Prevel Y, Traissac P, *et al.* Measuring dietary diversity in rural Burkina Faso: comparison of a 1-day and a 3-day dietary recall. Public Health Nutr 2007; 10(1): 71-8. http://dx.doi.org/10.1017/S1368980007219627

Received on 15-09-2012 Accepted on 01-12-2012 Published on 31-12-2012

http://dx.doi.org/10.6000/1929-4247.2012.01.02.6