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Gestational Iron Deficiency and the Related Anaemia in Northern Zone of Ebonyi State

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Abstract: Iron is one instrumental micronutrient to any healthy pregnancy. Its deficiency (with or without overt anaemia) remains a significant risk factor to gestational complications. In the present study, 307 pregnant women were prospectively recruited from Northern zone of Ebonyi State to assess their gestational iron status. The iron status of the subjects was determined with serum iron level and heamoglobin concentration, using atomic absorption (flame) spectrometric and Drabkin's methods respectively. Statistical analysis was performed using the computer software: "Statistical Program for Social Sciences" (SPSS for windows version 15.0). The result showed that 177 (59.8%) of the pregnant women were iron deficient, while 45.6% of them was at the risk of iron deficiency anaemia. Parity, educational level, occupation and living accommodation showed significant ($p<0.05$) influence on the iron status of the subjects. It could be concluded that gestational iron deficiency with its related anaemia was yet to be effectively brought under control in our society; with parity and economic status implicated as risk factors.

Key words: Gestation, iron, deficiency, anaemia, Ebonyi state

INTRODUCTION

Iron is an important trace element in human nutrition. As a transition metal, it has two important properties relevant to its biological role: ability to exist in several oxidation states and ability to form stable coordination complexes (Rang *et al*., 2003). Its importance in human body is based on its occurrence in many haemoproteins (Murray *et al*., 2003).

Unique to iron is its high cost (1000 mg^{-1} pregnancy) of pregnancy (Van Den Broek, 2003), compared to other micronutrients like zinc or folic acid (Seshadri, 2001). The gestational iron demand is 3-4 folds the requirement of the non-pregnant women (Zavaleta *et al*., 2000). Although it can be mobilized from the maternal stores to meet this requirement, women in general, are found to have low iron stores (due probably to the monthly loss of blood in menstruation) (Beard, 1994) and pregnant women in particular, may have no stores of iron at all (Carriaga *et al*., 1991). Once these stores are depleted, the mother will develop iron deficiency (Godfrey *et al*., 1991). A deficiency of iron causes a reduction in the rate of haemoglobin synthesis and can result in iron-deficiency anaemia (Champe and Harvey, 1994). Iron deficiency, with or without anaemia, is reported to affect about 25% of the poorer pregnant women even in developed countries like USA (Beard, 1994).

Iron deficiency can occur as a result of a diet poor in iron or impaired intestinal absorption of iron (Champe and Harvey, 1994). Insufficient supplies of such a micronutrient can lead to a state of biological competition between the mother and conceptus, which can be detrimental to the health status of both (King, 2003). Iron deficiency is usually considered to develop in three sequential stages: depletion of iron stores, iron deficiency erythropoiesis and overt anaemia with low haemoglobin levels (Seshadri, 2001). Iron Deficiency Anaemia (IDA) during pregnancy can result to serious consequences for both the mother and her baby. Iron deficient women are at higher risk of preterm delivery (Allen, 2001), perinatal mortality and an increased incidence of LBW babies (WHO, 2000; Srivastava *et al*., 2002). In Ebonyi State, there have been instances of such gestational complications, including those as mentioned above. Therefore, the present study prospectively looks into the iron status of pregnant women of the Northern Zone of Ebonyi State, Nigeria.

MATERIALS AND METHODS

Study site and setting: Two hospitals - Federal Teaching Hospital Abakaliki (FETHA) and St Vincent Hospital, Ndubia (SVHN) - within the Northern zone of Ebonyi State were selected for the study. Three hundred and seven

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(307) pregnant women attending antenatal clinics in the two hospitals were recruited. The selection was done by simple random method.

The main occupation of the people was subsistence-level farming-mainly rice, yam and cassava-with some animal husbandry. Other professions included civil service; trading and "artisanry" were also practiced.

Sample collection: At recruitment, the obstetric and demographic data of the participants were collected through a semi-structured questionnaire. The maternal anthropometrics were also taken. With the help of the health experts, non-fasting venous blood sample (5.0 mL) was collected from each participant at the antenatal care (ANC) halls of the study hospitals, using dry disposable plastic syringes. Aliquot of 2.0 mL was dispensed into EDTA bottle and used for haematological studies the same day. The remaining blood sample was dispensed into plane glass test tube and allowed to clot, from where serum was extracted. The serum was transported frozen to Kogi State University, Ayimgba for determination of serum iron level.

Determination of haemoglobin (Hb) concentration: Drabkin's method as described by Cheesbrough (2000) was used in determining the maternal Hb concentration. This method has taken an edge of reliability over other tested methods like Sahli's method (Balasubramaniam and Malathi, 1992). It is based on the principle that haemoglobin is oxidized to methaemoglobin by potassium ferricyanide which reacts with cyanide ions of potassium cyanide to form cyanmethaemoglobin whose absorbance is measured at 540 nm. Haemoglobin concentration was then estimated with the help of cyanmethaemoglobin curve. Samples were ran in triplicates and the average forms the final result. Maternal Hb level of <11 g dL^{-1} during pregnancy was indicative of anaemia (WHO/UNICEF/UNU, 1996).

Determination of serum iron level: The maternal serum iron level was determined using the method of atomic absorption (flame) spectrometry as described by Wojck *et al.* (2009). The blood serum was subjected to wet mineralization and was hot dissolved in nitric acid solution [1 mL of serum +10 mL solution of $H_2SO_4 + HNO_3$ (1:1) and heated]. The iron level in the cleared solution (resulted mineralizate) was determined through an atomic absorption spectrometer in triplicates and the average taken as the final result. Iron level <10 μmol L^{-1} was considered deficient.

Data analysis: Data were analyzed using the computer software "Statistical Programme for Social Sciences" (SPSS for windows, version 15.0). One way ANOVA, students' t-test and Pearson's correlation (X^2) were used for basic statistics; while statistical significance was considered at 95% confidence limit ($p<0.05$).

Ethical approval: Approval for the study was given by the Health and Ethics Committee of the two hospitals (FETHA and SVHN). The study was also approved by Ebonyi State University, Abakaliki, Nigeria, the institution within which the research was carried out.

RESULTS

Out of 307 pregnant women recruited for this study, two (2) were dropped along the line on health ground, one declined to donate her blood sample (for her reserved reason(s)), one of the blood samples was found clotted during screening (for [Hb]), while seven (7) of the serum samples were lost along the line due to cracks sustained on the vials and consequent contamination with the ice.

The age of the subjects ranges from 15-40 years, with the mean age (±SD) of 27.3±5.18 years. Their mean gestational age (±SD) was 23.0±4.48 weeks (range 11-38 weeks). Their [Hb] ranges from 6.3-13.3 g dL^{-1} (mean 10.1±1.33 g dL^{-1}) and the range of serum Fe was 0.36-128.57 μmol L^{-1} (mean 12.1±12.6 μmol L^{-1}) (Table 1).

From Fig. 1, the result showed that 59.80% of the women screened for iron status indicated Fe deficient, while 46.96% of them had developed iron deficiency anaemia.

The mean serum Fe of the pregnant women depended significantly on their ages (in years) but the prevalence of GID did not (Table 2). The women, 30 years of age and above, showed significantly higher mean serum Fe than their younger counterparts ($p<0.05$). The women below 20 years showed the least prevalence of gestational Fe deficiency (46.7%) than the older women but not statistically significant.

The BMI of the pregnant women had no significant influence on either the mean serum Fe level or the prevalence of GID (Table 2). The severely and moderately malnourished women showed the lowest

Table 1: General Characteristics of the Pregnant Women

Parameter	N	Range	Mean (SD)
Age (years)	304	15-40	27.3 (5.18)
Gestational age (weeks)	305	Nov-38	23.0 (4.48)
Weight (kg)	305	40-109	64.8 (12.7)
Height (m)	305	1.3-1.8	1.57 (0.09)
BMI (kg m^{-2})	305	17.3-42.6	26.3 (3.91)
Hb (g dL^{-1})	303	6.3-13.3	10.1 (1.33)
Serum Fe (μmol L^{-1})	296	0.36-128.57	12.1 (12.6)

N: population size; S.D.: Standard deviation

Table 2: The Prevalence of Gestational Iron Deficiency (GID) according to Anthropometric Factors (Maternal Age and BMI)

		Serum Fe (μmol L^{-1})			
	No. of subjects	Range	Mean±SD	GID (%)	IDA (%)
Maternal age (years)					
<20	15	4.5-28.8	12.0±6.79[a]	46.7	43.8
20-24	68	0.4-61.8	9.78±9.23[a]	70.6	56.3
25-29	112	1.8-80.0	12.0±10.7[a]	59.8	44.2
30-34	72	1.1-72.0	12.3±12.4[a]	56.9	39.2
35-39	22	2.2-44.5	14.1±11.0[a]	50.0	41.7
>39	6	0.4-128.6	29.0±49.1[a]	50.0	50
Total	295	0.4-128.6	12.1±12.6[a]	60.0	45.7
BMI group					
Severe	2	2.7-7.7	5.21±3.58	100.0	100
Moderate	16	4.4-128.6	19.8±30.5	56.3	43.8
Normal	99	0.4-80.0	11.7±10.1	62.6	49
Overweight	66	1.4-72.0	13.6±13.8	63.6	39.4
Obese	113	0.4-44.8	10.7±9.13	63.7	45.6
Total	296	0.4-128.6	12.1±12.6	63.2	45.6

Values with superscript showed statistical significance at $p<0.05$-ANOVA used

Table 3: The Prevalence of Gestational Iron Deficiency (GID) according to Obstetric Factors (Gestational Age and Parity)

		Serum Fe (μmol L^{-1})			
	No. of subjects	Range	Mean±SD	GID (%)	IDA (%)
Gestational age (weeks)					
<12	2	5.0-9.8	7.41±3.41[a]	100	100
12-17	26	1.8-44.8	12.7±10.4[a]	46.2	31
18-23	127	0.4-44.5	9.76±7.60[a]	66.1	50
24-29	126	0.4-80.0	13.4±13.1[a]	57.1	45.2
30-35	11	1.8-128.6	21.1±36.2[a]	54.5	42.9
>35	4	8.2-29.5	18.6±10.7[a]	25	16.7
Total	296	0.4-128.6	12.1±12.6[a]	59.8	45.6
Parity					
Primigravida	98	0.4-61.8	11.2±9.35[a]	59.2	51.0[b]
Primipara	59	1.8-43.0	9.94±8.62[a]	69.5	45.9[b]
2	42	1.8-72.0	11.5±13.0[a]	69	46.5[b]
3	30	3.5-33.2	10.3±6.69[a]	56.7	53.3[b]
>3	67	0.4-128.6	16.5±19.1[a]	47.8	33.8[b]
Total	296	0.4-128.6	12.1±12.6[a]	59.8	45.6[b]

Values with superscript "a" showed statistical significance at $p<0.05$-ANOVA used. *Values with superscript "b" showed statistical significance at $p<0.05$-Pearson's X2 used

(5.21±3.58 μmol L^{-1}) and the highest (19.8 ±30.5 μmol L^{-1}) mean serum Fe level respectively; while GID decreased in prevalence from the severely to the moderately malnourished subjects and then increased from the normal women down to the obese, but no significant difference was detected in each case.

There was no significant effect of either the maternal age or BMI shown on the prevalence of IDA among the pregnant women in any case (Table 2). However, the women at the age 20-24 years and >39 years showed higher prevalence of IDA than the other groups though not statistically significant ($p>0.05$).

From the result in Table 3, it showed that the gestational age of the pregnant women has significant effect on the mean value of the serum Fe ($p<0.05$) but not on the prevalence of GID. The women in their third trimester were significantly of higher mean serum Fe level followed by those in their second trimester while those in their first trimester ranked last (7.41±3.41 μmol L^{-1}).

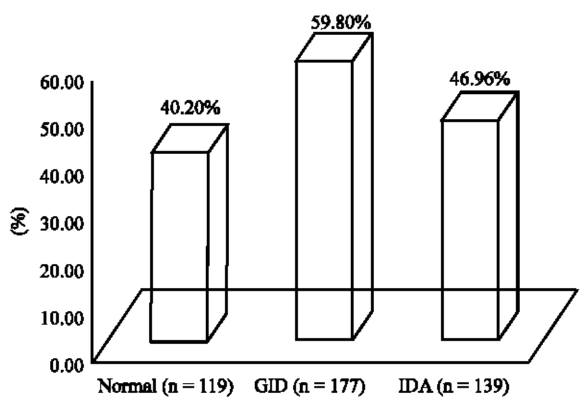

Fig.1: The serum Fe Distribution of the pregnant women, Population size, Fe deficient = serum Fe <10 μmol/L; Fe normal = serum Fe =10 μmol/L (Robets *et al*., 2006)

Table 4: The Prevalence of Gestational Iron Deficiency (GID) according to the Socio-economic Factors

Socio-economic factors		No. of subjects	Serum Fe (μmol L^{-1}) Range	Mean±SD	GID (%)	IDA* (%)
Occupation	House wives	49	3.1-45.1	10.7±8.79[a]	61.2	50.0[d]
	Civil servants	76	2.1-44.8	10.3±9.00[a]	67.1	45.5[d]
	Artisans	8.9	0.4-61.8	11.5±10.1[a]	60.7	51.1[d]
	Students	33	2.4-25.2	9.15±5.35[a]	63.6	42.4[d]
	Farming	49	0.4-128.6	19.4±22.3[a]	42.9	34.0[d]
	Total	296	0.4-128.6	12.1±12.6[a]	59.8	45.6[d]
Level of education	None	48	0.4-128.6	22.6±23.8[a]	37.5[c]	32.7[c]
	Primary	71	0.4-33.2	10.7±7.51[a]	62.0[c]	52.7[c]
	Secondary	104	1.8-44.8	9.93±7.59[a]	64.4[c]	46.2[c]
	Tertiary	70	2.1-43.0	9.67±7.75[a]	65.7[c]	45.7[c]
	Total	293	0.4-128.6	12.1±12.7[a]	59.7[c]	45.4[c]
Living accommodation	Single room	140	2.1-45.1	9.51±7.41[b]	65.8	48.8[d]
	Flat	72	1.8-43.0	10.5±8.10[b]	63.9	42.5[d]
	Bungalow	100	0.4-128.6	16.3±18.2[b]	51	5.8[d]
	Duplex	1	11.79	11.2±0.00[b]	0	0.00[d]
	Total	293	0.4-128.6	12.1±12.7[b]	60.1	46.0[d]

Values with superscript "c" and "d" were statistically significant at $p<0.01$ and $p<0.05$, respectively-Pearson's X2 used. [+]Values with superscript "a" and "b" showed statistical significance at $p<0.001$ and $p<0.01$, respectively-ANOVA used

Parity of the subjects also had significant relationship with their mean serum Fe level but not with the prevalence of GID (Table 3). Those with parity greater than 3 showed significantly higher mean serum Fe level (16.5±19.1 μmol L^{-1}) than the rest of them ($p<0.05$). While higher prevalence of GID was shown in women with parity less than 3 though not statistically significant.

Table 3 also showed the relationship between the prevalence of IDA and the parity of the pregnant women. The primigravida and those with parity of 3 showed significantly higher prevalence of IDA ($p<0.01$).

Table 4 presented the effect of socio-economic status of the pregnant women on their Fe status. The more actively engaged women (farmers and artisans) showed significantly higher mean serum Fe level than the less actively engaged ($p<0.001$); while those somehow engaged in sedentary work (C/S, students and H/W) showed higher prevalence of GID though not statistically significant ($p>0.05$).

The result also displayed significant relationship between the mean serum Fe level and the prevalence of GID with the educational level of the pregnant women (Table 4). The less formal educated women (none and primary education) showed significantly higher mean serum Fe level ($p<0.001$) and lower prevalence of GID ($p<0.01$).

There was significant influence of the living accommodation of pregnant women on their mean serum Fe level but not on the prevalence of GID (Table 4). Those living in single room and flat, showed significantly lower mean serum Fe level ($p<0.01$) and higher incidence of GID (statistically insignificant, $p>0.05$) than their counterparts in bungalow and duplex.

It showed that the artisans ranked significantly ($p<0.05$) highest in the prevalence of IDA (51.1%), while the sedentary house wives ranked next (50.0%) followed by the civil servants and the students with the prevalence of 45.5% and 42.4% respectively (Table 4). The farmers ranked lowest with the prevalence of 34.0%.

The women who never acquired any formal education recorded lower prevalence of IDA (32.7%) than those who have acquired one level of formal education or the other, which was significant at $p<0.01$ (Table 4). The result further recorded that those living in single rooms and bungalows were significantly more vulnerable to IDA at pregnancy ($p<0.05$), than those living in flats and duplex (Table 4).

DISCUSSION

Pregnant women are particularly vulnerable to Fe deficiency as a result of the increased demand for Fe (Van Den Broek, 2003). In 2003, National Food Consumption and Nutrition Survey (NFCNS) reported 43.7% prevalence of Fe deficiency among Nigerian pregnant women (IITA, 2004). From the present study, it was observed that 177(59.8%) of the surveyed women were Fe deficient (Fig. 1). Studies have implicated Fe deficiency to adverse pregnancy outcomes (Lozoff, 2007; Georgieff, 2008). Increased incidence in this finding therefore calls for high public concern. This result however aligns with the earlier finding of 48% (Daouda *et al*., 1991) and recent finding of 63.6% (Ugwuja *et al*., 2010) prevalence from similar studies. These are indications that Government's efforts alongside World Health intervention programmes to reduce nutrients deficiencies during pregnancy in developing countries have so far yielded but a little fruit. Possible reasons to this have been given to include low compliance due to inadequate patient motivation, low motivation of health personnel, poor access to health services, adverse effects and inadequate supplies of supplement tablets (Zavaleta *et al.*, 2000). In their recent study on the level of compliance of pregnant Malaysian women, Thirukkanesh and Zahara (2010) observed that up to 50% of the women did not comply with the nutrients supplementation. This likely explains the high level of Fe deficiency still detected in our present study, as they have been found to display similar attitude toward antenatal services (Nwonwu *et al.*, 2009). Another possible reason in this case might come from dietary practices of relying on staple food crops that characterize people of developing countries (Faber *et al.*, 2005). In Nigeria, starch and vegetables form the major dietary staples. The inhibitory constituents such as fibers, polyphenolics, phosphates, some proteins and organic acids commonly present in such diets can prevent dietary iron absorption (Whittaker and Ologunde, 1990).

Habit of eating pica (compulsive eating of non-nutritive substances) has been associated with iron deficiency (Lopez *et al.*, 2004) and might be another contributory risk factor here. This could be applicable to the environment of our study where much of the pregnant women crave for a special type of clay of the kaolinite group (called *nzu* in Igbo Language), which is easily accessible in the open markets within the area.

In the present study, level of education was identified as a significant risk factor for the prevalence of iron deficiency. The more formally educated women showed significantly lower mean serum Fe ($p<0.001$) and higher prevalence of iron deficiency ($p<0.01$). This present finding does not tally with the common believe that more educated mothers would more likely keep to better nutrition and good health. Reasonable explanation to this seems far-fetched. However, one can easily reason that women of this caliber engage in white collar jobs and can often spend long hours in the office works at the cost of keeping to their food supplements regimen. And pregnancy is so iron costly that no one's store of iron alone can pay off.

The maternal age (Table 2), gestational age, parity (Table 3) and occupation (Table 4) all showed significant relationship with the mean serum Fe level. Their relationship with the prevalence of GID however, did not show any statistical significance at all cases. This implies that these variables seem not significant risk factors to GID, apart from educational level, which was also indicated in the recent work of Okwu and Ukoha (2008).

Okwu and Ukoha (2008) reported higher incidence of IDA (68.78%) in their earlier work than in the present study. The lower prevalence in our own finding might stem from the difference in the use of indicators for the surveys. Their study used [Hb] alone to determine IDA. But Cook *et al* (1976) demonstrated earlier that use of multiple indices of iron status provides a more accurate measure of Fe status than any single index. Scholl and Reilly (2000) used serum ferritin in addition to heamatological parameters to differentiate IDA from anaemia due to other causes. Then Hashizume *et al.* (2005) combined serum ferritin with serum Fe, in addition to hematological parameters for the purpose of the same distinction. In the present study, serum iron with heamatological parameters were used to solve the same problem. This is because, though overt anaemia is the last stage of iron deficiency, anaemia from other causes is not associated with low biochemical parameters (Institute of Medicine, 1990). And Hashizume *et al.* (2003) reported that only one-third of the incidence of anaemia in their surveyed population could be attributed to Fe deficiency. While Scholl (2005) insisted that anaemia is not synonymous with IDA whatsoever. The present study detected a higher proportion of the anaemic women to be Fe deficient. Our finding thus corroborates the earlier claim that iron deficiency is the most common cause of anaemia, which the 2010 report of Ugwuja *et al.* (2010) rather contradicts.

There was earlier claim that prevalence of IDA increased 2-fold or more for those women who are minor, below the poverty level or less than 12 years of education (Scholl, 2005). In our present study, parity and socioeconomic factors (occupation, educational level and living accommodation) were detected to impact significantly on the incidence of IDA among the surveyed population, in support of the above claim. Parity appeared to have somewhat direct relationship with the prevalence of IDA, from the primipara to parity of 3 that showed significantly highest prevalence of IDA (Table 3). This evinces the claim of Looker *et al.* (1997) that risk increases with parity, higher for women with 2-3 children. This further strengthens the correlation between iron depletion and parity multiplicity. Parity of >3 showed the least prevalence, while the women who went into pregnancy for the first time ranked 2nd highest, next to parity of 3 in the prevalence of IDA. The reasons for this trend remain obscure, but one possible explanation to the relatively high prevalence of IDA among the primigravida is that these women might have entered pregnancy with low Fe status, implying that the control policy of micronutrient supplementation was yet to appreciate in them.

The women who never acquired beyond primary education in our surveyed population showed significantly ($p<0.01$) higher prevalence of IDA than the rest of the groups (Table 4). The high prevalence in this group is an indication that they can easily fall prey to parasitic infections, which have been shown to increase the incidence of IDA (Allen, 2005). It is a common belief that more enlightened women would keep better hygienic practices, hence lower incidence of IDA due possibly to reduced chances of parasitic infections, already found to be common in this population (Nwonwu *et al*., 2009). The relatively lower prevalence of IDA (32.7%) detected among "no-formal-education" group in the present study is not very clear, but could be due to low data size.

The unemployed women (H/W) and artisans were detected to be significantly ($p<0.01$) more vulnerable to IDA than others (Table 4). These are the economically weaker ones with the associated consequences of low purchasing power and hence low access to better nutrition, lack of early access to antenatal care and better health conditions, which make deficiencies inevitable. The association of these socioeconomic factors in the present study is in conformity with the claim of Nantel and Tontisirin (2002).

In conclusion, GID and the consequent IDA were still prevalent among pregnant women of Northern zone of Ebonyi State. Parity, occupation, educational level and living accommodation were significant risk factors to iron status of the screened population.

However, the scope of this study is not enough and cannot be claimed to have a full representation of the entire State. Thus a wider range of study is recommended to assess the gestational iron status of Ebonyi State women that would be more encompassing to represent the entire State.

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