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# Iron Deficiency among Pregnant Women Attending Antenatal Clinic at the KNUST Hospital, Kumasi, Ghana

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***Authors' contributions***

*This work was carried out in collaboration between all authors. Authors CO, FYB and LA designed the study and its coordination and participated in the drafting of the manuscript. Authors SA and IA carried out all the haematological and biochemical assays, performed the statistical analysis and helped in the drafting of the manuscript. All authors read and approved the final manuscript.*

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## ABSTRACT

**Background:** Pregnant women constitute a high risk group for iron deficiency due to increased iron requirements for foetal and maternal tissues growth. This study sought to find out the prevalence of iron deficiency among Ghanaian pregnant women obtaining antenatal care at the University hospital, Kumasi, Ghana.

**Methods:** The study was conducted between January and May, 2013. A total of 180 women, 150 at various stages of pregnancy and 30 non-pregnant women as control group were recruited for the study. Information on socio-demographic characteristics was obtained from the subjects by means of face-to-face interviews. Using venous blood samples, iron status of subjects was

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assessed by the determination of haemoglobin, haematocrit, mean cell volume, red cell distribution width, serum ferritin, serum iron, serum transferrin, total iron binding capacity, unoccupied iron binding capacity and percentage saturation of transferrin. Intestinal helminthic infestation was determined by stool examination.

**Results:** Decreasing levels of haemoglobin, serum iron, transferrin, Total iron binding capacity and increasing levels of Mean cell volume and RDW-SD were observed as pregnancy advanced. None of the subjects had helminthic infestation. Anaemia, iron deficiency (ID) and iron deficiency anaemia (IDA) were present in 44.0%, 21.5% and 10.4% of the pregnant women, respectively. These prevalence rates increased as pregnancy advanced to term (15.2%, 51.2%, 56.0% for anaemia; 13.8%, 22.9%, 26.1% for ID and 0%, 12.0%, 17.4% for IDA, respectively for the 1st, 2nd and 3rd trimesters).

**Conclusions:** In spite of iron supplementation in pregnancy, a high percentage of the pregnant women are iron deficient and/or anaemic and this remains a public health problem.

*Keywords: Anaemia; supplementation; parity; ferritin; transferring; helminthic.*

## 1. INTRODUCTION

Iron deficiency is considered the most common nutritional deficiency worldwide[1]. There are no current national figures for iron deficiency, but using anaemia as an indirect indicator it can be estimated that, about 1.62 billion people globally, corresponding to 24.8% of the world's population are iron deficient [2]. About 41.8% of pregnant women are anaemic worldwide with the highest proportion in Africa where 57.1% of pregnant women are anaemic [2].

The body's homeostatic mechanisms conserve iron efficiently. However iron deficiencies can still arise, following extensive negative iron balance, leading to decreased or exhausted iron stores [3]. Iron deficiency arises when the intake fails to meet physiologic needs and it is worsen in conditions that require increased iron demand as in pregnancy and this can deplete the iron stores [3].

Pregnant women constitute a high risk group for iron deficiency due to increased physiological and metabolic demands imposed by the growing placenta, foetus and maternal tissues [4]. Iron deficiency with consequent anaemia during pregnancy is associated with an increased risk of low birth weight neonates, preterm delivery and infant or maternal mortality [5-7]. In Ghana, 1 in 10 infants are born with a low birth weight as indicated by UNICEF report in 2009. Iron deficiency in pregnant women is therefore a serious public health problem especially in tropical countries [2].

This hospital-based cross-sectional study was carried out to determine the prevalence of iron deficiency and anaemia among pregnant women visiting the University hospital, Kwame Nkrumah University of Science and Technology (KNUST), Kumasi, Ghana. The study aimed at evaluating the prevalence of iron deficiency among pregnant women with differences in iron supplementation, parity and socioeconomic status, as well as determining correlations among serum ferritin, serum iron, serum transferrin, total iron binding capacity, haemoglobin, means red cell volume, haematocrit and red cell distribution width in pregnancy.

## 2. MATERIALS AND METHODS

### 2.1 Settings

This hospital-based study was conducted in the antenatal clinic at the Kwame Nkrumah University of Science and Technology hospital, Kumasi, Ghana between January and May, 2013.

### 2.2 Study Subjects

A total 180 Ghanaian women between 18 and 40 years of age, who visited the KNUST hospital were included in this study. The test group comprised of 150 pregnant women and were classified into three subgroups according to the stage of pregnancy, thus, first, second and third trimester. The remaining 30 were healthy non-pregnant control group whose ages were comparable to those of the test group. The participation of all the subjects was voluntary and informed consent was obtained from each of them. Information on age, parity, educational level, occupation, drugs currently in use, whether or not subject was on iron supplement, as well as clinical history for both pregnant and non-pregnant subjects were obtained by means of written questionnaire. Women with known renal disease or disorders such as hypertension, diabetes and haemoglobinopathies were excluded. Women on non-steroidal anti-inflammatory drugs, pregnant women with diagnosed complications of pregnancy as well as control subjects taking haematinics or oral contraceptives were also excluded. The study was approved by the local Committee on Human Research Publication and Ethics (CHRPE/KNUST–SMS/KATH) with reference number CHRPE/AP/051/13.

## 2.3 Sample Collection and Laboratory Procedure

A total of five (5) ml of venous blood was drawn from each subject. About 2 ml of this was dispensed into an EDTA-containing tube with remaining 3 ml dispensed into gel serum separator tube. A complete blood count was done on the EDTA blood using the haematology autoanalyser, Sysmex KX-21N (Sysmex Corporation, Kobe, Japan). The 3 ml blood was spun to obtain the serum for biochemical determination of serum ferritin, serum iron, serum transferrin, total iron binding capacity (TIBC), unoccupied iron binding capacity (UIBC) and transferrin saturation (TSAT). The determination of serum ferritin, serum iron and serum transferrin were by solid phase sandwich enzyme-linked immunosorbent assay (an immunoenzymometric sequential assay), colorimetric and immunoturbidimetric methodsrespectively, using Fortress Diagnostics (UK) assay kits. In the serum ferritin assay, absorbances were read at 450 nm with an ELx800™ Microplate Reader (Bio-Tek Instruments, Winooski, VT, USA). Serum samples not readily used were stored below –80ºC.

From experimentally determined relationship provided in the assay kit, TIBC was calculated for each of the specimens using the relationship: $\text{TIBC } (\mu\text{mol/l}) = 0.2275 \times \text{transferrin (mg/dl)}$

UIBC and TSAT were then calculated as follows:

$$\text{UIBC } (\mu\text{mol/l}) = \text{TIBC } (\mu\text{mol/l}) - \text{serum iron } (\mu\text{mol/l})$$

$$\text{TSAT}(\%) = \frac{\text{Serum iron } (\mu\text{mol/l})}{\text{TIBC } (\mu\text{mol/l})} \times 100$$

Stool samples were also collected from each subject in clean wide mouth containers to determine the presence or otherwise of intestinal helminthiasis.

## 2.4 Data Analysis

All statistical analyses were done using Microsoft Excel, 2007 and GraphPad Prism version 5.00 for windows (GraphPad software, San Diego California USA, www.graphpad.com). Continuous variables were expressed as their mean ± SEM, while categorical variables were expressed as proportion. Comparisons of the pregnant women against the control group were performed using unpaired *t* tests.
The differences between means of more than two groups were tested by performing one way ANOVA. Pearson correlation coefficients were calculated to determine correlations among haemoglobin, haematocrit, MCV, serum iron, TIBC, UIBC, TSAT and serum ferritin levels. A level of $P<.05$ was acceptable as statistically significant.

# 3. RESULTS

Out of the total 150 pregnant women selected into the study, 22.0% (33/150) were in their first trimester of pregnancy whereas 61.3% (92/150) and 16.7% (25/150) were in their second and third trimesters respectively. The mean age of the test group was 29.15±0.41 years and that of control group was 27.47±0.84 years, which were comparable ($P$ = 0.0937).Among the test group, 50.0% were on iron supplements. None of the subjects had helminthic infestation.

The age distribution and haematological and biochemical variables in the studied groups: test group (pregnant women) and controls (non-pregnant women) are shown in Table 1.

In general, haemoglobin ($p$=0.0001) and haematocrit ($p$=0.0006) were significantly lower in the test group while MCV ($p$=0.0153) and RDW-SD ($p$=0.0016) were significantly higher in the test group, as compared to the controls.

Although serum ferritin levels were higher in the controls than the test group, the difference was not significant ($p$ = 0.7640). Significantly, serum transferrin, TIBC and UIBC were each higher in the test group than the controls while serum iron and transferrin saturation were significantly lower in the test group than the controls ($p$<0.0001).

**Table 1. Distribution of age, haematological and biochemical variables in the studied groups: test group (pregnant women) and controls (non-pregnant women)**

| Parameter | Total (n = 180) | TG (n = 150) | CG (n = 30) | **P*-value |
|---|---|---|---|---|
| **Age** | 28.87±0.37 | 29.15±0.41 | 27.47±0.84 | 0.0937 |
| **Haematological profile** | | | | |
| Hb (g/dl) | 11.15±0.09 | 11.00±0.09 | 11.88±0.21 | 0.0001 |
| Hct (%) | 33.85±0.24 | 33.48±0.26 | 35.68±0.54 | 0.0006 |
| MCV (fl) | 82.63±0.49 | 83.16±0.50 | 79.98±1.52 | 0.0153 |
| RDW-SD (fl) | 44.37±0.34 | 44.85±0.36 | 42.00±0.85 | 0.0016 |
| **Biochemical profile** | | | | |
| Serum ferritin (ηg/ml) | 42.78±2.95 | 42.39±3.39 | 44.77±5.11 | 0.7640 |
| Serum iron (µmol/l) | 10.59±0.42 | 9.11±0.37 | 17.26±0.82 | <0.0001 |
| ST (mg/dl) | 329.80±8.76 | 347.90±9.88 | 248.80±9.10 | <0.0001 |
| TIBC (µmol/l) | 75.04±1.99 | 79.14±2.25 | 56.61±2.07 | <0.0001 |
| UIBC (µmol/l) | 60.58±2.08 | 65.30±2.33 | 39.35±1.65 | <0.0001 |
| TSAT (%) | 19.80±1.33 | 17.39±1.53 | 30.62±1.23 | <0.0001 |

*Data are expressed as mean ± SEM (standard error of mean). *Unpaired t test for means compared with controls. TG = Test group, CG = Control group. Hb, haemoglobin; Hct = haematocrit; MCV = mean corpuscular volume; RDW-SD = red cell distribution width-standard deviation; SF = Serum ferritin, SI = Serum iron, ST = Serum transferrin, TSAT = Transferrin saturation, TIBC = Total iron binding capacity, UIBC = unoccupied iron binding capacity.*

The age distribution, haematological and biochemical variables among test group according to the trimester of pregnancy are summarised in Table 2. In general, Hb, Hct, serum ferritin, serum iron, serum transferrin, TIBC and TSAT decreased with increasing trimester of pregnancy but only Hb, Hct and serum ferritin showed statistically significant differences among the three trimesters (*P*-value for one way ANOVA <0.05). MCV and RDW-SD however, increased with increasing trimester of pregnancy but only MCV showed significant differences among the three trimesters (*P*-value for one way ANOVA <0.05).

The distribution of components of iron status and prevalence of anaemia, iron deficiency (ID) and iron deficiency anaemia (IDA) in test group with or without iron supplementation is provided in Table 3. Hb, Hct, serum ferritin, serum iron and TSAT were higher among those without iron supplements as compared to those with iron supplement, although the differences were not significant (*P*> 0.05). On the other hand, MCV (*p*=0.0191) and RDW-SD (*p*=0.0143) were significantly higher in those with iron supplement as compared to those without iron supplement.

Those without iron supplements had higher levels of transferrin, TIBC and UIBC than those with iron supplement, although the differences were not significant (*P*> 0.05). Anaemia, ID and IDA were each insignificantly more prevalent among those on iron supplements as compared to those without iron supplements.

Table 4 provides Pearson correlation coefficients among some demographical and, haematological and biochemical variables for test and controls groups. Amongst the test group, Hb, Hct and serum ferritin decreased significantly with increasing trimester of pregnancy. MCV and RDW-SD however, indicated significant positive correlations with trimester of pregnancy. Both Hb and Hct showed significant negative correlation with serum iron. Hb also showed significant negative correlation with RDW-SD. MCV on the other hand, positively correlated with RDW-SD. Serum transferrin, UIBC and TIBC all correlated negatively with TSAT. No significant correlations however, were found between Hb, Hct or MCV (from the complete blood count) and any of the markers of iron status, including serum ferritin, serum transferrin, TIBC, UIBC and TSAT.

Among the controls however, MCV positively correlated with Hct and RDW-SD. Serum iron showed significant positive correlation with TSAT. Unlike the test group, only UIBC negatively correlated significantly with transferrin saturation among the controls.

Prevalence of anaemia, iron deficiency (ID) and iron deficiency anaemia (IDA) were 44.0%, 21.5% and 10.4% respectively among the pregnant women. Anaemia was present in 16.7% of the controls but none of them was found to be iron deficient or iron deficient anaemic. Haemoglobin levels and iron status decreased as pregnancy advanced to term and prevalence of anaemia, ID and IDA increased accordingly.

**Table 2. Distribution of age, haematological and biochemical variables among test group according to trimester of pregnancy**

| Parameter | 1st trimester (n = 33) | 2nd trimester (n = 92) | 3rd trimester (n = 25) | Anova |
|---|---|---|---|---|
| **Age** | 27.70±0.91 | 27.31±0.47 | 28.24±1.24 | 0.2113 |
| **Haematological profile** | | | | |
| Hb (g/dl) | 11.55±0.16 | 10.87±0.11 | 10.77±0.29 | 0.0057 |
| Hct (%) | 34.99±0.51 | 33.03±0.30 | 33.17±0.81 | 0.0074 |
| MCV (fl) | 81.42±0.93 | 83.16±0.57 | 85.43±1.67 | 0.0441 |
| RDW-SD (fl) | 43.74±0.65 | 44.81±0.34 | 46.44±1.51 | 0.0664 |
| **Biochemical profile** | | | | |
| SF (ηg/ml) | 57.88±8.68 | 40.24±4.16 | 29.83±5.80 | 0.0273 |
| SI (µmol/l) | 9.34±0.55 | 9.07±0.52 | 8.94±0.92 | 0.9420 |
| ST (mg/dl) | 383.6±20.42 | 339.3±12.58 | 333.6±24.44 | 0.1631 |
| TIBC (µmol/l) | 87.28±4.65 | 77.19±2.86 | 75.90±5.56 | 0.1632 |
| UIBC (µmol/l) | 72.16±5.27 | 62.71±2.97 | 65.99±5.25 | 0.2701 |
| TSAT (%) | 22.14±5.49 | 16.72±1.50 | 13.83±1.83 | 0.2121 |

*Data are expressed as mean ± SEM. One way ANOVA test; for the differences among means of the three trimesters. Hb, haemoglobin; Hct, haematocrit; MCV, mean corpuscular volume; RDW-SD, red cell distribution width-standard deviation; SF = Serum ferritin, SI = Serum iron, ST = Serum transferrin, TSAT = Transferrin saturation, TIBC = Total iron binding capacity, UIBC = unoccupied iron binding capacity.*

**Table 3. Distribution of components of iron status and prevalence of anaemia, iron deficiency and iron deficiency anaemia in test group with or without iron supplementation**

| Parameter/Category | With iron supplement (n = 75) | Without iron supplement (n = 75) | *p*-value |
|---|---|---|---|
| Hb (g/dl) | 10.94±0.16 | 11.04±0.11 | 0.5911 |
| Hct (%) | 33.32±0.44 | 33.60±0.31 | 0.5994 |
| MCV (fl) | 84.48±0.84 | 82.14±0.58 | 0.0191 |
| RDW-SD (fl) | 45.85±0.65 | 44.08±0.38 | 0.0143 |
| Serum ferritin (ηg/ml) | 39.37±5.73 | 44.69±4.09 | 0.4381 |
| Serum iron (µmol/l) | 8.51 ±0.55 | 9.54±0.50 | 0.4577 |
| Serum transferrin (mg/dl) | 335.2±15.63 | 357.1±12.71 | 0.2763 |
| TIBC (µmol/l) | 76.27±3.56 | 81.24±2.89 | 0.2762 |
| UIBC (µmol/l) | 60.83±3.73 | 68.57±2.94 | 0.1013 |
| TSAT (%) | 16.61±1.89 | 17.97±2.27 | 0.6616 |
| Anaemia | 37 (49.3) | 30 (40.0) | 0.3244 |
| Iron deficiency | 17 (22.7) | 15(20.0) | 0.8423 |
| Iron deficiency anaemia | 8 (10.7) | 7(9.3) | 1.0000 |

*Data are expressed as mean ± SEM or number (%).*

Thus prevalence rates were 15.2%, 51.2%, 56.0% for anaemia; 13.8%, 22.9%, 26.1% for ID and 0%, 12.0%, 17.4% for IDA, respectively for the 1$^{st}$, 2$^{nd}$ and 3$^{rd}$ trimesters.

In this study, lower prevalence of iron deficiency (ID) was observed among pregnant women with higher parity (11.8%) as compared those with lower parity (24.8%), although difference not significant ($P$ = 0.1561).

Anaemia, ID and IDA were all found to be lower among those working (38.5%, 17.3%, and 8.8% respectively) as compared to those not working (45.2%, 25.0%, and 16.7% respectively) although the differences were not significant ($P$> 0.05).

However, there was higher prevalence of anaemia (20.0%), ID (11.2%) and IDA (6.2%) among pregnant women of low educational status as compared to those of higher educational status (12.7%, 7.1% and 2.3% respectively for anaemia, ID and IDA).

**Table 4. Pearson Correlation Coefficients between age, trimester of pregnancy, parity and haematological and biochemical variables for test group (Lower Left-Hand Side) and controls (Upper Right-Hand Side)**

| Parameter | Parity | Trimester | Hb | Hct | MCV | RDW-SD | SF | SI | ST | TIBC | UIBC | TSAT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Parity | | - | 0.01 | -0.08 | -0.17 | -0.28 | 0.10 | 0.60 | 0.13 | 0.13 | 0.12 | -0.03 |
| Trimester | 0.05 | | - | - | - | - | - | - | - | - | - | - |
| Hb | -0.00 | -0.23** | | 0.78*** | 0.28 | -0.19 | 0.21 | 0.05 | 0.20 | 0.20 | 0.19 | -0.02 |
| Hct | -0.03 | -0.20* | 0.89*** | | 0.64*** | 0.34 | 0.07 | 0.07 | 0.15 | 0.15 | 0.13 | 0.00 |
| MCV | -0.06 | 0.20* | -0.03 | -0.06 | | 0.71*** | 0.05 | 0.11 | 0.01 | 0.01 | -0.01 | 0.01 |
| RDW-SD | -0.12 | 0.19* | -0.18* | -0.07 | 0.66*** | | -0.19 | 0.02 | 0.02 | 0.02 | 0.03 | -0.04 |
| SF | 0.07 | -0.21** | -0.00 | -0.06 | 0.05 | -0.04 | | -0.23 | -0.31 | -0.31 | -0.28 | -0.01 |
| SI | 0.18* | 0.07 | -0.19 | -0.22 | 0.12 | 0.00 | -0.06 | | 0.65*** | 0.65*** | 0.32 | 0.69*** |
| ST | 0.10 | 0.05 | 0.10 | 0.06 | 0.00 | -0.08 | -0.06 | 0.08 | | 1.00*** | 0.93*** | -0.09 |
| TIBC | 0.10 | 0.05 | 0.10 | 0.06 | 0.00 | -0.08 | -0.06 | 0.08 | 1.00*** | | 0.93*** | -0.09 |
| UIBC | 0.15 | 0.11 | -0.01 | -0.01 | 0.01 | -0.06 | 0.00 | -0.01 | 0.82*** | 0.82*** | | -0.46*** |
| TSAT | -0.04 | -0.13 | 0.14 | 0.10 | -0.00 | -0.08 | -0.04 | 0.06 | -0.29*** | -0.29*** | -0.54*** | |

**. Correlation is significant at the 0.05 level (2-tailed), **. Correlation is very significant at the 0.05 level (2-tailed), ***. Correlation is extremely significant at the 0.05 level (2-tailed).SF = Serum ferritin, SI = Serum iron, ST =Serum transferrin, TSAT = Transferrin saturation, TIBC = Total iron binding capacity UIBC = unoccupied iron binding capacity.Hb, haemoglobin; Hct, haematocrit; MCV, mean corpuscular volume; RDW-SD, red cell distribution width-standard deviation.*

## 4. DISCUSSION

A salient finding of this study is a 44.0% prevalence of anaemia among the pregnant women. According to WHO (2001), this is regarded as a severe public health problem (anaemia of >40% in the population). Varying prevalence rates of anaemia in pregnancy have been reported with Bondevik et al. [8] reporting as high as 76.6%, Engmann [9] reported 34% in Ghana and Dim & Onah [10] reported 40.4% in Enugu, Nigeria. The prevalence of anaemia in pregnancy of 44.0% in this study compares well with that reported by Dim & Onah [10]. Engmann et al. [9] reported 16% and 7.5% for iron deficiency and iron deficiency anaemia, respectively among Ghanaian pregnant women. Comparatively, the prevalence rates obtained in this study were higher for iron deficiency (21.5%) and iron deficiency anaemia (10.4%). A similar study by Raza et al. [11] in Pakistan indicated prevalence rates of 50-60% and 26% for iron deficiency and iron deficiency anaemia respectively among pregnant women. While none of the controls in this study was either iron deficient or iron deficient anaemic, 20% of controls in the study by Raza et al. [11] were iron deficient but none of them was iron deficient anaemic. The inconsistency in these prevalence rates may be contributed to, in part, by the different sample sizes, as well as different geographic, demographic and social factors, resulting in differences in worm infestation, parity rate, dietary pattern and socioeconomic status, even in different parts of the same country. In pregnancy, an increase in iron demand is required to meet the expansion in maternal haemoglobin mass and to meet the needs of foetal growth [12]. Irrespective of maternal iron status, there is constant active transport of iron to the foetus almost the entire pregnancy. Negative iron balance throughout pregnancy, particularly in the latter half, may lead to iron deficiency anaemia during the third trimester [12]. This affirms the findings that, in this study, anaemia, iron deficiency (ID) and iron deficiency anaemia (IDA) were highest in the third trimester.

The levels of serum ferritin in this study decreased significantly in all the three trimesters. This is in agreement with results reported by other studies [11,13,14]. Studies by Lee et al. [15] and Raza et al. [11] reported significantly decreasing levels of serum iron in all the three trimesters. Consistently, this pattern was observed for serum iron in this study. Whiles Raza et al. [11] reported increasing levels of serum TIBC and UIBC throughout pregnancy, the results of this study indicated decreasing levels of serum transferrin, TIBC and UIBC with paradoxical decreasing levels of transferrin saturation throughout pregnancy. The corresponding decrease in serum iron with decreasing TIBC perhaps explains the decreasing levels transferrin saturation since transferrin saturation is a ratio of serum iron to TIBC expressed as a percentage. The study further observed increasing MCV and RDW-SD with increasing gestational age even among pregnant women taking iron supplements. Macrocytosis is physiological in pregnancy [16,17]. It is therefore normal for the MCV to increase by about 4 fl in pregnancy but in a few women the increase can be as high as 20 fl [16]. The increased MCV returns to the normal range post-natally. Sometimes, this physiological macrocytosis is enough to mask the microcytosis normally seen in iron deficiency [11]. As has been indicated, the prevalence of iron deficiency increased with increasing gestational age in this study. The increasing RDW-SD with increasing gestational age indicated increasing degree of anisocytosis among the pregnant women, which is a pattern observed in iron deficiency.

A single best marker of iron deficiency does not exist [11]. A more effective method is to use various combinations of measurements to define varying stages of iron lack or to enhance the specificity of prevalence estimates. However, places such as parts of Ghana and other developing countries where facilities are not available, the standard obstetrical practice is the measurement of Hb, Hct and MCV to provide information about iron status. This has included iron therapy for patients with anaemia (Hb<11 g/dl) without requiring the determination of iron deficiency [14]. This study therefore sought to determine correlations between each of Hb, Hct and MCV, and serum ferritin, serum transferrin, TIBC, UIBC and transferrin saturation.

In this study, no significant correlation was observed between Hb, Hct and MCV, and serum ferritin, serum transferrin, TIBC and UIBC. While a similar study by Raza et al. [11] reported significant correlations for TIBC, UIBC and TSAT against serum iron in pregnancy, this study found no significant correlations between these parameters.

A study by Alper et al. [14] indicated that the use of haematological indices provided on complete blood count were not useful in predicting iron deficiency based on serum ferritin levels. In reference to this and together with the fact that Hb, Hct, MCV reduce late following iron depletion [18,19], the use of these haematological indices in assessing iron status in pregnancy must be carefully looked at.

Oral iron supplementation is widely used in the treatment and prophylaxis against iron deficiency in pregnancy [20]. Some studies have reported improvement in iron status with iron supplementation in pregnancy [21,22]. A study by Hemminski & Rimpela [23] however indicated that, in women close to iron depletion at the time of conception, there is the development of iron deficiency in early pregnancy and that traditional iron intervention would be ineffective in preventing iron depleted state. According to Allen [24], iron supplementation often fails to prevent iron deficiency in women who enter pregnancy with inadequate iron stores. In this study, as high as 22.7% and 10.7% of pregnant women taking iron supplement were iron deficient and iron deficient anaemic respectively. Anaemia, ID and IDA were higher among those taking iron supplement, as compared to those without although the differences were not significant ($P > 0.05$ for each comparison). Also there were no significant differences in Hb, Hct, serum ferritin, serum iron, serum transferrin, TIBC, UIBC and transferrin saturation levels between those taking iron supplements and those who were not. RDW-SD was also significantly increased in those taking iron supplements, as compared to those without iron supplement. Therefore, it could be elucidated that some of the pregnant women on iron supplementation were close to iron depletion and hence developed iron deficiency which could not respond to iron supplementation. Dose-dependent side effects and lack of compliance may also explain such a phenomenon [24,25]. Insufficient duodenal iron absorption thereby reducing the efficacy of the supplement may also be a factor; however this study could not explain whether or not this was a phenomenon due to lack of data on diet and gastrointestinal disorder.

Several studies [10,26,27] have considered associations between factors such as high parity, socioeconomic status, and the development of iron deficiency or anaemia in pregnancy. In spite of this, there have been inconsistent reports on the effect of high parity on iron status. While some studies did not find high parity to have significant effect on iron status [10,26,27], Raza et al. [11] have reported increased risk of iron deficiency or anaemia among pregnant women with high parity.

In this study, the lower prevalence of iron deficiency (ID) among pregnant women with high parity than those with lower parity, although difference was not significant ($p = 0.1561$), is no different from that by Asif et al. [26]. According to Asif et al. [26], high parity had no significant effect on serum ferritin levels. However, the high prevalence of anaemia, ID and IDA among pregnant women of low socioeconomic status in this study is consistent with studies by Isah et al. [27] and Raza et al. [11]. Chotnopparatpattara et al. [28] have similarly reported higher prevalence of anaemia among pregnant women with low level of education, as compared to the well-educated. Low socioeconomic status is considered a risk factor for iron deficiency when coupled with the increased iron demands imposed by pregnancy [29,30].

## 5. CONCLUSION

The prevalence of anaemia and iron deficiency is high among pregnant women obtaining antenatal care at the University hospital, Kumasi. The prevalence of anaemia in the study population is therefore a severe public health problem in accordance with criteria set by the World Health Organization. The results of this study also suggest that anaemia predates pregnancy in the majority of cases. Furthermore, the results of this study suggest that, iron supplementation does not seem to protect against iron deficiency among some pregnant women. Results from this study suggest more thorough investigations which should include markers of iron status rather than the routine obstetrical practice of determining haemoglobin, haematocrit and mean cell volume which are unreliable as early predictors of iron deficiency and anaemia in pregnancy. A thorough assessment of this approach should therefore be considered.

## CONSENT

The consent of all subjects were sought through signing a consent form. All subjects who did not consent were excluded from the study.

## ETHICAL APPROVAL

All authors hereby declare that all experiments have been examined and approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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