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Haematological profile of healthy pregnant women in Ibadan, South-western Nigeria

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Summary

There is a dearth of information on the reference values for haematological indices particularly according to the relevant trimesters of pregnant women in Nigeria. The objective of this study was to provide reference values for Nigerian pregnant women. The study took place at the Adeoyo Maternity Hospital and the University College Hospital, both in Ibadan. This descriptive study was carried out over a period of 8 months. Subjects were apparently healthy pregnant women that satisfied the inclusion and exclusion criteria. The mean values (and 95% confidence intervals, CI) of haematological indices were as follows:

First trimester: Haemoglobin (Hb) 112.44 (101.64–123.25) g/l, haematocrit (hct) 35 (32–38)%, WBC 5.488 (4.025–6.950) $\times 10^9$/l and platelet counts 227.56 (165.21–289.90) $\times 10^9$/l;
Second trimester: Hb 100.39 (97.85–102.92) g/l, hct 29.3 (28.5–30.1)%, WBC 6.57 (6.19–6.95) $\times 10^9$/l, platelet count 229.56 (211.86–247.26); and the
Third trimester: Hb 98.06 (96.12–100.00) g/l, hct 29.4 (28.7–29.9)%, WBC 6.92 (6.53–7.30), platelet count 186.52 (177.67–195.38) $\times 10^9$/l.

These results were compared with those of 52 non-pregnant age matched women volunteers as controls whose mean haematological indices and 95% CI were: Hb 120.51 (116.61–124.41) g/l, hct 36 (25–48)%, WBC 5.28 (2.9–8.7) $\times 10^9$, platelet count 330.87 (176–538) $\times 10^9$/l. The following haematological indices: WBC, platelet counts, RBC, PCT, and PDW, of women between the trimesters showed statistical significance (p value < 0.001 in each case). The WBC is inversely proportional to the PCT and the MCV in the pregnant women was slightly raised. In this study, pregnancy is characterised by lowest values of haemoglobin parameters in trimester three and there are statistically significant differences between the WBC, platelet counts, RBC, PCT, and PDW of women between the three trimesters.

Introduction

Over the years, there are established differences between the accepted normal adult haematological values derived from Caucasian populations and values from healthy Nigerians (Ezeilo 1981; Ukaejiofo et al. 1979; Essien 1973).

Nigeria has an extremely high maternal mortality rate (MMR) (Akande et al. 2001). The 1999 Multiple Indicator Cluster Survey reported a MMR of 704 per 100,000 live births, implying that with about 2.4 million live births annually, some 170,000 Nigerians die as a result of complications associated with pregnancy or childbirth. The most common direct obstetric causes of death in Nigeria include haemorrhage, sepsis, pre-eclampsia/eclampsia and anaemia (Kisekka et al. 1992), all of which manifest alterations of normal haematological indices. Women who are at higher risk of maternal morbidity and mortality need to be identified early so that appropriate timely measures can be taken. Pregnancy poses a major physiological challenge to the human body and a number of haematological changes accompany it. Maternal plasma volume increases by approximately 50% during the first and second trimesters of pregnancy, whereas the corresponding increases in the red cell mass (RCM) is only 20–30% (Letsky 1987, 1995).

The maintenance of normal blood counts during gestation is very relevant in the overall wellbeing of the woman and reproductive health status of a nation and a very useful basic tool in the prediction of morbidity and mortality of the childbearing age group and their offsprings. However, there is paucity of information in this field in Nigeria and the reference values available have been mainly those based on healthy Caucasians (Dacie and Lewis 2001). These may not be completely appropriate owing to well-recognised nutritional, environmental and genetic factors, which influence reference values.

The main objective of this study was therefore to define the haematological characteristics of healthy pregnant mothers in southwestern Nigeria.

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Subjects and methods

This is a comparative cross-sectional study of apparently healthy pregnant and non-pregnant (controls) Nigerian women attending two hospitals in Ibadan, the capital of Oyo State, in the South West of Nigeria. Ibadan is the second largest city in Nigeria, with a population of about 2.5 million (1991 Census).

Convenient samples from healthy pregnant women during their booking clinic visit in the index pregnancy were studied from May to December 2001. The two hospitals for this study were the Adeoyo Maternity Hospital, a secondary health centre and the University College Hospital, a tertiary hospital in Ibadan. All apparently healthy pregnant women with no adverse medical or obstetric history that satisfied the inclusion criteria were recruited into the study. The exclusion criteria included fever in the past week, a history or features suggestive of haemoglobinopathy, chronic medical ailments, bleeding in early pregnancy and other major complications of pregnancy (e.g. hypertension, diabetes, and pre-eclampsia/eclampsia).

The women were categorised into the traditional first, second or third trimesters. Healthy non-pregnant women-volunteers in similar age groups were recruited as controls. A structured questionnaire was used for data collection.

A total of 3 ml of venous blood was obtained from the anti-cubital vein, with minimal stasis, and placed into vacutainer tubes containing di-potassium ethylene diamine tetra-acetic acid (K_2-EDTA) as the anticoagulant.

The samples were processed within 2–4 h of collection, using the ADVIA 60 closed tube (CT) automated haematology system.

RBC/WBC/Platelet detection principles

The counting is based on an impedance variation generated by the passage of cells through the calibrated micro-aperture.

The data were analysed on a microcomputer using the SPSS software package for data entry and statistical analysis. The significances, associations or between categorical variables were investigated using the χ^2-test. The Student *t*-tests were used to compare two mean values, while the 95% confidence interval (CI) was used to describe the normal range of values of haematological parameters. A one-way analysis of variance (ANOVA) technique was used to compare the means of haematological values between the three trimesters. All tests were at the 5% statistical level ($p < 0.05$). Ethical clearance was obtained from the Adeoyo hospital and UI/UCH Institutional Review Board.

Results

During the period of study (May–November 2001), a total of 349 pregnant women aged 15–42 years were recruited from the two hospitals, but only 333 or 95.4% had both complete blood counts and items of information in other questionnaires. The distribution of 333 women according to trimesters showed there were nine subjects (2.7%) in the first trimester, 124 (37.2%) in the second and 181 (54.4%) in the third trimester. It was not possible to calculate the exact trimester of 19 pregnant women (5.7%), as their precise gestational ages at booking were unknown; hence the results of these subjects were not included in the analysis.

The summary statistics of haematological indices of the women are presented in Table I. There were statistically significant differences between the WBC, platelet counts, RBC, PCT, and PDW of women between the three trimesters. While the WBC increased, the PCT decreased. The normal range of values from this study and other studies are presented in Table I.

Haematocrit

The mean haematocrit (hct) in the first, second and third trimesters are 35.200%, 29.340% and 29.361%, respectively.

A much lower (but significant) proportion (13/52 = 25%) of healthy subjects than 75.7% (252/333) of pregnant women have Hb <11 g/dl. The range of Hb was 9.3–10.9 g/dl in the anaemic controls, as against 3.7–10.9 g/dl in the (anaemic) pregnant subjects.

Red cell indices

Red blood cell count (RBC) decreases from the first to third trimester ($p < 0.01$).

White blood cell count (WBC)

The mean absolute granulocyte count was 4.29×10^9/l (range of $1.484 - 23.836 \times 10^9$/l) while the mean WBC for the study groups was 6.898×10^9/l.

The mean WBC increased from 5.767×10^9/l to 6.599×10^9/l and 6.803×10^9/l in the first, second and third trimesters, respectively ($p < 0.05$). Comparing the means of the lymphocyte, monocyte and granulocyte, count showed no statistical significant differences ($p > 0.05$). In the same vein, the *t*-test showed there was no statistical significant difference in the means of the lymphocytes ($p = 0.378$), monocytes ($p = 0.251$) and granulocytes ($p = 0.645$). For the values of WBC $> 11.0 \times 10^9$/l, five out of seven (5/7) were in their third trimester (Figure 1). Two outliers with WBC 24.8×10^9/l at 30/52 gestation in a 32-year-old para 1, and 41.6×10^9/l in the first trimester (9/52) in a primigravida, were excluded from the analysis.

Platelet counts

The mean platelet counts were similar for the first and second trimesters (227.56×10^9/l and 228.79×10^9/l) and decreased in the third trimester (186.52×10^9) ($p < 0.05$). There is evidence of thrombocytopaenia in 3.6% of subjects with a range of $38 - 93 \times 10^9$/l. A total of 11 (91.7%) of these thrombocytopaenic women presented in the third trimester. None of the thrombocytopaenic women presented with severe anaemia, but 50% had moderate anaemia, while another 50% presented with mild anaemia. History of previous blood transfusion was not significant, since only one of the 12 gave a positive history. However, from this cohort of pregnant women, 29 pregnant women (8.9%) whose mean age was (28.9) years (SD = 5.21) gave a positive history of previous blood transfusion. Only one of the previously transfused 29 subjects had a mildly deranged platelet count (86×10^9/l) and she presented in the third trimester. Comparing the means of platelet counts in the

Table I. Summary statistics of the haematological parameters in Nigerian pregnant women in Ibadan and the normal range of values (modified from standard references)

Parameter	*n*	Trimester	Mean ± SD	95% CI	ADVIA 60 (normal adult values)	European values (Dacie and Lewis 2001) (male and female)
HCT (l%)***	9	1	35.200 ± 3.7417	32.324–38.076	35.0–50.0	0.40–0.50
	124	2	29.340 ± 4.4156	28.545–30.134		0.45 ± 0.05 (M)
	181	3	29.361 ± 4.2237	28.739–29.982		0.36–0.46
	52	Control	36.637 ± 4.5377	35.361–37.913		0.41 ± 0.05 (F)
Hb g/l	9	1	112.44 ± 10.4054	101.64–123.25	110–165	130–170
	124	2	100.39 ± 14.079	97.85–102.92		150 ± 20 (M)*
	181	3	98.06 ± 13.199	96.12–100.00		120–15.0
	52	Control	120.51 ± 13.811	116.61–124.41		135 ± 15 (F)
RBC count × 10^{12}***	9	1	3.9878 ± 0.56491	3.5536–4.4220	3.80–5.80	4.5–5.5
	124	2	3.4150 ± 0.60558	3.3060–3.5240		5.0 ± 0.5 (M)
	181	3	3.3073 ± 0.59279	3.2201–3.3945		3.8–4.8
	52	Control	4.5631 ± 0.55446	4.4072–4.7191		4.3 ± 0.5 (F)
MCV (μm^3)	9	1	82.67 ± 4.093	79.52–85.81	80.0–97.0	83–101
	124	2	84.55 ± 6.236	83.43–85.68		92 ± 9 fl (M, F)
	181	3	84.36 ± 6.136	83.46–85.26		
	52	Control	81.02 ± 5.152	79.57–82.47		
MCH (pg)	9	1	28.2889 ± 1.89634	26.8312–29.7465	26.5–33.5	27.0–32.0
	124	2	29.7116 ± 3.12459	29.1492–30.2740		29.5 ± 2.5 (M, F)
	181	3	31.3656 ± 2.91890	28.2888–34.4423		
	52	Control	26.7686 ± 2.67249	26.0120–27.5203		
MCHC (gl)	9	1	34.200 ± 1.1630	33.506–35.094	31.5–35.0	31.5–34.5 (M, F)
	124	2	35.095 ± 2.0978	34.717–35.473		33.0 ± 1.5
	181	3	35.302 ± 2.5042	34.933–35.670		
	52	Control	32.145 ± 2.4911	31.444–32.846		
PCT	9	1	0.18244 ± 0.060879	0.13565–0.22924	0.100–0.500	
	124	2	0.17786 ± 0.066444	0.16590–0.18982		
	181	3	0.14608 ± 0.045400	0.13940–0.15276		
	52	Control	0.28471 ± 0.059457	0.26798–0.30145		
RDW (l %)	9	1	12.744 ± 1.9301	11.261–14.228	10.0–15.0	11.6–14.0
	124	2	12.562 ± 1.2285	12.341–12.785		12.8 ± 1.2
	181	3	12.820 ± 1.3208	12.626–12.015		
	52	Control	14.480 ± 1.8430	13.962–14.999		
MPV	9	1	8.089 ± 0.8781	7.414–8.764	6.5–11.0	
	124	2	7.896 ± 0.8846	7.737–8.055		
	181	3	7.878 ± 0.8678	7.751–8.006		
	52	Control	8.637 ± 0.5916	8.471–8.804		
PDW	9	1	14.078 ± 2.6033	12.077–16.079	10.0–18.0	
	124	2	16.083 ± 2.1876	15.690–16.477		
	181	3	16.118 ± 1.9585	15.830–16.406		
	52	Control	13.845 ± 1.4573	13.435–14.255		
WBC × 10^9/l**	9	1	5.488 ± 1.7496	4.025–6.950	3.5–10.0	4.0–11.0
	124	2	6.611 ± 2.1317	6.194–6.959		
	181	3	6.800 ± 2.2726	6.466–7.136		
	52	Control	5.290 ± 1.2736	4.932–5.648		
% Lympho × 10^9/l	9	1	36.778 ± 8.3775	30.338–43.217	17.0–48.0	1.0–3.0
	124	2	32.063 ± 12.0126	29.882–34.244		
	181	3	30.312 ± 8.9458	28.981–31.643		
	52	Control	45.849 ± 8.8763	43.353–48.346		
Abs Lympho	9	1	1.933 ± .7036	1.393–2.474	1.2–3.2	1.0–3.0
	124	2	1.870 ± .6129	1.758–1.981		
	181	3	1.953 ± .8701	1.824–2.083		
	52	Control	2.384 ± .5938	2.217–2.551		
% MON × 10^9/l	9	1	9.311 ± 5.8207	4.837–13.785	4.0–10.0	0.2–1.0
	124	2	9.894 ± 7.5964	8.515–11.275		
	181	3	8.650 ± 5.8359	7.782–9.518		
	52	Control	7.257 ± 3.1148	6.381–8.133		
Abs MON	9	1	0.444 ± .2007	0.290–0.599	0.3–0.8	0.2–1.0
	124	2	0.485 ± .2431	0.441–0.529		
	181	3	0.483 ± .3060	0.437–0.528		
	52	Control	0.380 ± .1854	0.328–0.432		
% GRA	9	1	55.756 ± 12.7352	45.966–65.545	43.0–76.0	42–80
	124	2	58.798 ± 15.7471	55.939–61.656		
	181	3	60.820 ± 13.1441	58.864–62.775		

(*continued*)

Table I. (*Continued*)

Parameter	*n*	Trimester	Mean ± SD	95% CI	ADVIA 60 (normal adult values)	European values (Dacie and Lewis 2001) (male and female)
	52	Control	46.892 ± 8.3978	44.530–49.254		
Abs GRA	9	1	3.711 ± 1.7446	2.370–5.052	1.2–6.8	2–7
	124	2	4.192 ± 1.7818	3.869–4.516		
	181	3	4.391 ± 1.7408	4.133–4.650		
	52	Control	2.526 ± .8985	2.273–2.779		
Platelet × 10^9/l****	9	1	227.56 ± 81.110	165.21–289.90	150–390	15.0–40.0
	124	2	229.56 ± 98.349	211.86–247.26		
	181	3	186.52 ± 60.217	177.67–195.38		
	52	Control	331.75 ± 76.422	310.25–353.24		

M, male; F, female; *n*, sample size. ****$p < 0.00001$, ***$p < 0.0001$, **$p < 0.05$.

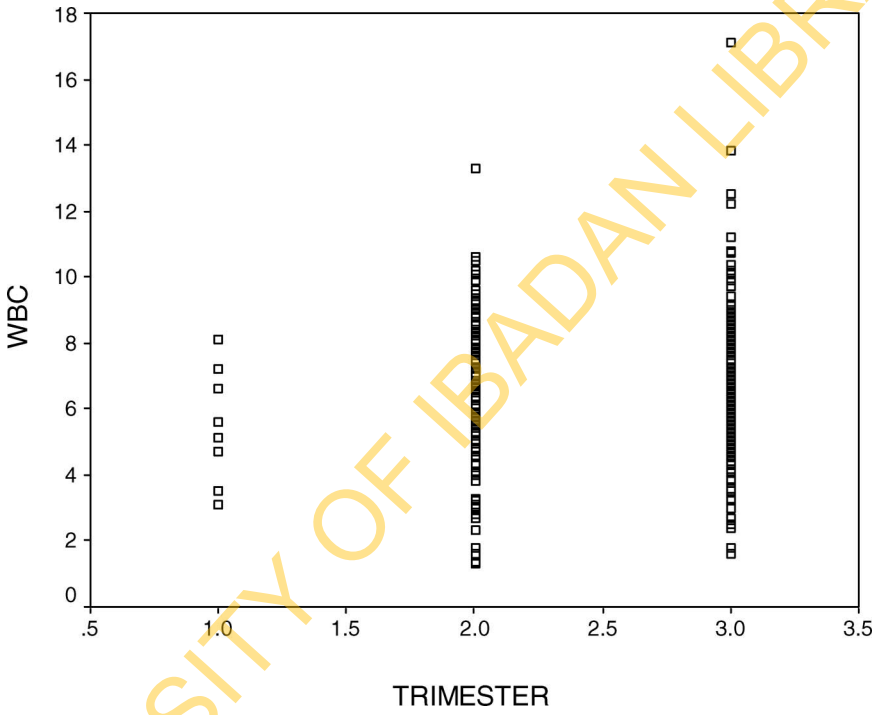

Figure 1. WBC and trimester.

three trimesters, showed a highly statistical significance ($p < 0.0001$).

Discussion

Despite several studies on blood counts, the effect of normal gestation on blood counts is unclear. In Nigeria, previous studies have been based on manual and morphologic techniques (Onwukeme and Uguru 1990).

We report here the results of a cross-sectional study of complete blood counts utilising automated techniques of counting 10,000 cells per sample in normal pregnant women compared with age-matched controls. This study shows clearly that in this environment, there is a significant fall in Hb and haematocrit (hct) in pregnancy at booking, particularly in the second and third trimesters as shown by mean haemoglobin drop from 112.4 g/l (hct 35%) in the first trimester to 100.39 g/l (hct 29%) in the second trimester and 98.06 g/l in the third trimester (Table I).

Using the WHO minimum acceptable standard (WHO 1972), almost three-quarters (73.3%) of our pregnant population presented with a mild or moderate form of anaemia but only 1.2% with severe anaemia (WHO 1972). This is a slightly different picture when compared with 55.72%, using a lower Hb value of 100 g/l or PCV of 30% (Ogunbode 1995). Several other studies document incidences of anaemia (Iloabachie and Meniru 1990, 50–60%; Reviews 1998, 36–56% for Africa; Aimakhu and Olayemi 2003, 51.4%). The incidence of Anaemia in our study is high and agrees with the Tanzanian report (Bergsjo et al. 1996) where 74.5% were <110 g/l but 7.0% were <70 g/l. Estimation of hct by the electronic counter for example the Coulter S. counter, Advia (Pinkerton et al. 1970) has a greater accuracy if calibration is precise. The previous techniques might have over-estimated haematocrit, since the centrifuged red cell column always contains between 2% and 6% trapped plasma (England et al. 1972). There are other inaccuracies due to the inability to obtain a flat

seal at the bottom of the haematocrit tube and the relative difficulty in reading the height and column of the red cells.

Anaemia is common among pregnant women globally because of the increased physiological demands of pregnancy. Its effects are more marked in developing countries like Nigeria, due to lack of balanced dietary intake, short inter-pregnancy interval and prolonged lactation, coupled with women's daily routine of heavy physical exercise.

The increased requirements of pregnancy and inadequate intake stemming from anorexia, nausea, vomiting and lack of economic access to appropriate foods, have far reaching effects on the mother and fetus. Over 90% of anaemia worldwide is due to iron deficiency associated with depleted iron stores and deficient intake. As pregnancy advances, serum iron falls and total iron binding capacity (TIBC) increases due to plasma volume. Other potential causes of anaemia include malaria, placental hormones secreted in pregnancy or increased erythropoietin production. Pregnant women with anaemia are at an increased risk of miscarriage, stillbirths, premature birth, delivery of babies with intrauterine growth retardation and low birth weight, who are also prone to infection because of reduce immune competence (Mora and Nestel 2000).

In our study, whether a patient was previously transfused or not did not show any statistical significance when compared with the following variables: PCV, RBC, haemoglobin, red cell indices, age, platelet count and red cell distribution width (RDW).

Over 90% of the anaemic pregnant women we studied had mild anaemia (i.e. haemoglobin $<100-110$ g/l) and, iron deficiency anaemia could be a major aetiological factor.

Leukocyte count

For well over a century, it has been an acknowledged fact that pregnancy is accompanied by a tendency towards leukocytosis. Analysis of leukocyte count in this study shows mildly increasing white count from the first to the last trimester (Figure 2). There was little or no change in lymphocyte and monocyte counts with gestation in this report. Our findings agree with other observations with automated methodology (Efrati et al. 1964; Mitchell et al. 1966) that the elevation in leukocyte count is mostly mild and occurs relatively early in gestation. The phenomenon of leukocytosis due to neutrophilia in pregnancy was also demonstrated in our study, though more marked in the third trimester.

Based on absolute lymphocyte and monocyte, counts remained fairly constant in spite of increasing white count. This is a divergence from the findings by Pitkin and Witte (1979) who in a longitudinal study reported a monocytosis.

In our study, thrombocytopaenia, i.e. platelet count $<100\times10^9$/l (Essien et al. 1973) was documented in 3.6% of our healthy pregnant women (Table II). The normal range for the platelet count did not alter during pregnancy in this study and is in agreement with other studies (Sejeny et al. 1975). Fenton and Cavill (1977), despite the longitudinal nature of his study documented no change in platelet count; but it is also notable that he did not compare with controls. Our findings agree with some other reports that observed a progressive tendency for platelet count to decline, yet maintaining a normal range (Pitkin and Witte 1979). Thrombocytopaenia occurring during pregnancy, requires evaluation. It is the second most common haematological abnormality during pregnancy and is usually benign (Levy and Murphy 2002). Despite its wide differential diagnosis, the cause of thrombocytopaenia during pregnancy can usually be determined with a thorough history, physical examination and directed laboratory studies. This further buttresses the point that some pregnant 'normal women' go about their daily activities without major complaints and optimal performance status, as high as 80–90% in spite of grossly deranged haematological indices. However, thrombocytopaenia in pregnancy could be an early indicator of the presence of some disorders such as autoimmune haemolytic anaemia (AIHA), disseminated intravascular coagulopathy (DIC),

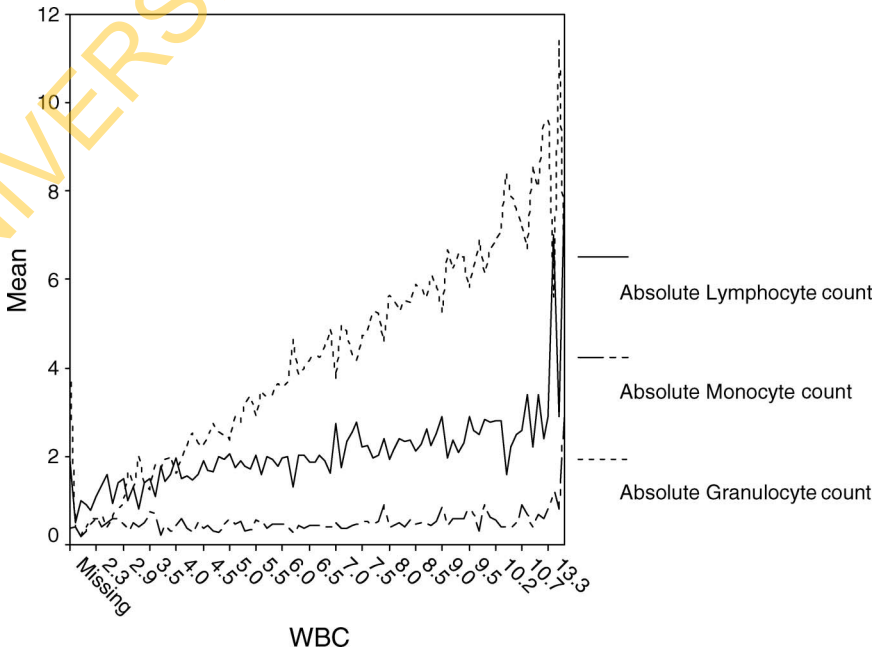

Figure 2. Absolute white counts and gestational age in pregnant women.

Table II. Overview of haematological parameters in thrombocytopaenic pregnant women

	n	Minimum	Maximum	Mean	SD
PCV	12	18.7	39.2	28.183	6.0169
WBC	12	3.2	7.5	5.617	1.3697
Plates	12	38	93	74.58	19.167
Lympho	12	16.3	44.5	30.267	8.9587
Absolute lymphocyte count	12	0.5	2.9	1.733	0.8381
MON	12	5.6	12.5	8.325	2.1218
Absolute monocyte count	12	0.2	0.7	0.408	0.1564
GRA	12	45.2	75.9	61.408	9.2368
Absolute granulocyte count	12	2.5	4.6	3.475	0.6355
RBC	12	2.23	4.99	3.1925	0.71639
HGB	12	6.5	13.6	9.692	1.7784
PCT	12	0.033	0.089	0.06300	0.019074
MCV	12	74	93	84.75	6.468
MCH	12	25.40	36.00	30.7000	3.40027
MCHC	12	34.5	40.3	36.125	2.1192
RDW	12	11.1	14.9	13.108	1.2731
MPV	12	7.0	10.3	8.392	0.9858
PDW	12	10.2	21.9	15.583	3.1522
HGBREC	12	1.00	2.00	1.1667	0.38925
Valid *n* (listwise)	12				

SD, standard deviation.

severe pre-eclamptic/eclampsia, hypertension (Adediran et al. 1999), migraine, connective tissue disorders, drug-induced thrombocytopaenia, and it can also be congenital or a manifestation of allergy. Recent reports are consistent with the possibility that thrombocytopaenia frequently observed in women with pre-eclampsia or eclampsia may be immunologically mediated (Rote et al. 1987; Samuels et al. 1987). Early screening of pregnant women will aid prompt detection and amelioration of complications of rare disorders like HELLP syndrome. The diagnosis of thrombocytopaenia must be confirmed by examination of a well-prepared blood film. Artifactual thrombocytopaenia should also be considered as a strong differential diagnosis. The common mechanism for this phenomenon is *in vitro* clumping, and platelet counts performed on automated particle counters are also prone to errors.

In our study, the majority of our subjects presented for booking in the second and third trimesters confirming findings of other studies that most pregnant women present late (Adinma et al. 2002). Due to low levels of availability of antenatal services, as shown in our study, the failure to address problems of anaemia in pregnant women is one the principal causes of the high maternal mortality in Nigeria.

Conclusion

At the National level, there is a need to identify and address the specific barriers to the effectiveness of maternal anaemia prevention and control programmes. We suggest a multiregional longitudinal survey of haematological parameters in pregnancy should be undertaken.

Abnormalities of haematological profile, though usually with mild clinical presentation (should be thoroughly evaluated) could be a pointer. Pre-conception care should be formulated into primary healthcare to serve women in the childbearing age group and with iron deficiency as the main cause of anaemia worldwide. We suggest iron therapy for all women. This would be an inexpensive and important public health measure. Routine full blood counts should be done at least once every trimester.

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