Hematological parameters of healthy pregnant women in three trimesters compared with parameters of non-pregnant women

H. F. Kasim[1], R. M. Rashied[2], S. A. Rahman[3]
[1]Mustansiriyah University, College of Science, Baghdad, Iraq
[2]University of Anbar College of Science, Anbar, Iraq
[3]AL-Farabi University College, Baghdad, Iraq

Anemia is a public health problem, especially in developing countries. All over the world iron deficiency is the main cause of anemia, especially during pregnancy. Pregnant women belong to the most vulnerable population group in Iraq.
The objective: **to determine the impact of pregnancy on hematological parameters and to compare the hematological indicators in different periods of gestation with the indicators of non-pregnant women.**
Materials and methods**. The study was conducted over a three-month period at Baghdad hospitals and medical centers, including Baghdad Teaching Hospital, Al-Karam Hospital, and a health center in Al-Dorrah and Al-Shaab, Baghdad province, from September 1 to December 1, 2022. 60 pregnant women, 20 persons in each trimester, and 25 non-pregnant women (control) aged 18–35 years were included in the study. All participants were examined for hematological parameters: hemoglobin, erythrocytes, packed cell volume (PCV), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), measured of the concentration of hemoglobin in red blood cells (MCHC) and determined the level of iron in the blood (serum iron – SI, total iron binding capacity – TIBC, transferrin saturation – TS and serum ferritin – SF).**
Results**. A significant decrease in the hematological indicators of pregnant women in the first trimester of pregnancy compared to non-pregnant women was established – hemoglobin, erythrocytes, PCV, MCH, MCHC. The dynamics of the decrease in the level of these parameters increases in the second trimester, and also progressively decreases in the third trimester, which leads to anemia.**
Starting from the first trimester and during the second and third trimesters, a decrease in the level of serum iron, transferrin saturation and serum ferritin was found in pregnant women compared to non-pregnant women, but the level of TIBC increased. During the second trimester, the need for iron begins to increase and continues to growth until the end of pregnancy. In addition, these research results indicate the importance of iron deficiency in the development of iron deficiency anemia.
Conclusions**. During pregnancy, anemia and a decrease in the level of some hematological parameters were determined, which progresses with increasing gestational age and is less compared to that in non-pregnant women. A decrease in the level of iron in the blood serum was established from the first to the third trimester of pregnancy. The severity of anemia is related to many factors, especially age, education level, low income, type of diet and parity.**
Keywords: *three trimesters, pregnancy, anemia, hematology.*

Гематологічні показники здорових вагітних протягом трьох триместрів гестації порівняно з невагітними жінками

Х. Ф. Касим, Р. М. Рашид, С. А. Рахман

Анемія є однією з проблем охорони здоров'я, особливо в країнах, що розвиваються. У всьому світі дефіцит заліза є основною причиною анемії, насамперед під час вагітності. Вагітні належать до найбільш вразливої групи населення в Іраку.
Мета дослідження: визначення впливу вагітності на гематологічні параметри та порівняння гематологічних показників у різних термінах гестації з показниками невагітних жінок.
Матеріали та методи. Дослідження виконане протягом трьох місяців на базі лікарень та медичних центрів Багдада, зокрема, Багдадської навчальної лікарні, лікарні Аль-Карама та центру охорони здоров'я в Аль-Дорра та Аль-Шааб, провінція Багдад, – з 1 вересня по 1 грудня 2022 р. До дослідження включено 60 вагітних по 20 осіб у кожному триместрі та 25 невагітних жінок (контроль) віком 18–35 років. В усіх учасниць досліджували гематологічні показники: гемоглобін, еритроцити, об'єм упакованих клітин (PCV), середній корпускулярний об'єм (MCV), середній корпускулярний гемоглобін (MCH), вимірювали концентрації гемоглобіну в еритроцитах (MCHC) і визначали рівень заліза у крові (сироваткове залізо – SI, загальна залізозв'язувальна здатність – TIBC, насичення трансферином – TS і сироватковий феритин – SF).
Результати. Установлено значуще зниження гематологічних показників вагітних у I триместрі гестації порівняно з невагітними жінками – гемоглобіну, еритроцитів, PCV, MCH, MCHC. Динаміка зниження рівня зазначених параметрів посилюється у II триместрі, а також прогресивно зменшується у III триместрі, що призводить до анемії.
Починаючи з I триместра і протягом II та III триместрів виявлено зниження рівня сироваткового заліза, насичення трансферином і сироваткового феритину у вагітних порівняно з невагітними, проте рівень TIBC збільшується. Про-

тягом II триместра потреба у залізі починає збільшуватися і продовжує зростати до кінця вагітності. Крім того, ці результати дослідження свідчать про значення дефіциту заліза у розвитку залізодефіцитної анемії.
Висновки. Під час вагітності відзначається анемія та зниження рівня деяких гематологічних параметрів, яке прогресує зі збільшенням терміну гестації та є меншим щодо такого у невагітних жінок. Установлено зниження рівня заліза у сироватці крові з I до III триместра вагітності. Тяжкість анемії пов'язана з багатьма факторами, особливо віком, рівнем освіти, низьким рівнем доходу, типом харчування та паритетом.
Ключові слова: *три триместри, вагітність, анемія, гематологія.*

Approximately 1.62 billion people worldwide – or 24.8% of the world's population – are affected by anemia. The groups with the highest rates of anemia prevalence include pregnant women (41.8%) and preschoolers (47.4%). Pregnancy-related anemia is quite common, even in industrialized nations (between 30 and 40%) [1]. The body changes dramatically during the first trimester. Hormonal changes have an impact on almost every organ system in the body. These changes can cause symptoms even in the early stages of pregnancy.

Pregnant women had significantly lower hemoglobulin levels and hematocrit values than non-pregnant women [2]. Pregnancy-related anemia is most commonly caused by iron shortage. Anemia's onset and course are influenced by a person's iron reserves. Additionally, an individual's final iron status and the onset of anemia are influenced by a number of factors, including age, dietary status, iron absorption, and iron loss [3]. Pregnancy-related anemia might have detrimental effects. The illness carries a risk of difficulties for both the mother and the fetus [4]. Causes of anemia are inclusive of nutritional deficiencies, genetic factors, and infectious agents. Therefore; deficiency of iron is perhaps the greatest and significant due to physiological changes related to pregnancy, that lead to a demand for extra iron that is required for fetus transfer [5].

Pregnant women with anemia have a twice as high risk of premature births as pregnant women without anemia [6]. Anemia during pregnancy has been shown in numerous studies to be a separate risk factor for premature delivery [7].

The current study **aimed to** determine the impact of pregnancy on hematological parameters and to compare hematological parameters at various stages of pregnancy with non-pregnant women's parameters (control).

MATERIALS AND METHODS

This work was completed in the Baghdad province for three months, including many Baghdad hospitals and health centers. including Baghdad teaching hospital, Al-Karama hospital and a health center in Al-Dorra and Al-Shaab during 1st September until 1 December 2022 in this research 60 pregnant women (20 in each trimester) between the ages of (18–35) years was selected from antenatal clinic. 25 non -pregnant age matched women used as control.

Included questionnaire for each pregnant: age, the date of the last menstrual period. It has been excluded from this study who had vaginal bleeding in the current pregnancy, diabetes mellitus, hemolytic disease, chronic hematological diseases and infected with the pressure, cardiac or liver diseases.

5 ml of venous blood was collected from each pregnant (in the first trimester blood was collected in the sixth week, the second trimester in the nineteenth week and third trimester the thirty-fifth week) and nonpregnant women (control), under aseptic condition and were divided blood into two parts contain per part 2.5 ml.

The first part of the blood is placed in a tube containing an anticoagulant substance (EDTA), and the second part is taken for blood tests. The second part of the blood is placed in a tube that does not contain an anticoagulant, then placed in a centrifuge at a speed of 3000 rpm to obtain serum, serum is stored at -20c, and biochemical tests are performed.

Calculated complete blood count (CBC) which included measurement of hemoglobin blood (Hb/dl),red blood cells (RBCs $\times 10^6/\mu m$), packed cell volume (PCV%), mean corpuscular volume (MCV fl), mean corpuscular hemoglobin (MCH pg.) and mean corpuscular hemoglobin concentration (MCHC g/dl) by device (HORIBA) and using solution processed by the company, the inserted blood samples found in the EDTA tube in the device that withdraw 0.5 cm^3 of the blood, and the result are printed.

Measurement of the biochemical tests such as: the level of serum iron (SI) estimated by method of E. Burtis and E. Ashwood,1994 [8]. The reference value of SI in female 9–30.4 M mol/Ls measurement of Transferrin saturation (Ts) and total iron binding capacity (TIBC)by method of A. Gowenlock *et al.*, 1988 [9]. Normal value of TIBC (44.5–73.5 M mol) and Ts (15–25%). The level of serum ferritin by P. Aisen,1990 [10] Normal value in women (20–200 ng/ml).

Statistical Analysis System SAS (2012), according to [11], used analysis of variance one way (ANOVA) to measure the effect of groups in study parameters, and the least significant difference (LSD) test was used to compare means in this study.

RESULTS AND DISCUSSION

Table 1 shows the hematological parameters according to the three trimesters of pregnancy and control (non-pregnant).Hemoglobin value in first trimester was (10.87±0.78) g/dl, Second trimester (9.90±0.66) g/dl and third trimester was (9.64±0.33) g/dl that decreased significantly ($P<0.01$) in comparison with the control (12.79±1.68) g/dl. On the other hand, Hematocrit (PCV%) was highly significant decreased ($P<0.01$) in 1st trimester (33.71±3.63)%, 2nd trimester (31.69±2.21)% and third trimester (31.52±3.56)% compared with control (39.12±5.61)%.

The current study's findings agreed with those recorded by C. Breymann *et al.*, 2017 who discovered the decrease in the Hb, hematocrit and RBC count, presumably because of hem dilution of plasma effect [12]. The increased volume of plasma is primarily due to a hormonal effect, as both aldosterone and estrogen, which have been

ISSN 2708-8723 (print)
ISSN 2708-8731 (online)

Table 1

Comparison of blood parameters in the three trimesters of pregnancy and control (non-pregnant)

Parameters	Trimesters			Control	LSD value
	1st	2nd	3rd		
Hb (g/dl)	10.87±0.78b	9.90±0.66b	9.64±0.33b	12.79±1.68a	1.51**
RBC (10^6/MM^3)	3.43±0.36b	3.14±0.52b	3.12±0.35b	5.90±0.65a	0.50**
PCV %	33.71±3.63b	31.69±2.21b	31.52±3.56b	39.12±5.61a	3.52**
MCV (fl)	84.95±4.82b	83.75±4.33c	83.17±5.11c	87.25±4.73a	1.15*
MCH (Pg)	31.69±4.55b	31.53±3.87c	30.90±3.21c	32.80±4.45a	1.10*
MCHC (g/dl)	32.25±4.11b	31.24±4.34c	30.58±2.41d	32.77±4.45a	0.50*

Notes: all results are presented as mean± SE value; * – significant at (P<0.05); ** – significant at (P<0.01); mean having different small letter in horizontal raw are significant.

greatly increased during pregnancy, cause enhanced fluid retention by the kidney. Furthermore, the bone marrow becomes more active and produces more red blood cells to compensate for the increased fluid volume.

As a result, at the time of the body's birth, the mother's circulatory system contains 1 to 2 liters of extra blood [13]. Many hormonal changes occur during pregnancy to ensure adequate blood flow from the maternal to the fetal unit [14]. Because of plasma volume expansion, hemoglobin concentrations may fall by 5 g/L during pregnancy [15].

The World Health Organization presently suggests Hb cutoffs, which vary depending on the trimester of pregnancy and should be defined as follows: <110 g/L in the first trimester, <105 g/L in the second trimester, and <110 g/L in the third trimester [16]. Hemoglobin and body mass index (BMI) are positively correlated; ethnicity influences hemoglobinopathy traits; and socioeconomic hardship is more likely to be associated with inadequate nutrition and/or co-occurring chronic illness, both of which are anemia risk factors [17].

The most important cause of hemoglobin lowering in pregnant females is relative hemodilution due to plasma expansion by 30–50% [18]. Iron deficiency, in addition to plasma expansion, can play a significant role in lowering hemoglobin concentrations, making them more likely to develop anemia [3].

Table 1 shows RBC has a highly significant different (P<0.01) were found decrease in the mean value of RBC in first, second and third trimesters (3.43±0.36,3.14±0.52 and 3.12±0.35) 10^6/mm^3 respectively compared with value of control (3.90±0.65) 10^6/mm^3. These findings corroborate previous research., which found that a physiological decrease in Hb concentration occurs due to hemodilution and an assumed decrease in erythrocyte life span and result from increased plasma volume combined with inadequate iron intake [19] [2]. But, WBC count increased this could be due to the fetus's body developing immunity [2].

This finding is consistent with a study conducted in Nigeria, which found that the PCV value of pregnant women was (31.72±4.30), indicating anemia, which leads to a decrease in blood Hb and PCV values in pregnant women, resulting in an increase in plasma and a decrease in RBC [20].The MCV value in third trimester (83.17±5.11) fl was significantly lower than first (84.95±4.82) fl second (83.75±4.33 fl) trimesters and control (87.25±4.73) fl. While the MCHand MCHC values were significantly (P<0.05) higher in first trimesters (31.69±4.55) Pg and (32.25±4.11) g/dl respectively, than second (31.53±3.87) Pg and (31.24±4.34) g/dl respectively, and third trimester (30.90±3.21) Pg and (30.58±2.41) g/dl respectively.

Although the MCH and MCHC in control (32.80±4.45) Pg and (32.77±4.45) g/dl respectively increased significantly (P<0.05) compared with three trimesters. The current study showed increased value of MCV, MCH and MCHC for control were agreement with [20]. In Kirkuk and [21] done in India, they came to that MCH is depend upon Hb.

Table 2 Shows a highly significant, increase (P<0.01) in SI, TS and SF of three trimesters compared with con-

Table 2

Comparison between indices of the iron status (SI,TIBC,TS and SF) in the three trimesters of pregnancy and control (non-pregnant)

Parameters	Trimesters			Control	LSD
	1st	2nd	3rd		
Serum iron(SI) µmol/L	8.18±0.88b	8.68±1.54b	7.87±0.32c	13.25±1.14a	0.52**
TIBC (µmol/L)	86.15±6.12c	82.34±7.81d	94.42±4.56b	76.34±6.67a	3.71**
Transferrin saturation(TS%)	10.15±0.88b	10.69±1.34b	8.96±1.32c	17.89±1.55a	1.12**
Serum ferritin (Sf) ng/ml	18.33±1.18b	13.18±1.37c	12.68±1.35c	34.38±2.88a	5.11**

Notes: all results are presented as mean± SE value; * – significant at (P<0.05); ** – significant at (P<0.01); mean having different small letter in horizontal raw are significant.

ISSN 2708-8723 (print)
ISSN 2708-8731 (online)

trol, on the other hand TIBC was highly significant decreased (P<0.01) in control (76.34±6.67) M mol/L compared with first, second and third trimesters (86.15±6.12, 82.34±7.81 and 94.42±4.56) M mol/L resp.

Iron deficiency anemia during pregnancy is a very common and preventable problem due to the expansion of plasma volume without the normal expansion of maternal hemoglobin mass [22]. Ferritin is the most often used index since it is essential to ascertain the body's iron status throughout pregnancy and the most useful and accurate screening test for iron buildup during pregnancy is serum ferritin (SF), which has been advised as the screening test [23].

Because of the increased iron consumption in the maternal red blood cell mass, SF concentration began to clearly decrease between 12 and 24 weeks of pregnancy [24]. This is consistent with the findings of our research. The obvious drop in the TS with iron, as well as the small size of the RBC, all indicate a lack of iron [25].

These results are in line with those of [26], In Nigeria, who demonstrated that the SI was lower in the first trimester than the second. Moreover. Additionally, demonstrated a decrease in the SI, SF, and SF highly significant (P 0.01) in the third trimester compared to the control group, which is similar with the findings of our study. However, according to [27], the average iron intake was less than 60%, suggesting that rather than food hardship or disease, the significant prevalence of anemia was most likely caused by inadequate iron intake and poor dietary practices.

The causes of maternal anemia during pregnancy should therefore be further investigated. Additionally, Al-Mehaisen noted a prevalence of anemia of 49.4% in the third trimester in Jordan, which may have been brought on by the period's increased need for micronutrients in the setting of unhealthful eating practices. It is generally known that throughout the second and third trimesters of pregnancy, maternal iron reserves decrease[28]. The majority of iron transfer from mother to fetus happens at this time, which coincides to the maximal efficiency of maternal iron absorption [18].

CONCLUSIONS

The results of the study showed a strong effect of pregnancy on the pregnant woman, as anemia increased with its progression in the months of pregnancy, as well as the rest of the blood analyzes, compared to non-pregnant women, and this was accompanied by a decrease in the status of iron in the serum from the first trimester until the third trimester. Severity of anemia is related to many factors especially age, educational level, low income, nutrients, and parity.

Recommendation

All pregnant women should receive an intervention to increase their intake of iron-rich foods and iron supplements. More research is needed because anemia during pregnancy is a serious condition that increases morbidity and motility.

Information about the authors

Hala Fouad Kasim – Msc., Department of Biology, College of Science, Mustansiriyah University, Baghdad, Iraq. *E-mail: dr.halaal_eqabi@uomustansiriyah.edu.iq, dr.halaal.eqabi@gmail.com*
ORCID: 0009-0009-9090-900X

Rashied Mohammed Rashied – Dr., PhD–Biology, Assistant of Professor, Department of Biology, College of Science, University of Anbar, Anbar, Iraq. *E-mail: sc.rashied_mr@uoanbar.edu.iq*
ORCID: 0000-0001-5446-3121

Sabah A. Rahman – Dr., PhD–Biology, Assistant of Professor, Department of Biology, College of Science, AL-Farabi University College, Baghdad, Iraq. *E-mail: sabah.abdulhamid@alfarabiuc.edu.iq*
ORCID: 0000-0003-4103-3530

Інформація про авторів

Хала Фуад Касим – магістр наук, кафедра біології, Науковий коледж, Університет Мустансірія, м. Багдад, Ірак. *E-mail: dr.halaal_eqabi@uomustansiriyah.edu.iq, dr.halaal.eqabi@gmail.com*
ORCID: 0009-0009-9090-900X

Рашид Мохаммед Рашид – д-р філософії, асистент, кафедра біології, Науковий коледж, Анбарський університет, м. Анбар, Ірак. *E-mail: sc.rashied_mr@uoanbar.edu.iq*
ORCID: 0000-0001-5446-3121

Сабах А. Рахман – д-р філософії, асистент, кафедра біології, Науковий коледж, Університетський коледж Аль-Фарабі, м. Багдад, Ірак. *E-mail: sabah.abdulhamid@alfarabiuc.edu.iq*
ORCID: 0000-0003-4103-3530

REFERENCES

1. Gebereselassie Y, BirhanSelassie M, Menjetta T, Alemu J, Tsegaye A. Magnitude, Severity, and Associated Factors of Anemia among Under-Five Children Attending Hawassa University Teaching and Referral Hospital, Hawassa, Southern Ethiopia, 2016. Anemia. 2020;2020:7580104. doi: 10.1155/2020/7580104.

2. Bajaj SS. To study the hematological parameter in all pregnant women in different trimester of pregnancy and compare them with healthy non pregnant women [Internet]. IJMBS. 2021;5(1). Available from: https://www.ijmbs.info/index.php/ijmbs/article/view/1748.

3. Kerna NA, Akabike LU, Solomon E, Pruitt KD, Ortigas MAC, Jean-Baptiste J, et al. Anemia in Pregnancy: a Practical Review. Gynaecol. 2021:10(1):35-43. doi: 10.31080/ecgy.2021.10.00565.

4. Means RT. Iron Deficiency and Iron Deficiency Anemia: Implications and Impact in Pregnancy, Fetal Development, and Early Childhood Parameters. Nutrients. 2020;12(2):447. doi: 10.3390/nu12020447.

5. James V, Jones K, Turner E, Sokol R. Statistical analysis of inappropriate results from current Hb screening methods for blood of donors. 2019;43(3):400404. doi: 10.1046/j.15372995.2003.00316.x.

6. Symington EA, Baumgartner J, Malan L, Wise AJ, Ricci C, Zandberg L. Maternal iron-deficiency is associated with premature birth and higher birth weight despite routine antenatal iron supplementation in an urban South African setting: The NuPED prospective study. PLoS ONE. 2019;14(9):e0221299. doi: 10.1371/journal.pone.0221299.

7. Xi C, Luo M, Wang T, Wang Y, Wang S, Guo L, Lu C. Association between maternal lifestyle factors and low birth weight in preterm and term births: a case-control

ISSN 2708-8723 (print)
ISSN 2708-8731 (online)

study. Reprod Health. 2020;17(1):93. doi: 10.1186/s12978-020-00932-9.
8. Burits E, Ashwood E. Tietz textbook of clinical chemistry. 2nd ed. Gründing: W.B. Saunderes Co.; 1994. 345 p.
9. Gowenlock A, Murray J, Mclauchlan D. Varleys practical clinical biochemistry [Internet]. 6th ed. London: Heinemann Medical Book; 1988. Available from: https://archive.org/search?query=external-identifier%3A%22urn%3Alcp%3Avarle yspractical00varl%3Aepub%3Abe82e931- c7f6-4160-88d3-1d9ba5778acb%22.
10. Aisen P. Iron transport and storage proteins. Ann Rev Biochem. 1990;49:357-93.
11. Snedecor GW, Cochran WC Statical Methods. 7th ed. Iowa: State Univ; 1980. 503 p.
12. Breymann C, Honegger C, Hösli I, Surbek D. Diagnosis and treatment of iron-deficiency anaemia in pregnancy and postpartum. Arch Gynecol Obstet. 2017;296(6):1229-34. doi: 10.1007/s00404-017-4526-2.
13. Mansoor AR. Some parameters of Anemia during pregnancy of women in Tikrit Teaching Hospital. Tikrit J pure Sci. 2010;15(1):5.
14. Buren D, Ulku A, Somay O, Melies A, Emin U. The effect of first trimester hemoglobin levels on pregnancy outcomes. Turk J Obstet Gynecol. 2018;15:165-70.
15. Churchili D, Manisha SJ, Marian K. The change in hemoglobin concentration between the first and third trimesters of pregnancy. BMC Pregnancy Children. 2019;10:1186.
16. Ohumaa EO, Youngb MF, Martorellb R, Ismailc LC, Pena-Rosas JP, Purwarf M, et al. International values for haemoglobin distributions in healthy pregnant women. Clin Med. 2020;29-30:100660.
17. Elmugabil A, Adam I. Prevalence and Associated Risk Factors for Anemia in Pregnant Women in White Nile State, Sudan: A Cross-Sectional Study. SAGE Open Nurs. 2023;9:23779608231173287.
18. Aguree S, Gernand AD. Plasma volume expansion across healthy pregnancy: A systematic review and meta-analysis of longitudinal studies. BMC Pregnancy Childbirth. 2019;19:508.
19. Figueroa-Mujica R, Ccahuantico LA, Ccorahua-Rios MS, Sanchez-Huaman JJ, Vásquez-Velasquez C, Ponce-Huarancca JM, et al. A Critical Analysis of the Automated Hematology Assessment in Pregnant Women at Low and at High Altitude: Association between Red Blood Cells, Platelet Parameters, and Iron Status. Life. 2022;12:727. doi: 10.3390/life12050727.
20. Kadhim NA, Iqbal SA. Prevalence of Anemia among pregnant women Attending Primary health care. Kirkuk: Kirkuk Univ. J Sci Studies. 2013;18(3):25-34.
21. Sunitha N, Styanaryan M, Ckathi B. Pradeep Hematological response to oral administration of iron polymaltose in anemia and normal pregnant. J Med Nepal. 2010;6(3):17.
22. Georgieff MK. Iron deficiency in pregnancy. Am J Obstet Gynecol. 2020;223(4):516-24. doi: 10.1016/j.ajog.2020.03.006.
23. Fite MB, Bikila D, Habtu W, Tura AK, Yadeta TA, Oljira L, et al. Beyond hemoglobin: uncovering iron deficiency and iron deficiency anemia using serum ferritin concentration among pregnant women in eastern Ethiopia: a community-based study. BMC Nutr. 2022;8(1):82. doi: 10.1186/s40795-022-00579-8.
24. Allen LH. Anemia and iron deficiency: effects on pregnancy outcome. Am J Clin Nutr. 2000;71(5):1280-4. doi: 10.1093/ajcn/71.5.1280s.
25. Biesalski HK, Erhardt JG. Diagnosis of nutritional anemia–laboratory assessment of iron status: Kraemer K, Zimmermann MB. Nutritional anemia. Basel, Switzerland: Sight and Life Press, 2007:45-57.
26. Shu EN, Ogbodo SO. Role of ascorbic acid in prevention of iron deficiency anemia in pregnancy. Biomed Res. 2005;16(1):40-4.
27. Ali EH, Alkindi S, Osman MA, Hilali W, Mirgani HM, Adam G, et al. Nutritional and Hematological Status of Sudanese Women of Childbearing Age with Steady-state Sickle Cell Anemia. Oman Med J. 2021;36(3):e270. doi: 10.5001/omj.2021.81.
28. Al-Mehaisen L, Khader Y, Al-Kuran O, Abu Issa F, Amarin Z. Maternal anemia in rural jordan: room for improvement. Anemia. 2011;2011:381812. doi: 10.1155/2011/381812.