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Hemoglobin Levels in Pregnant Women: A Cross-Sectional Study at Puskesmas Purwokerto Timur II, Indonesia

Jazilatur Rohmah[1], Dita Pratiwi Kusuma Wardani[1*], Dewi Ambarwati[2], Tantri Analisawati Sudarsono[1]

[1]Medical Laboratory Technology, Faculty of Health Science, Universitas Muhammadiyah Purwokerto
[2]Midewifery, Faculty of Medicine, Universitas Muhammadiyah Purwokerto
*Corresponding Author: ditapratiwi@ump.ac.id
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ABSTRACT

Introduction: Hemoglobin is a crucial protein in red blood cells responsible for transporting oxygen and carbon dioxide throughout the body. According to the World Health Organization (WHO), an estimated 41.8% of pregnant women worldwide experienced iron deficiency anemia in 2012. In Indonesia, the prevalence of anemia among pregnant women remains high at 37.1%, with Banyumas District reporting an even higher rate of 50.7% in 2016.
Objective: This study aimed to assess hemoglobin levels in pregnant women attending the Puskesmas Purwokerto Timur II, Banyumas District.
Methods: A descriptive observational study with a cross-sectional design was conducted from April to May 2021. Data collection included respondent identity and medical history through questionnaires, while hemoglobin (Hb) levels were measured using the Azidemet method with the POCT (Point of Care Testing) device. A purposive sampling technique was employed, enrolling 20 respondents.
Results: The results showed that 95% (19 out of 20) of the participants had normal hemoglobin levels. The mean Hb levels were 13.929 ± 0.6047 mg/dL in the first trimester, 11.500 ± 1.7804 mg/dL in the second trimester, and 13.067 ± 0.8501 mg/dL in the third trimester.
Conclusions: Overall, none of the pregnant women included in the study were diagnosed with anemia.

Introduction

In 2012, the World Health Organization (WHO) estimated that 41.8% of pregnant women worldwide experienced iron deficiency anemia. In Indonesia, the prevalence of anemia among pregnant women remains high at 37.1%, while in Banyumas Regency, the rate exceeded the national average, reaching 50.7% in 2016. These figures highlight the urgent need for enhanced efforts to address anemia in pregnant women (Purwati & Noviyana, 2018). The Health Office has implemented various measures to prevent anemia in pregnant women, including the routine provision of folic acid and iron supplements for a specific duration to help increase hemoglobin levels (Rizki et al., 2018).

Hemoglobin plays a crucial role in maintaining the biconcave shape of red

blood cells, ensuring their optimal passage through capillaries. Any disruption in this shape can hinder blood flow efficiency. Hemoglobin level assessment is a fundamental component of routine blood tests, serving as a key diagnostic tool for identifying various health conditions. It helps detect hemoglobin deficiencies, commonly known as anemia (Yusniati, 2019), and monitors the progression of diseases related to anemia and polycythemia (Wirahartari et al., 2019).

According to data from the Centers for Disease Control and Prevention (CDC), hemoglobin (Hb) levels in healthy pregnant women tend to decline during the first trimester (normal Hb >11 g/dL, Hct >33%), reaching their lowest point at the end of the second trimester (normal Hb >10.5 g/dL, Hct >32%), before gradually increasing again in the third trimester. Hb testing is recommended at least twice during pregnancy, specifically in the first and third trimesters. This approach ensures early detection of anemia, allowing for timely intervention with iron (Fe) supplementation. In healthcare centers, pregnant women typically receive 90 Fe tablets to prevent anemia. Studies have shown a significant correlation between Fe tablet supplementation and hemoglobin levels in third-trimester pregnant women, particularly among those aged 20–35 years (70%) ($p<0.05$) (Rizki et al., 2018)

Hemoglobin (Hb) is essential for transporting oxygen throughout the body. In cases of maternal anemia, reduced oxygen circulation can disrupt metabolic processes, which naturally increase during pregnancy (Yusniati, 2019). This study aims to assess hemoglobin levels in pregnant women at Puskesmas Purwokerto Timur II, Banyumas Regency.

Methods

Study Design

This study employed a descriptive observational approach with a cross-sectional design conducted between April and May 2022 at Puskesmas Purwokerto Timur II, Banyumas Regency. Ethical approval was obtained from the Health Research Ethics Commission of Muhammadiyah Purwokerto University (Approval Number: KEPK/UMP/36/IV/2021).

The study population comprised pregnant women registered as patients at Puskesmas Purwokerto Timur II, Banyumas Regency. A total of 20 pregnant women who met the inclusion and exclusion criteria were selected as study participants. The sample size was determined based on the number of pregnant women visiting the health center between March and June 2021, using a purposive sampling technique.

The inclusion criteria for this study were pregnant women in their first to third trimesters who attended antenatal check-ups at Puskesmas Purwokerto Timur II and provided written informed consent. Exclusion criteria included pregnant women who declined participation, those who withdrew during the study, and those diagnosed with eclampsia or blood disorders, as well as individuals with injuries that could interfere with the sampling process.

Equipment and Materials

The equipment utilized in this study included a Point of Care Testing (POCT) device, hemoglobin test strips, a lancet device, blood lancets, label paper, sterile cotton, tissues, face masks, and disposable gloves. The materials used consisted of capillary blood samples and 70% alcohol for disinfection.

Capillary Blood Collection Procedure

All necessary equipment is prepared on a clean surface. To minimize discomfort, gentle pressure is applied to the selected fingertip before disinfection with 70% alcohol, allowing it to dry completely. A sterile lancet is then used to puncture the fingertip swiftly, ensuring the incision is perpendicular to the fingerprint lines. The first drop of blood is wiped away using a dry cotton swab, while the subsequent drop is collected for testing (Priyana, 2017).

POCT Device Calibration Procedure

Insert the code chip into the POCT device to begin the calibration. Press and hold the power button for 3 seconds until a *beep* is heard, and the display shows **SET** on the LCD screen. Press the ▲ button to activate the quality control solution testing mode, at which point the LCD will display 'CTL.' Then, press the power button to proceed. (Nidianti et al., 2019)

Insert the test strip and verify the code number on the test strip container. Shake the control solution bottle gently and press it to release a drop of the solution. Discard the first drop and repeat until a clear drop is obtained. Apply the control solution drop to the blood zone of the test strip, ensuring it is absorbed.

Once the liquid is absorbed, the measurement begins. Be sure to securely close the control solution bottle after use. Press the ▲ button to display the measurement result on the screen. The control solution symbol will appear on the LCD. Press the power button to store the results in the device. If the results fall outside the acceptable range, repeat the calibration. Successful calibration is confirmed by comparing the results to the reference values listed on the test strip container.

Hemoglobin Test Procedure Using the Azidemet POCT Method

Prepare all necessary tools on the table. Match the chip code number with the code on the test strip bottle. Insert the test strip into the POCT device until a 'beep' sound is heard and confirm the code number on the strip bottle. Using a mini pipette, collect 7 µL of the blood sample. Gently press the mini pipette against the test strip to apply the blood, allowing it to be absorbed. The measurement result will be displayed within 5 seconds. (Nidianti et al., 2019)

Data Analysis

Hemoglobin levels in pregnant women at the Puskesmas Purwokerto Timur II were analyzed using a univariate test

Results and Discussion

According to Table 1, the majority of the pregnant women were aged 20-30 years, with 14 individuals (70%) having an average age of 29.90 ± 4.315 years. The youngest was 24 years old, while the oldest was 41 years old. Most of the participants were in the 1-12 week and 13-27 week gestational age groups, with 7 women (35%) in each group, resulting in a mean gestational age of 19.80 ± 10.837 weeks. The youngest gestational age was 4 weeks, and the oldest was 36 weeks. Regarding pregnancy history, the majority had their second pregnancy (9 women, 45%), had completed senior high school (9 women, 45%), and were housewives (15 women, 75%).

The majority of pregnant women had normal Hb levels, with 19 women (95%) showing a mean Hb of 12.820 ± 1.5558 g/dL. The lowest Hb level recorded was 8.9 mg/dL, and the highest was 14.9 g/dL. Regarding medical history, 19 women (95%) did not have a history of anemia, 17 women (85%) took blood-boosting tablets, and 18 women (90%) complied with their prescribed tablet regimen.

The mean Hb level for pregnant women in the first trimester was 13.929 ± 0.6047 g/dL, with the lowest Hb being 13.3 g/dL and the highest 14.9 g/dL. In the second trimester, the mean Hb level was 11.500 ± 1.7804 g/dL, with a minimum of 8.9 g/dL and a maximum of 14.7 g/dL. For the third trimester, the mean Hb level was 13.067 ± 0.8501 g/dL, with a minimum of 11.9 g/dL and a maximum of 13.9 g/dL

Table 1. The characteristics of the subject

No.	Characteristic	Frequency (n)	Percentages (%)	Mean ± SD	Median (Min-Max)
1	**Age (y.o)**				
	20-30	14	70,0		
	31-40	5	25,0	29,90 ± 4,315	29,50 (24-41)
	41-50	1	5,0		
2	**Gestational age (week)**				
	1-12	7	35,0		
	13-27	7	35,0	19,80 ± 10,837	20,50 (4-36)
	28-40	6	30,0		
3	**Pregnancy order**				
	1	6	30,0		
	2	9	45,0		
	3	4	20,0		
	6	1	5,0		
4	**Education**				
	Junior high school	5	25,0		
	Senior high school	9	45,0		
	University	6	30,0		
5	**Job**				
	Private Employee	4	20,0		
	Self-employed	1	5,0		
	Housewife	15	75,0		
6	**Hemoglobin levels (g/dL)**				
	Low	1	5,0	12,820±1,5558	13,350 (8,9-14,9)
	Normal	19	95,0		
7	**Hemoglobin levels per trimester (g/dL)**				
	1St trimester	7	35,0	13,929±0,6047	13,600 (13,3-14,9)
	2nd trimester	7	35,0	11,500± 1,7804	11,400 (8,9-14,7)
	3rd trimester	6	30,0	13,067±0,8501	13,250 (11,9-13,9)
8	**History of anemia**				
	Yes	1	5,0		
	No	19	95,0		
9	**Take blood-boosting tablets**				
	Yes	17	85,0		
	No	3	15,0		
10	**Compliance with blood supplement consumption**				
	Yes	18	90,0		
	No	2	10,0		

In this study, the majority of pregnant women were aged 20-30 years, comprising 14 respondents (70%). This suggests that the majority of women who undergo hemoglobin checks at Puskesmas Purwokerto Timur II are within the productive age range. These findings are consistent with a study by Baharutan et al. which reported that 80% of pregnant women were aged 20-35 years. Pregnant women under 20 years old are considered too young for pregnancy and childbirth, while those over 35 years old face higher risks during pregnancy and delivery

(Baharutan et al., 2016). This is further supported by Youssry et al. research was reported that age both under 30 and over 30 influences the severity of anemia in pregnant women (Youssry et al., 2018).

The age range of 20-35 years is considered optimal for pregnancy and childbirth because, at this age, the body's organs are fully developed and functioning properly, making it suitable for conception and delivery. Pregnant women under 20 years old face increased risks during childbirth, such as breech delivery, due to narrower pelvic dimensions, which can complicate the labor process. On the other hand, women over 35 may experience a decline in tissue regeneration, particularly in the endometrium, due to biological aging and associated health conditions that could lead to complications, including abnormal fetal positioning (Amini et al., 2018).

Pregnant women should avoid being in the "4T" conditions, which include being too young (<20 years), too frequently pregnant, too close to their previous birth (<3 years), or too old (>35 years). Adhering to these guidelines helps minimize the risks to both the mother and baby (K. Anggraini et al., 2018).

In this study, the majority of pregnant women were in the first trimester (1-12 weeks) and second trimester (13-27 weeks), each comprising 35% of respondents, while 30% were in the third trimester (28-40 weeks). These findings align with Baharutan et al. research showed a higher proportion of second-trimester respondents (60%) compared to third-trimester respondents (40%) at Puskesmas Bahu, Malalayang District, Manado City (Baharutan et al., 2016).

During the second trimester, a pregnant woman's need for iron increases due to a rise in red blood cell production, driven by the growing oxygen demands of the fetus. Hemoglobin levels tend to decrease during this period, typically by around 1 g/dL. In addition to iron supplementation, it is crucial for pregnant women to consume foods rich in iron to support their health (Tarwoto, 2013).

The demand for iron is highest during the third trimester of pregnancy, as the fetus stores iron for future use. Iron deficiency can lead to insufficient hemoglobin, which is essential for oxygen transport to both the fetus and the mother's cells (Nurhayati & Fikawati, 2016). Pregnant women in their third trimester are at 19 times higher risk of anemia ($p = 0.000$, OR = 19.95) (Sjahriani & Faridah, 2019).

In the first trimester, the iron requirement is lower due to the absence of menstruation and slower fetal growth. However, during the second and third trimesters, blood volume increases by up to 35%, which requires approximately 450 mg of iron to produce red blood cells that

deliver oxygen to the fetus. Additionally, pregnant women need an extra 300-350 mg of iron before delivery to account for blood loss. On average, pregnant women require about 40 mg of iron per day, which is double the amount needed by non-pregnant women (Susiloningtyas, 2012).

In this study, the majority of pregnant women had a high school education, with 9 participants (45%). This contrasts with a study by Desy & Darmawati, which found that most pregnant women in Aceh Besar Regency had a lower level of education, with 62 respondents (38.5%). The study also identified a significant relationship between education level and the incidence of anemia ($p<0.05$) (Desy & Darmawati, 2018).

The high prevalence of anemia among pregnant women may be attributed to a lack of knowledge about the consequences of hemoglobin deficiency. Additionally, the limited financial resources of these women can hinder their ability to access iron-rich foods and supplements necessary during pregnancy (Edison, 2019).

In this study, the majority of pregnant women were housewives, with 15 participants (75%). This contrasts with the findings of Isnaini et al. reported that the majority of pregnant women with anemia at Puskesmas Sanggeng were non-working, with 96 participants (85.71%). No significant relationship was found between employment status and the incidence of anemia among pregnant women (Isnaini et al., 2021). Both working and non-working pregnant women can be affected by varying degrees of anemia, including mild and severe forms ($p<0.05$) (Youssry et al., 2018).

In this study, the majority of pregnant women had normal hemoglobin levels, with 19 participants (95%) showing normal Hb levels. Only one respondent (5%) had low Hb levels and was in the second trimester of pregnancy. The average Hb levels across the first, second, and third trimesters remained within normal ranges. These findings are consistent with research by Baharutan et al., which reported that 16 out of 30 pregnant women (88.89%) in their second trimester had normal Hb levels (>10.5 g/dL), while 2 (11.11%) experienced anemia (Baharutan et al., 2016). Similarly, 9 (75%) of third-trimester pregnant women had normal Hb levels (>11 g/dL), while 3 (25%) had anemia. Anggraini's research also supports these results, showing that 24 (70.6%) pregnant women had normal hemoglobin levels, while 10 (29.4%) experienced anemia (D. D. Anggraini, 2018). In contrast, a study by Syantih et al. found a higher incidence of anemia, with 63 pregnant women (54.8%) having anemia at Puskesmas Kuta Selatan, compared to 52 (45.2%) without anemia (Syantih et al., 2021).

The mean of hemoglobin levels in the 1st trimester in this study was 13,929±0,6047 g/dL, the 2nd trimester was 11,500±1,7804 g/dL, and the 3rd trimester was 13,067±0,8501 g/dL, slightly different from Nurhajimah et al. reported for the mean of hemoglobin levels in the 1st trimester was 11,7442 ± 0,67517 g/dL, the 2nd trimester was 11,0269 ± 0,55699 g/dL, and the 3rd trimester was 10,2846 ± 0,58222 g/dL (Nurhajimah et al., 2024)

During pregnancy, low hemoglobin levels are commonly associated with physiological hemodilution, a normal process that begins around the 10th week and peaks between 32 and 36 weeks of gestation. Hemodilution reduces blood viscosity, which can lower cardiac workload, decrease peripheral resistance to help prevent hypertension, and minimize iron loss during delivery. This process contributes to the gradual decline in hemoglobin levels observed across all three trimesters (Hudono, 2013).

Some studies suggest that low hemoglobin levels in pregnant women can stimulate corticotropin synthesis, leading to the release of hormones that induce pregnancy and fetal stress. This can increase the risk of hypertension, eclampsia, and premature rupture of membranes. On the other hand, high hemoglobin levels can lead to increased blood viscosity, which may impair optimal oxygen and nutrient supply to the placenta and fetus. Additionally, inadequate plasma volume expansion can contribute to complications such as hypertension, preeclampsia, and diabetes in pregnant women (Jung et al., 2019).

The majority of pregnant women in this study took blood supplement tablets, with 17 respondents (85%) reporting regular consumption. Furthermore, 18 respondents (90%) were compliant with their prescribed blood supplement regimen. These findings align with Anggraini's study which found that 52.9% of pregnant women at the South Region Health Centre in Kediri City were highly compliant with taking iron supplements, while 17.6% were moderately compliant, and 29.4% were non-compliant (D. D. Anggraini, 2018).

Adherence to iron (Fe) supplementation plays a crucial role in maintaining optimal haemoglobin (Hb) levels during pregnancy. This is because the physiological expansion of plasma volume exceeds the increase in haemoglobin mass and red blood cell volume, increasing the body's demand for iron. Sufficient iron intake is essential for effective haemoglobin synthesis, as iron deficiency leads to the production of smaller red blood cells with reduced haemoglobin content, resulting in anaemia. Iron also supports oxygen transport and is a vital component of key respiratory

enzymes, including cytochrome oxidase, catalase, and peroxidase (Handayani, 2012).

Daily iron requirements vary depending on physiological conditions such as menstruation, pregnancy, lactation, and growth. During pregnancy and lactation, iron needs increase by approximately 3.0 mg per day. In the second and third trimesters, iron requirements rise to about 5-6 mg per day, leading to a total iron demand of around 1000 mg throughout pregnancy (Kurniati, 2020).

Abnormal hemoglobin (Hb) levels can manifest through symptoms such as fatigue, pale skin, dizziness, fainting, shortness of breath, swelling in the hands and feet, and excessive sweating. Several factors contribute to abnormal Hb levels, including excessive physical activity, dehydration, inadequate nutritional intake, bleeding, infections, and the use of certain medications. To maintain optimal Hb levels, pregnant women across all trimesters are advised to limit strenuous physical activity, stay well-hydrated, and consume a nutrient-rich diet comprising vegetables, fruits, fish, eggs, and nuts (Walyani, 2018).

A study conducted on 367 pregnant women in Southwest Ethiopia found that factors such as meal frequency, inter-pregnancy intervals, upper arm circumference, fruit and vegetable consumption, coffee intake, and a history of infant mortality were associated with haemoglobin (Hb) levels in pregnant women (Kuma et al., 2021). Additionally, factors including primigravida and multigravida parity, mode of delivery (caesarean or vaginal), low birth weight (LBW), chorioamnionitis-related wound infections, preterm birth, neonatal birth weight, and postpartum bleeding were linked to both mild and severe anaemia in pregnant women. The primary cause of anaemia during pregnancy is iron deficiency (92.8%), followed by thalassemia (0.5%), sickle cell anaemia (2.6%), and other causes (4%) (Youssry et al., 2018).

To accurately diagnose anemia caused by iron deficiency in pregnant women, a comprehensive hematological assessment is required in addition to measuring hemoglobin (Hb) levels. This includes evaluating hematocrit levels, reticulocyte count, and Reticulocyte Hemoglobin Content (CHr), as well as erythrocyte indices such as mean corpuscular volume (MCV), mean cell hemoglobin (MCH), and mean cell hemoglobin concentration (MCHC). Furthermore, biochemical tests should be conducted, including assessments of serum ferritin, Total Iron-Binding Capacity (TIBC), zinc protoporphyrin (ZPP), serum iron levels, and transferrin saturation (Kurniati, 2020).

Conclusion

The majority of respondents (95%) had haemoglobin levels within the normal range. The mean Hb level for pregnant women in the first trimester was 13.929 ± 0.6047 mg/dL, while in the second trimester, it averaged 11.500 ± 1.7804 mg/dL. It is necessary to monitor the hemoglobin level of pregnant women periodically

To ensure a comprehensive diagnosis of anaemia in pregnant women, additional haematological assessments are recommended, including haematocrit levels, reticulocyte count, Reticulocyte Haemoglobin Content (CHr), and erythrocyte indices such as mean corpuscular volume (MCV), mean cell haemoglobin (MCH), and mean cell haemoglobin concentration (MCHC).

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