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DIAGNOSTIC UTILITY OF THE MENTZER INDEX IN DIFFERENTIATING IRON DEFICIENCY ANEMIA AMONG PREGNANT WOMEN

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Abstract

Objective: *To determine the diagnostic accuracy of the Mentzer Index for differentiating iron deficiency anemia (IDA) in pregnant women, using serum ferritin levels as the gold standard.*

Study Design: *Cross-sectional validation study.*

Study Setting: *The study conducted at the Department of* Obstetrics and Gynecology, PIMS Hospital, Islamabad.

Study Duration: *Six* Months *(December'24 to May'25)*

Methodology: *A total of 152 anemic pregnant women (hemoglobin <11 g/dL) aged 18-45 years were enrolled via non-probability convenience sampling. A complete blood count (CBC) was performed to calculate the Mentzer Index, and serum ferritin levels were measured to confirm IDA. Diagnostic performance was assessed by calculating sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy.*

Results: *The prevalence of IDA (serum ferritin <30 ng/mL) was 57.24%. The Mentzer Index demonstrated a sensitivity of 80.46%, a specificity of 80.00%, a PPV of 83.33%, an NPV of 76.71%, and an overall diagnostic accuracy of 80.25%.*

Conclusion: *The Mentzer Index is a reliable, cost-effective, and simple screening tool with good sensitivity and specificity for diagnosing iron deficiency anemia in pregnant women, particularly in resource-limited settings where advanced tests are not routinely available.*

INTRODUCTION

Anemia, the most common nutritional deficiency among pregnant women, is a major public health issue in low- and middle-income nations. Southeast Asia (48.15%), Africa (46.16%), and the Eastern Mediterranean (40.91%) have the greatest rates, whereas the Americas have 25.48%. [1] In recognition of its global burden, the 65th World Health Assembly had targeted a 50% reduction in anemia among women of reproductive age by 2025; however, little progress has been made toward this goal. [2] WHO defines anemia as a condition in which red blood cell (RBC) count or hemoglobin (Hb) concentration falls below established thresholds. For pregnant women, anemia is diagnosed when Hb levels fall below 110 g/L,

though in the second trimester, physiological hemodilution lowers this threshold to 105 g/L. [3]
Iron deficiency anemia (IDA) is the most common cause of anemia in pregnancy and contributes significantly to adverse maternal and fetal outcomes. IDA is associated with fatigue, breathlessness, irritability, and microcytic hypochromic anemia on complete blood count (CBC) testing. [4] Beyond iron deficiency, other causes of anemia in pregnancy include parasitic diseases such as malaria and hookworm, HIV, chronic inflammation, and protein-energy malnutrition. [5] The inability to afford specialized tests such as serum ferritin or hemoglobin electrophoresis to differentiate IDA from other forms of anemia has driven the adoption of indices derived from basic hematological parameters.
Among these indices, the Mentzer Index proposed by Mentzer in 1973, remains widely used. It is calculated by dividing the mean corpuscular volume (MCV) by the RBC count and helps distinguish IDA from thalassemia trait. [6] In IDA, the Mentzer Index is typically greater than 13 due to reduced RBC production and low MCV. [7] In a study conducted by Tabassum et al., the Mentzer Index demonstrated a sensitivity of 91% and specificity of 83% for detecting IDA in pregnant women, with serum iron studies used as the gold standard. [8]
Differentiating anemia types early in pregnancy is vital, especially in resource-constrained settings like Pakistan where routine use of complex diagnostics is limited. Studies such as that by Srour et al. have highlighted the significant prevalence of IDA—up to 25.7% in certain populations—underscoring the need for reliable and cost-effective screening tools. [9] Utilizing the Mentzer Index with routine CBCs could enhance early diagnosis and reduce mismanagement of anemia during pregnancy.
Anemia is diagnosed based on reduced hemoglobin levels: <11.0 g/dL in the first trimester and <10.5–11.0 g/dL in later trimesters, depending on the clinical guideline used. [10] Based on severity, anemia in pregnancy is categorized as mild (10.0–10.9 g/dL), moderate (7.0–9.9 g/dL), or severe (<7.0 g/dL). Globally, nearly 30% of pregnant women are anemic, and despite multiple interventions, anemia remains one of the most prevalent hematological disorders during pregnancy. [10, 11]
The consequences of anemia in pregnancy are profound. Severe maternal anemia is associated with a twofold increase in maternal mortality, often due to complications such as hemorrhage or cardiovascular strain. For the fetus, it increases the risk of preterm birth, low birth weight, and neonatal iron deficiency. [12–15] Furthermore, maternal anemia increases the likelihood of needing a blood transfusion during delivery and is associated with adverse childhood developmental outcomes. [12–16]
The WHO categorizes anemia prevalence as follows: <5% (minimal), 5–19.9% (mild), 20–39.9% (moderate), and ≥40% (severe), with many low-resource countries falling into the severe category. [1]
The American College of Obstetricians and Gynecologists (ACOG) recommends routine screening for anemia during pregnancy through CBC testing in the first trimester and again between 24 $^{0}/_{7}$ and 28 $^{6}/_{7}$ weeks of gestation. [10] A hemoglobin level of ≥10.0 g/dL with a low or borderline MCV is suggestive of iron deficiency anemia.
Iron requirements increase substantially during pregnancy due to fetal growth, placental demands, expanded maternal blood volume, and anticipated blood loss at delivery. Inadequate dietary intake of iron-rich foods such as meat, leafy greens, and fortified cereals further contributes to this deficiency. [13–16] Iron depletion progresses in three stages: diminished iron stores (reflected by low ferritin), reduced iron transport, and finally iron-deficiency anemia with low hemoglobin levels. [17]
Given the widespread burden and implications of anemia in pregnancy, simple tools like the Mentzer Index may prove invaluable for early screening and differentiation of anemia types in clinical settings with limited diagnostic resources. Continued validation in varied populations, particularly in ethnically diverse and resource-poor settings, remains essential.

METHODOLOGY:
This cross-sectional study was conducted in the Department of Obstetrics and Gynaecology, PIMS Hospital, Islamabad, over a duration of six months (December'24 to May'25) following the ethical approval from the CPSP and Institutional Review

Board (Ref No: F-5-2/2024(ERRC)/PIMS, Dated: 11/11/2024)

The study included 152 anemic pregnant patients, aged between 18 and 45 years, with a singleton pregnancy confirmed via obstetric ultrasound, a gestational age of more than 20 weeks based on the last menstrual period (LMP), and a hemoglobin level of less than 11 g/dL. The sample size was calculated using the WHO sensitivity and specificity calculator, based on an iron deficiency anemia (IDA) prevalence of 25.7%, a 95% confidence interval, and a 9% precision for both sensitivity and specificity. A non-probability convenience sampling technique was employed to recruit eligible patients.

Eligible participants were pregnant women meeting the above criteria. Exclusion criteria comprised a history of autoimmune hemolytic anemia, aplastic anemia, anemia of chronic disease, a blood transfusion within the last month, known hemoglobinopathies, bleeding disorders, recent major surgical intervention, active malignancy, chronic kidney disease, or chronic liver disease. Patients who provided informed consent were enrolled in the study.

Venous blood samples were collected from all participants in Ethylenediamine Tetra acetic Acid (EDTA) tubes. All samples were analysed at the same institutional laboratory to eliminate inter-laboratory variability. A complete blood count (CBC) was performed to calculate the Mentzer Index, and serum ferritin levels were measured as the gold standard for the definitive diagnosis of iron deficiency anemia.

The diagnostic performance of the Mentzer Index was assessed by evaluating its sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall diagnostic accuracy against the serum ferritin reference. All relevant data, including baseline demographic variables such as age, gestational age, and parity, were systematically recorded in a structured proforma for analysis.

RESULTS:

A total of 152 pregnant women meeting the inclusion criteria were enrolled in the study. The participants' ages ranged from <18 years to >40 years, with the highest proportion in the 26–30 years age group (25.00%), followed by 18–25 years (23.03%) and 31–35 years (17.76%). A lower percentage of participants were >40 years (8.55%) or <18 years (9.87%). Regarding gestational age, the majority of participants were in the third trimester (27–40 weeks, 69.74%), while 17.76% were in the second trimester (13–26 weeks) and 12.50% were in the first trimester (1–12 weeks). Among the participants, 23.03% were primigravida, 44.74% were multigravida (having 2 to <5 pregnancies), and 32.24% were classified as grand multigravida (≥5 pregnancies). The Mentzer Index was calculated for all participants, with 55.26% (n=84) having a value >13 and 44.74% (n=68) having a value <13. Serum ferritin levels were measured to assess iron deficiency anemia. A majority (57.24%, n=87) had serum ferritin levels <30 ng/mL, indicative of iron deficiency. 32.24% (n=49) had serum ferritin levels between 30–200 ng/mL, while 10.53% (n=16) had levels >200 ng/mL.

The diagnostic accuracy of the Mentzer Index in predicting iron deficiency anaemia was assessed using sensitivity, specificity, and predictive values. The test demonstrated a sensitivity of 80.46%, a specificity of 80.00%, a positive predictive value (PPV) of 83.33%, and a negative predictive value (NPV) of 76.71%. The overall diagnostic accuracy of the Mentzer Index in identifying iron deficiency anaemia was calculated to be 80.25%. These findings indicate that the Mentzer Index serves as a reliable screening tool for identifying iron deficiency anaemia in pregnant women, with a high predictive capacity.

TABLE 1: SHOWING THE DETAILS OF THE DEMOGRAPHICS OF THE PATIENTS ENROLLED IN THE STUDY

Variables		Frequency	Percentage
Age	<18yrs	15	9.87
	18-25yrs	35	23.03
	26-30yrs	38	25.00
	31-35yrs	27	17.76
	36-40yrs	24	15.79
	>40yrs	13	8.55
Gestational Age	1-12weeks	19	12.50
	13-26weeks	27	17.76
	27-40weeks	106	69.74
Parity	Primigravida	35	23.03
	Multigravida (>2-<5)	68	44.74
	Grand Multigravida (5 or More)	49	32.24
Mentzer index	>13	84	55.26
	<13	68	44.74
Serum Ferritin	<30 ng/mL	87	57.24
	30–200 ng/mL	49	32.24
	>200 ng/mL	16	10.53

TABLE 2: DIAGNOSTIC PERFORMANCE OF MENTZER INDEX

MENTZER INDEX	Positive	Negative
Positive	70	56
Negative	14	17

DISCUSSION:

This study aimed to evaluate the diagnostic performance of the Mentzer Index in identifying iron deficiency anemia (IDA) among pregnant women and to assess its correlation with serum ferritin levels. A total of 152 pregnant women were enrolled, with demographic patterns and clinical characteristics aligning with findings from previous research in similar populations.

The highest proportion of participants belonged to the 26–30 years age group (25%), followed by 18–25 years (23.03%) and 31–35 years (17.76%). These age trends are consistent with regional studies highlighting the peak reproductive and childbearing

age as mid to late twenties. [10] Most participants were in the third trimester of pregnancy (69.74%), a stage at which iron demands significantly rise due to rapid fetal growth and increased maternal blood volume. [13]
The prevalence of iron deficiency among the study population was high, with 57.24% of participants presenting with serum ferritin levels below 30 ng/mL, a cutoff indicative of depleted iron stores. [17] This aligns with global estimates from the WHO, which report anemia prevalence rates of 40% in pregnant women, with IDA being the leading cause. [1] The high percentage of iron-deficient women in our study reinforces concerns raised by WHO regarding minimal progress in achieving anemia reduction targets in low-resource settings. [2]
Parity distribution in our study revealed that 44.74% were multigravida and 32.24% were grand multigravida. Increased parity has been previously linked to higher risk of iron depletion, particularly in populations where nutritional support is inadequate and inter-pregnancy intervals are short. [9]
The diagnostic evaluation of the Mentzer Index revealed a sensitivity of 80.46%, specificity of 80.00%, PPV of 83.33%, and NPV of 76.71%, with an overall diagnostic accuracy of 80.25%. These values are comparable to those reported by Tabassum et al., who observed a sensitivity of 91% and specificity of 83% for the Mentzer Index in detecting IDA in pregnant women. [8] The slightly lower sensitivity and specificity in our study may be attributed to population differences or variability in concurrent nutritional deficiencies that can influence hematologic indices. [4]
Importantly, 55.26% of participants had a Mentzer Index >13, typically indicative of IDA, while 44.74% had a value <13, suggestive of thalassemia trait or other non-iron deficiency causes. [7] Given the limitations of routine ferritin testing in resource-poor settings, the Mentzer Index remains a valuable preliminary screening tool. [3] Our findings support its utility as a cost-effective alternative for early differentiation between IDA and other microcytic anemias in pregnancy.
Further, WHO's classification of anemia burden in populations places Pakistan in the "severe" category (≥40% prevalence). [1] This underscores the urgency for scalable and affordable diagnostic strategies, such as the Mentzer Index, to improve maternal outcomes. Early diagnosis and treatment of IDA can reduce risks such as preterm delivery, low birth weight, and maternal mortality. [12, 14]
The rising iron demands in pregnancy, if unmet, lead to progressive iron depletion and clinical anemia. The three-stage progression from depleted iron stores (low ferritin) to iron-restricted erythropoiesis and overt anemia can be detected using a combination of simple hematological parameters and clinical assessment. [17] Our study emphasizes the potential of the Mentzer Index to bridge the diagnostic gap, especially in antenatal care settings lacking access to iron studies or electrophoresis testing.[5, 6]
In conclusion, the Mentzer Index demonstrated good diagnostic accuracy in identifying iron deficiency anemia in our pregnant population. Its predictive reliability, affordability, and ease of calculation make it a practical tool for screening pregnant women, particularly in resource-limited healthcare environments. Further large-scale, multicentric studies are recommended to validate these findings across diverse populations.

OUTCOMES AND LIMITATIONS:

The study demonstrated that the Mentzer Index is a diagnostically accurate and clinically useful screening tool for iron deficiency anemia in pregnant women, exhibiting strong performance with 80.46% sensitivity, 80.00% specificity, and an overall accuracy of 80.25%; however, its utility is limited by the potential for misclassification in cases of coexisting anemias or underlying inflammatory conditions that can elevate serum ferritin, and the generalizability of the findings may be constrained by the use of a convenience sampling method from a single center.

CONCLUSION:

In conclusion, this study highlights the Mentzer Index as a simple, effective screening tool for diagnosing iron deficiency anemia in pregnancy, with good sensitivity, specificity, and overall accuracy. While it cannot replace definitive biochemical testing, it serves as a useful first-line diagnostic tool, particularly in low-resource settings where serum ferritin testing may not be routinely available.

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