Available online on 15.12.2024 at ijmspr.com

International Journal of Medical Sciences and Pharma Research

Open Access to Medical Science and Pharma Research

Copyright © 2024 The Author(s): This is an open-access article distributed under the terms of the CC BY-NC 4.0 which permits unlimited use, distribution, and reproduction in any medium for non-commercial use provided the original author and source are credited

Open Access **Review Article**

Anemia in Pregnancy: Mentzer Index as a Predictor for Iron Supplementation Needs

Emmanuel Ifeanyi Obeagu [1]* and Getrude Uzoma Obeagu [2]

[1] Department of Medical Laboratory Science, Kampala International University, Uganda.
[2] School of Nursing Science, Kampala International University, Uganda.

Article Info:

Article History:

Received 21 August 2024
Reviewed 10 October 2024
Accepted 08 November 2024
Published 15 December 2024

Cite this article as:

Obeagu EI, Obeagu GU, Anemia in Pregnancy: Mentzer Index as a Predictor for Iron Supplementation Needs, International Journal of Medical Sciences & Pharma Research, 2024; 10(4):39-43 *DOI: http://dx.doi.org/10.22270/ijmspr.v10i4.121*

*Address for Correspondence:

Emmanuel Ifeanyi Obeagu, Department of Biomedical and Laboratory Science, Africa University, Zimbabwe

Abstract

Anemia during pregnancy is a significant public health concern that affects a substantial proportion of women globally, with iron deficiency anemia being the most prevalent form. Effective early diagnosis and intervention are crucial to prevent adverse outcomes for both mothers and infants. The Mentzer Index, a simple calculation derived from the mean corpuscular volume (MCV) and red blood cell (RBC) count, serves as a useful tool to differentiate between iron deficiency anemia and thalassemia, thereby guiding appropriate treatment strategies. By categorizing the type of anemia, healthcare providers can more accurately assess the need for iron supplementation, which is essential for managing iron deficiency anemia but may not be beneficial in cases of thalassemia. The Mentzer Index has gained recognition for its ease of use, especially in resource-limited settings where access to advanced laboratory diagnostics may be restricted. With a straightforward calculation, it allows for rapid screening of pregnant women presenting with anemia symptoms. This index not only aids in timely diagnosis but also supports targeted interventions, ensuring that iron supplementation is administered only to those who truly need it. This targeted approach minimizes the risk of complications associated with unnecessary iron supplementation in individuals with thalassemia or other forms of anemia, highlighting the importance of accurate diagnostic tools in maternal health care.

Keywords: Anemia, Pregnancy, Mentzer Index, Iron Supplementation, Iron Deficiency, Thalassemia, Hematological Indices, Maternal Health

Introduction

Anemia during pregnancy is a significant global health issue, with the World Health Organization (WHO) estimating that approximately 38% of pregnant women are affected. This condition not only compromises maternal health but also poses risks to fetal development, leading to adverse outcomes such as preterm delivery, low birth weight, and increased maternal mortality. Among the various types of anemia encountered during pregnancy, iron deficiency anemia (IDA) is the most prevalent, often resulting from increased iron demands associated with fetal growth and placental development. Accurate identification and timely management of anemia in pregnant women are therefore essential to ensure optimal health outcomes for both mothers and their infants.[1] Iron deficiency anemia is characterized by reduced hemoglobin levels due to insufficient iron availability, leading to compromised oxygen transport throughout the body. In pregnant women, this deficiency can be exacerbated by physiological changes that occur during pregnancy, including increased blood volume and iron requirements. The resulting symptoms of anemia—such as fatigue, weakness, and dizziness—can significantly impact a woman's quality of life and her ability to care for her family. Furthermore, inadequate management of IDA can lead to severe complications, including postpartum hemorrhage and impaired cognitive and physical development in infants. As such, early detection and intervention are critical components of prenatal care.[2] Differentiating between iron deficiency anemia and other forms of anemia, such as thalassemia, is crucial for implementing appropriate treatment strategies. Thalassemia, an inherited blood disorder, often presents with microcytic anemia and shares similar clinical features with iron deficiency anemia. However, the management of thalassemia differs significantly from that of iron deficiency anemia; for instance, iron supplementation may exacerbate the condition in thalassemia patients. Thus, accurate diagnostic tools are needed to guide healthcare providers in making informed treatment decisions and preventing potential complications related to misdiagnosis.[3]

One such tool that has gained traction in clinical practice is the Mentzer Index, which is calculated by dividing the mean corpuscular volume (MCV) by the red blood cell (RBC) count. The resulting value assists clinicians in differentiating between iron deficiency anemia and thalassemia. A Mentzer Index value greater than 13 typically indicates iron deficiency anemia, while values below 13 suggest thalassemia. The simplicity of this calculation makes it particularly advantageous for use in resource-limited settings, where access to advanced laboratory diagnostics may be limited. The ability to quickly assess the type of anemia can facilitate timely interventions and improve overall maternal health outcomes.[4] In addition to its diagnostic utility, the Mentzer Index's role in guiding iron supplementation needs in pregnant women cannot be overstated. By accurately classifying anemia, healthcare providers can determine when iron supplementation is necessary, thereby preventing the unnecessary administration of iron in cases of thalassemia. This targeted approach not only reduces the risk of complications associated with iron overload but also ensures that resources are allocated efficiently, maximizing the impact of anemia management programs.[5] Despite its advantages, the Mentzer Index is not without limitations. Factors such as variations in population-specific hematological parameters and the presence of comorbid conditions can influence the index's accuracy. Therefore, it is essential to consider the Mentzer Index as a preliminary screening tool rather than a definitive diagnostic measure. In practice, it should be used in conjunction with other diagnostic tests, such as serum ferritin and hemoglobin electrophoresis, to enhance the accuracy of anemia classification and guide treatment decisions effectively.[6]

Understanding the Mentzer Index

The Mentzer Index is a valuable hematological tool used to differentiate between iron deficiency anemia (IDA) and thalassemia, particularly in the context of microcytic anemia. This index is calculated using a simple formula: the mean corpuscular volume (MCV) is divided by the red blood cell (RBC) count (in millions per microliter). The resulting value aids clinicians in determining the type of anemia present, which is crucial for guiding treatment decisions. Specifically, a Mentzer Index greater than 13 is typically indicative of iron deficiency anemia, while a value less than 13 suggests thalassemia. This threshold provides a quick and accessible means for healthcare providers to evaluate anemia, especially in settings where sophisticated laboratory diagnostics may be limited.[7] The rationale behind the Mentzer Index lies in the distinct pathophysiological mechanisms of iron deficiency anemia and thalassemia. In IDA, there is a deficiency of iron, leading to reduced hemoglobin synthesis and smaller red blood cells (microcytosis). Consequently, the MCV is low, and the RBC count may be relatively normal or slightly decreased, resulting in a higher Mentzer Index. In contrast, thalassemia is characterized by genetic defects in hemoglobin production, leading to an imbalance in alpha and beta chains. This condition also results in microcytic red blood cells, but the RBC count is often elevated, producing a lower Mentzer Index. Thus, the index serves as a helpful, preliminary screening tool for clinicians to differentiate between these two common forms of anemia.[8] In clinical practice, the Mentzer Index is especially useful due to its simplicity and ease of interpretation. It requires only routine complete blood count (CBC) parameters, making it feasible for primary care settings and emergency departments. The widespread availability of CBC testing ensures that many pregnant women can be screened for anemia without the need for specialized tests. However, while the Mentzer Index provides valuable insights, it should not be used in isolation. Clinicians are encouraged to consider the patient's clinical history, dietary factors, and other laboratory results when making a comprehensive assessment.[9]

Relevance of Early Anemia Detection in Pregnancy

Early detection of anemia during pregnancy is critical for several reasons, primarily related to maternal health, fetal development, and overall pregnancy outcomes. Anemia, particularly iron deficiency anemia (IDA), can have significant implications for both the mother and the developing fetus. For pregnant women, anemia can lead to various complications, including fatigue, weakness, and decreased exercise tolerance. These symptoms not only affect the quality of life but can also impair the woman's ability to engage in essential daily activities and self-care, leading to potential psychosocial effects.[10] From a clinical perspective, undiagnosed and untreated anemia can result in severe consequences. Pregnant women with anemia are at a higher risk of experiencing complications such as preterm labor, low birth weight, and postpartum hemorrhage. The physiological changes during pregnancy—such as increased blood volume—place additional demands on iron stores, making early detection of iron deficiency crucial. If IDA is not identified and treated promptly, the risks of adverse maternal outcomes, including increased morbidity and mortality, can significantly rise.[11]Moreover; the implications of anemia extend to fetal health as well. Iron is essential for fetal growth and brain development, and insufficient maternal iron levels can lead to fetal iron deficiency, which may result in long-term neurodevelopmental impairments and cognitive deficits. The newborn may also be born with low iron stores, leading to anemia during infancy, which can further affect growth and development. Early detection of anemia allows for timely interventions, such as iron supplementation, which can significantly improve both maternal and fetal health outcomes.[12] The importance of early anemia detection is further emphasized by the socioeconomic impacts of anemia in pregnancy. Women who experience complications due to untreated anemia may face prolonged recovery periods, increased healthcare costs, and loss of productivity. These factors not only affect the individual but also place a strain on healthcare systems and society as a whole. By implementing effective screening strategies, healthcare providers can mitigate these risks and promote healthier pregnancies, ultimately leading to better health for mothers and their children.[13] Additionally, early detection of anemia can facilitate better prenatal care and improve health equity. In many regions, pregnant women, particularly in low-resource settings, may lack access to comprehensive healthcare services. Simplified screening tools, such as the Mentzer Index, can be integrated into routine prenatal care, making it easier to identify at-risk populations and direct resources to those in need. By prioritizing early anemia detection, healthcare providers can work toward reducing health disparities and improving maternal and child health outcomes in vulnerable communities.

Mentzer Index Application in Clinical Settings

The application of the Mentzer Index in clinical settings has emerged as a practical approach to streamline the diagnosis of anemia, particularly in pregnant women. Given the high prevalence of anemia during pregnancy and the associated risks for both mothers and infants, efficient screening and accurate diagnosis are vital components of prenatal care. The Mentzer Index, derived from simple parameters available in routine complete blood count (CBC) tests, facilitates the early identification of iron deficiency anemia (IDA) versus thalassemia. This differentiation is crucial for guiding appropriate treatment and management strategies, ultimately improving maternal and fetal health outcomes.[14] In practice, the Mentzer Index is calculated by dividing the mean corpuscular volume (MCV) by the red blood cell (RBC) count. A value greater than 13 typically indicates iron deficiency anemia, while a value less than 13 suggests thalassemia. This straightforward calculation allows healthcare providers to quickly assess the type of anemia a patient may have, enabling timely interventions. In resource-limited settings where advanced diagnostic tools may not be readily available, the Mentzer Index can serve as a reliable first-line screening tool. Its ease of use empowers clinicians to make informed decisions about further testing and treatment, ensuring that patients receive the care they need without unnecessary delays.[15] In addition to aiding in the diagnosis of anemia, the Mentzer Index can be instrumental in determining the necessity and appropriateness of iron supplementation. Pregnant women diagnosed with iron deficiency anemia may require iron supplementation to replenish depleted stores and support fetal development. In contrast, administering iron to patients with thalassemia can exacerbate their condition due to the risk of iron overload. By providing a clear distinction between these two types of anemia, the Mentzer Index enhances the safety and effectiveness of treatment plans. This targeted approach minimizes the risk of complications and promotes optimal maternal health, which is particularly important in the context of pregnancy.[16]

Moreover, the Mentzer Index can play a role in routine prenatal care by being incorporated into the standard screening protocols for anemia. Health care providers can routinely calculate the Mentzer Index as part of the CBC results during initial prenatal visits. This integration not only streamlines the diagnostic process but also raises awareness among healthcare professionals about the importance of anemia screening in pregnant women. Early identification and intervention can lead to improved patient outcomes, as women can receive timely education and resources regarding diet, lifestyle changes, and treatment options tailored to their specific needs.[17] Despite its benefits, it is essential to recognize the limitations of the Mentzer Index in clinical practice. Factors such as population-specific variations in hematological parameters, the presence of comorbid conditions, and the overlap of anemia types can affect the accuracy of the index. Therefore, while the Mentzer Index serves as a valuable screening tool, it should be used in conjunction with other diagnostic tests and clinical assessments for a comprehensive evaluation. Healthcare providers are encouraged to supplement the Mentzer Index with additional tests, such as serum ferritin levels and hemoglobin electrophoresis, to confirm the diagnosis and guide treatment more effectively.[18]

Comparison of the Mentzer Index with Other Diagnostic Indices

The Mentzer Index is one of several diagnostic indices used to differentiate between types of anemia, particularly iron deficiency anemia (IDA) and thalassemia. While the Mentzer Index provides a straightforward approach, other indices and tests can complement or serve as alternatives in clinical practice. This section will compare the Mentzer Index with several commonly used diagnostic indices, such as the RDW (Red Cell Distribution Width) index, the Soluble Transferrin Receptor (sTfR) test, and the Ferritin levels, highlighting their unique features, applications, and limitations.

1. RDW Index:

Red Cell Distribution Width (RDW) measures the variation in the size of red blood cells. An elevated RDW is often seen in various types of anemia, including IDA and thalassemia, and can help in differentiating between these conditions. While both the Mentzer Index and RDW provide useful insights into anemia, the RDW is more sensitive to changes in red blood cell size, which may indicate iron deficiency or other causes of anemia. However, RDW can be affected by numerous factors, including inflammation and other hematological disorders, making it less specific than the Mentzer Index for distinguishing between IDA and thalassemia.[19]

2. Soluble Transferrin Receptor (sTfR) Test:

The sTfR test measures the level of soluble transferrin receptors in the blood, which increases when there is an iron deficiency. This test is particularly helpful in cases where the differentiation between IDA and thalassemia is challenging, as it can provide additional context for iron status. Elevated sTfR levels typically indicate iron deficiency, while normal levels suggest that thalassemia may be the cause of anemia. While the sTfR test is highly specific and sensitive for diagnosing iron deficiency, it requires laboratory facilities and may not be as readily available in resource-limited settings compared to the Mentzer Index.[10]

3. Ferritin Levels:

Ferritin is a protein that stores iron in the body, and its levels are an important marker for assessing iron status. Low serum ferritin levels typically indicate iron deficiency, while normal or high levels may suggest thalassemia or other types of anemia. Although ferritin testing is widely used in clinical practice, it can be influenced by inflammatory states, making it less reliable as a standalone diagnostic tool in certain contexts. In contrast, the Mentzer Index provides a quick calculation that requires only routine CBC parameters, making it advantageous for initial screenings, especially in settings where ferritin testing may not be accessible.[11]

4. The A2 Ratio:

Another index used in the differential diagnosis of thalassemia is the Hemoglobin A2 ratio. Elevated levels of Hemoglobin A2 (>3.5%) are often indicative of beta-thalassemia. While this test is more specific for thalassemia, it requires hemoglobin electrophoresis, which may not be readily available in all clinical settings. The Mentzer Index, on the other hand, can be calculated from basic CBC data, allowing for quicker decision-making in acute care scenarios.[12]

5. Clinical Application and Practicality:

The primary advantage of the Mentzer Index is its simplicity and rapid applicability in clinical settings. It is derived from routine laboratory values, making it accessible to a broad range of healthcare providers, particularly in primary care or emergency situations. In contrast, other indices, such as sTfR and hemoglobin electrophoresis, require specialized laboratory testing, which may delay diagnosis and treatment. The Mentzer Index thus serves as a valuable first-line screening tool, with the potential to prompt further diagnostic evaluation using more specific tests when necessary.[13]

6. Limitations:

While the Mentzer Index is a useful tool, it is essential to recognize its limitations. The index may not be accurate in all populations, as variations in red blood cell parameters can occur based on ethnic and geographic factors. Furthermore, the Mentzer Index is not definitive; a low score does not confirm thalassemia, and further testing is necessary to confirm the diagnosis. Other indices, while potentially more specific in certain contexts, may require more resources and time to interpret effectively.[14]

Challenges and Limitations

Despite the advantages of the Mentzer Index in the diagnosis of anemia, particularly in pregnant women, several challenges and limitations affect its utility in clinical practice. Understanding these challenges is crucial for healthcare providers to make informed decisions about anemia management and treatment strategies.

1. Population-Specific Variations:

The Mentzer Index is derived from population averages, meaning its thresholds for differentiation between iron deficiency anemia (IDA) and thalassemia may not hold true for all demographic groups. Variability in hematological parameters exists due to genetic, environmental, and nutritional factors across different populations. For example, individuals from regions with a high prevalence of thalassemia may exhibit mean corpuscular volume (MCV) and red blood cell (RBC) count values that can lead to misinterpretation when applying the Mentzer Index. Therefore, the standard cut-off values may need adjustment to enhance accuracy in specific populations.[15]

2. Overlap of Anemia Types:

Anemia is a heterogeneous condition, and overlapping features between different types can complicate diagnosis. For instance, in cases of anemia of chronic disease, patients may present with low MCV and low RBC count, which could mimic IDA on the Mentzer Index. Consequently, healthcare providers may face challenges in distinguishing between these conditions without additional tests. The presence of multiple comorbidities can further obscure the clinical picture, necessitating a more nuanced approach to diagnosis that considers the overall health status of the patient.[16]

3. Limited Diagnostic Information:

While the Mentzer Index is a useful screening tool, it provides limited diagnostic information on its own. A Mentzer Index value greater than 13 suggests IDA, but it does not indicate the severity of the deficiency or the underlying cause. Similarly, a lower value suggests thalassemia, but it does not elucidate the specific type or degree of thalassemia. Thus, additional laboratory tests—such as serum ferritin, sTfR levels, or hemoglobin electrophoresis—are often required to establish a definitive diagnosis and guide treatment plans. The reliance on supplementary tests may increase the time and cost of care, particularly in resource-limited settings.[17]

4. Influence of Inflammatory States:

Acute and chronic inflammation can significantly affect hematological parameters, complicating the interpretation of the Mentzer Index. Inflammatory conditions often lead to changes in iron metabolism, resulting in anemia of chronic disease, which can present with low MCV and low RBC counts. This overlap can make the Mentzer Index less reliable in the presence of inflammation, necessitating careful clinical assessment and consideration of other diagnostic markers. Consequently, healthcare providers must take into account the overall clinical context when interpreting the Mentzer Index values.[18]

5. Resource Limitations:

The application of the Mentzer Index is limited by the availability of complete blood count (CBC) tests, which may not be accessible in all clinical settings, particularly in low-resource environments. In some cases, the cost of laboratory testing may pose a barrier to timely diagnosis and treatment. This limitation can hinder the effective use of the Mentzer Index in routine anemia screening, particularly in underserved populations where the prevalence of anemia is often higher.

6. Need for Training and Awareness:

For the Mentzer Index to be effectively utilized in clinical practice, healthcare providers must be trained in its calculation and interpretation. There is a need for increased awareness of the importance of anemia screening during pregnancy and the role of the Mentzer Index in guiding diagnosis. In many cases, healthcare professionals may lack familiarity with the index or may not routinely incorporate it into their practice, which can result in missed opportunities for early detection and management of anemia.

Conclusion

The Mentzer Index is a valuable and practical tool for assessing anemia, particularly in pregnant women, where timely detection and appropriate management are crucial. By leveraging easily obtainable complete blood count (CBC) parameters, the Mentzer Index allows healthcare providers to differentiate between iron deficiency anemia and thalassemia effectively, facilitating early interventions that can significantly improve maternal and fetal health outcomes. Despite its advantages, the Mentzer Index is not without limitations. Variability in hematological parameters across different populations, potential overlaps in clinical presentations among various types of anemia, and the effects of inflammatory conditions can impact its reliability. Furthermore, while the index provides useful initial insights, it is not a definitive diagnostic measure. Additional laboratory tests and clinical evaluations are often necessary to confirm diagnoses and inform treatment decisions.

Conflict of Interest: The authors declare no potential conflict of interest with respect to the contents, authorship, and/or publication of this article.

Author Contributions: All authors have equal contribution in the preparation of manuscript and compilation.

Source of Support: Nil

Funding: The authors declared that this study has received no financial support.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data supporting in this paper are available in the cited references.

Ethics approval: Not applicable.

References

1. Rahman MM, Abe SK, Rahman MS, Kanda M, Narita S, Bilano V, Ota E, Gilmour S, Shibuya K. Maternal anemia and risk of adverse birth and health outcomes in low-and middle-income countries: systematic review and meta-analysis. The American journal of clinical nutrition. 2016; 103(2):495-504. https://doi.org/10.3945/ajcn.115.107896 PMid:26739036

2. Obeagu EI, Ezimah AC, Obeagu GU. Erythropoietin in the anaemias of pregnancy: a review. Int J Curr Res Chem Pharm Sci. 2016;3(3):10-8. https://doi.org/10.22270/ijmspr.v10i2.95

3. Okamgba OC, Nwosu DC, Nwobodo EI, Agu GC, Ozims SJ, Obeagu EI, Ibanga IE, Obioma-Elemba IE, Ihekaire DE, Obasi CC, Amah HC. Iron Status of Pregnant and Post-Partum Women with Malaria Parasitaemia in Aba Abia State, Nigeria. Annals of Clinical and Laboratory Research. 2017;5(4):206.

4. Petrakos G, Andriopoulos P, Tsironi M. Pregnancy in women with thalassemia: challenges and solutions. International journal of women's health. 2016:441-451. https://doi.org/10.2147/IJWH.S89308 PMid:27660493 PMCid:PMC5019437

5. Obeagu EI, Adepoju OJ, Okafor CJ, Obeagu GU, Ibekwe AM, Okpala PU, Agu CC. Assessment of Haematological Changes in Pregnant Women of Ido, Ondo State, Nigeria. J Res Med Dent Sci. 2021 Apr;9(4):145-8.

6. Agreen FC, Obeagu EI. Anaemia among pregnant women: A review of African pregnant teenagers. Journal of Public Health and Nutrition. 2023;6(1):138.

7. Arora S, Rana D, Kolte S, Dawson L, Dhawan I. Validation of new indices for differentiation between iron deficiency anemia and beta thalessemia trait, a study in pregnant females. International Journal of Scientific Reports. 2018; 4(2):26. https://doi.org/10.18203/issn.2454-2156.IntJSciRep20180394

8. Tabassum S, Khakwani M, Fayyaz A, Taj N. Role of Mentzer index for differentiating iron deficiency anemia and beta thalassemia trait in pregnant women. Pakistan Journal of Medical Sciences. 2022;38(4Part-II):878. https://doi.org/10.12669/pjms.38.4.4635

9. Matos JF, Dusse LM, Stubbert RV, Ferreira MR, Coura-Vital W, Fernandes AP, de Faria JR, Borges KB, Carvalho MD. Comparison of discriminative indices for iron deficiency anemia and β thalassemia trait in a Brazilian population. Hematology. 2013 May 1;18(3):169-74. https://doi.org/10.1179/1607845412Y.0000000054 PMid:23321282

10. Iolascon A, Andolfo I, Russo R, Sanchez M, Busti F, Swinkels D, Aguilar Martinez P, Bou-Fakhredin R, Muckenthaler MU, Unal S, Porto G. Recommendations for diagnosis, treatment, and prevention of iron deficiency and iron deficiency anemia. Hemasphere. 2024; 8(7):e108. https://doi.org/10.1002/hem3.108 PMid:39011129 PMCid:PMC11247274

11. Obeagu EI, Obeagu GU, Chukwueze CM, Ikpenwa JN, Ramos GF. Evaluation of protein C, protein S and fibrinogen of pregnant women with malaria in Owerri metropolis. Madonna University journal of Medicine and Health Sciences ISSN: 2814-3035. 2022 Apr 19;2(2):1-9.

12. Obeagu EI, Obeagu GU. Neonatal Outcomes in Children Born to Mothers with Severe Malaria, HIV, and Transfusion History: A Review. Elite Journal of Nursing and Health Science, 2024; 2(3): 38-58

13. Sahli CA, Bibi A, Ouali F, Fredj SH, Dakhlaoui B, Othmani R, Laouini N, Jouini L, Ouenniche F, Siala H, Touhami I. Red cell indices: differentiation between β-thalassemia trait and iron deficiency anemia and application to sickle-cell disease and sickle-cell thalassemia. Clinical Chemistry and Laboratory Medicine (CCLM). 2013; 51(11):2115-24. https://doi.org/10.1515/cclm-2013-0354 PMid:23800659

14. Hoffmann JJ, Nabbe KC, van den Broek NM. Effect of age and gender on reference intervals of red blood cell distribution width (RDW) and mean red cell volume (MCV). Clinical Chemistry and Laboratory Medicine (CCLM). 2015; 53(12):2015-9. https://doi.org/10.1515/cclm-2015-0155 PMid:26536583

15. Miftahussurur M, Husada D, Ningtyas WS. Association of shine and LAL index β-thalassemia trait screening results with anaemia and low birth weigh. international journal of nursing and midwifery science (IJNMS). 2023; 7(3):290-296. https://doi.org/10.29082/IJNMS/2023/Vol7/Iss3/543

16. Shahid H, Saleem M, Naseer N, Tabussam S, Aziz A, Ullah S. Evaluation of Srivastava index to distinguishing Beta-Thalassemia Trait from Iron Deficiency. Pakistan Journal of Medical & Health Sciences. 2022;16(05):1225-. https://doi.org/10.53350/pjmhs221651225

17. Vehapoglu A, Ozgurhan G, Demir AD, Uzuner S, Nursoy MA, Turkmen S, Kacan A. Hematological indices for differential diagnosis of Beta thalassemia trait and iron deficiency anemia. Anemia. 2014; 2014(1):576738. https://doi.org/10.1155/2014/576738 PMid:24818016 PMCid:PMC4003757

18. Urrechaga E. Discriminant value of % microcytic/% hypochromic ratio in the differential diagnosis of microcytic anemia. Clinical chemistry and laboratory medicine. 2008;46(12):1752-1758. https://doi.org/10.1515/CCLM.2008.355 PMid:19055451

19. Obeagu EI, Obeagu GU. Impact of Maternal Eosinophils on Neonatal Immunity in HIV- Exposed Infants: A Review. Elite Journal of Immunology, 2024; 2(3): 1-18 https://doi.org/10.22270/ajdhs.v4i2.82