

## **COMPARISON OF RICERCA INDEX VALUES AS A SCREENING METHOD FOR BETA THALASSEMIA MINOR AND IRON DEFICIENCY ANEMIA AT PROF. DR. MARGONO SOEKARJO HOSPITAL**

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### **ABSTRAK**

Beta thalassemia minor and iron deficiency anemia (IDA) are the most common causes of microcytic hypochromic anemia with similar laboratory features but require different management approaches, making differentiation between these two conditions often challenging. The Ricerca index is a simple screening method based on RDW and RBC parameters that can distinguish beta thalassemia minor from IDA. To analyze the optimal cut-off, sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy of the Ricerca index in differentiating beta thalassemia minor from iron deficiency anemia at Prof. Dr. Margono Soekarjo Regional General Hospital. This was an analytical observational study with cross-sectional design using consecutive sampling from secondary data of medical records of patients aged  $\leq 18$  years during the 2020-2025 period, obtaining 40 subjects with beta thalassemia minor and 40 subjects with IDA. The Ricerca index value was calculated using the RDW/RBC formula. Diagnostic test analysis of the Ricerca index was performed using Receiver Operating Characteristic (ROC) curve. There were significant differences in the distribution of subject age, Hb and RBC values, and Ricerca index values between both groups ( $p < 0.001$ ). The optimal cut-off value of the Ricerca index was  $< 4.3$  for beta thalassemia minor and  $> 4.3$  for IDA. The Area Under the Curve (AUC) value was 0.861 (95% CI: 0.776-0.945;  $p < 0.001$ ). The sensitivity, specificity, PPV, and NPV of the Ricerca index for beta thalassemia minor were 77.50%, 80.00%, 79.49%, and 78.05%, respectively, while for IDA they were 80.00%, 77.50%, 78.05%, and 79.49%, with a Youden index of 0.58. The Ricerca index has good diagnostic performance with an accuracy of 86.1%, making it suitable for use as a screening method to differentiate beta thalassemia minor from IDA.

**Keywords:** Beta thalassemia minor, iron deficiency anemia, microcytic hypochromic anemia, RBC, RDW, Ricerca index

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**INTRODUCTION**

Anemia remains a global public health problem, particularly in developing countries. Approximately 30% of women aged 15–49 years, 37% of pregnant women, and 40% of children aged 6–59 months are affected by anemia, with the highest prevalence reported in Southeast Asia and Africa (WHO, 2024). The most common form is microcytic hypochromic anemia, primarily caused by beta-thalassemia minor and iron deficiency anemia (IDA), which often present with similar laboratory findings but require different management strategies (Bahraen, 2021; Rashwan et al., 2022).

Beta-thalassemia minor is a hereditary genetic disorder resulting from mutations in the beta-globin gene, inherited in an autosomal recessive pattern, leading to ineffective erythropoiesis (Paloma, 2023). In contrast, IDA is caused by depleted iron stores that impair hemoglobin synthesis (Hidayat et al., 2023). The overlapping erythrocyte morphology in these two conditions frequently poses diagnostic challenges, particularly in primary healthcare settings. Misdiagnosis may result in inappropriate treatment, potentially causing iron overload in patients with thalassemia, delayed detection of genetic abnormalities, increased risk of long-term complications, and additional economic burden.

In Indonesia, particularly in the Banyumas region, anemia and thalassemia represent growing health concerns. The prevalence of IDA among children under five in Banyumas Regency, particularly in the Jatilawang Primary Health Center area, has reached 18.4% (Dewi, 2018). Indonesia lies within the global “thalassemia belt,” with a carrier frequency of approximately 5–10% of the population (Rujito, 2019). In Banyumas Regency, the carrier prevalence has been reported at 8%, with an increasing number of cases each year. These data highlight the need for referral healthcare facilities, such as Dr. Prof. Margono Soekarjo General Hospital, to implement accurate, simple, and cost-effective screening methods to differentiate these two conditions at an early stage.

Several simple hematological indices have been developed to distinguish beta-thalassemia minor from IDA. Among these, the *Ricerca* index has emerged as a promising approach because it is based on routine hematological parameters that are readily available and do not require additional cost. The *Ricerca* index is calculated as the ratio between Red Cell Distribution Width (RDW) and Red Blood Cell (RBC) count, making it easy to apply without specialized or expensive testing (Bhargava et al., 2020; Munkongdee et al., 2020).

Previous studies have reported variable diagnostic performance. Javed et al. (2025) reported that the *Ricerca* index demonstrated the highest sensitivity (95.83%), while other indices showed higher specificity. Similarly, Rabbani et al. (2021) observed variability in diagnostic accuracy among different indices in distinguishing beta-thalassemia minor from IDA. These inconsistencies indicate the absence of consensus regarding diagnostic accuracy and the optimal cut-off value of the *Ricerca* index, particularly in pediatric

populations. Moreover, studies evaluating the performance of the Ricerca index in local Indonesian populations, including Banyumas, remain limited.

Given these conditions, a research gap exists due to the lack of local data and the absence of an established cut-off value for the Ricerca index tailored to the characteristics of the local population. Therefore, this study aims to evaluate the diagnostic performance and determine the optimal cut-off value of the Ricerca index in differentiating beta-thalassemia minor from iron deficiency anemia at Dr. Prof. Margono Soekarjo General Hospital. The findings are expected to support the implementation of more accurate and practical hematological screening in healthcare facilities, thereby improving diagnostic accuracy and preventing complications resulting from inappropriate management.

## RESEARCH METHOD

This study was an analytic observational study with a cross-sectional design developed as a diagnostic accuracy study using a retrospective approach based on medical record data. The study aimed to evaluate the diagnostic performance of the Ricerca index in differentiating beta-thalassemia minor from iron deficiency anemia (IDA). The study population consisted of all patients diagnosed with beta-thalassemia minor or IDA at Dr. Prof. Margono Soekarjo General Hospital between 2020 and 2025. Samples were selected using consecutive sampling, resulting in a total of 80 subjects (40 with beta-thalassemia minor and 40 with IDA) who met the inclusion and exclusion criteria.

The independent variable was the Ricerca index value (RDW/RBC), while the dependent variable was the diagnosis of beta-thalassemia minor or IDA. The diagnosis of beta-thalassemia minor was established based on hemoglobin electrophoresis results or elevated HbA2 levels documented in the medical records. The diagnosis of IDA was confirmed using laboratory parameters such as serum ferritin, serum iron, or Total Iron Binding Capacity (TIBC), as recorded in the medical records and considered the reference standard.

## Instruments and Materials

This study used secondary data obtained from the Laboratory Information System (LIS) of Dr. Prof. Margono Soekarjo General Hospital, Purwokerto. The collected data included complete blood count parameters: hemoglobin (Hb), Red Blood Cell count (RBC), Mean Corpuscular Volume (MCV), Mean Corpuscular Hemoglobin (MCH), and Red Cell Distribution Width (RDW). Laboratory examinations were performed using an automated hematology analyzer at the study site. No direct sample collection or new biological specimens were involved. Data validity was ensured as laboratory examinations were conducted using standardized equipment that underwent routine calibration according to hospital operational procedures.

## Study Procedure

The study was conducted from November to December 2025. Data were retrieved from hematological examination records of patients diagnosed with beta-thalassemia minor or IDA during the period 2020–2025. Consecutive sampling was applied, in which all eligible subjects meeting the inclusion criteria during the study period were included until the required sample size was achieved.

The inclusion criteria were patients aged  $\leq 18$  years with a confirmed diagnosis of beta-thalassemia minor or IDA and complete hematological examination data. The exclusion criteria included patients with other types of anemia, a history of blood transfusion within the previous three months, or chronic diseases such as chronic kidney

disease, liver disease, HIV/AIDS, or tuberculosis. The Ricerca index (RI) was calculated using the formula:  $RI = RDW (\%) / RBC (10^6/\mu L)$  RDW was expressed as a percentage (%) and RBC in units of  $10^6/\mu L$ , obtained from automated hematological examination results. The RI values were subsequently analyzed to determine the optimal cut-off value for differentiating beta-thalassemia minor from IDA.

Bias control measures included: Selection bias, minimized through the use of consecutive sampling of all eligible subjects. Information bias, minimized by using systematically documented medical records and LIS data. Data validity, ensured through the use of standardized laboratory equipment and routine calibration procedures.

Data were analyzed using IBM SPSS Statistics version 26. Normality testing was performed using the Shapiro–Wilk test. Group comparisons were conducted using the Mann–Whitney test. Diagnostic performance was evaluated using Receiver Operating Characteristic (ROC) curve analysis to determine the optimal cut-off value, along with the Area Under the Curve (AUC), sensitivity, specificity, Positive Predictive Value (PPV), Negative Predictive Value (NPV), and Youden index. A p-value < 0.05 was considered statistically significant.

## RESULT AND DISSCUSSION

The analysis was conducted on 80 samples that met the inclusion and exclusion criteria, consisting of 40 cases of beta-thalassemia minor and 40 cases of iron deficiency anemia.

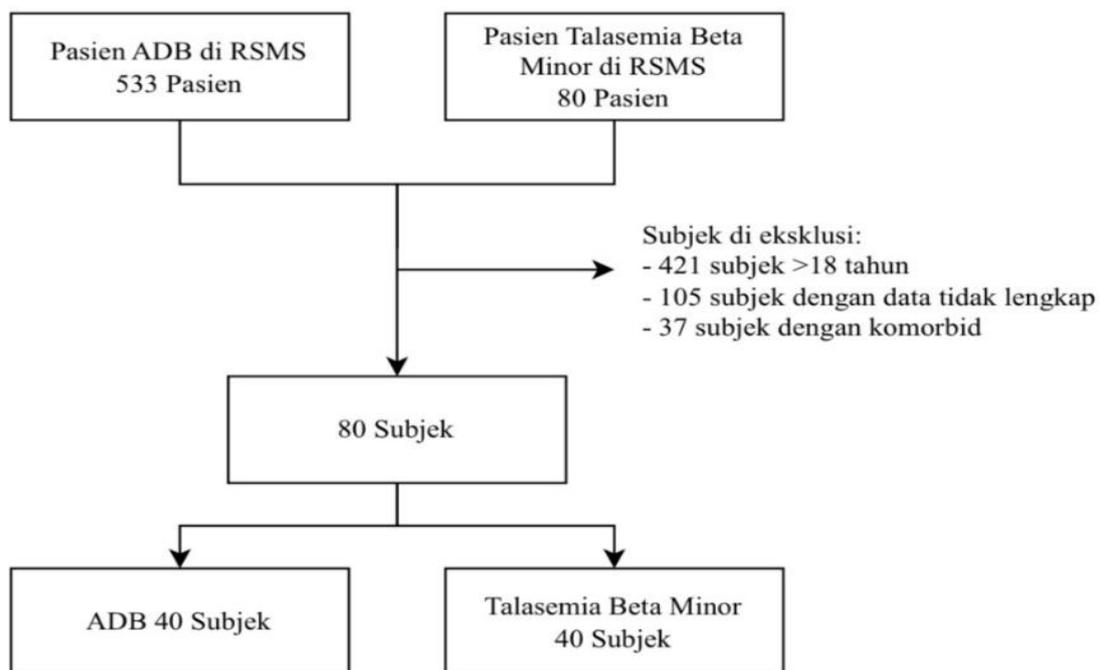


Figure 1. Flowchart of Study Subject Selection

Table 1. Characteristics of the Study Subjects and Laboratory Parameters

Variable	Beta-thalassemia Minor (n = 40)	Iron Deficiency Anemia (n = 40)	p-value
<b>Sex</b>			
Male	13 (32,5%)	15 (37,5%)	0,639
Female	27 (67,5%)	25 (62,5%)	
<b>Age</b>			
- 0-4 years	18 (45,0%)	23 (57,5%)	0,004
- 5-6 years	6 (15,0%)	1 (2,5%)	
- 7-9 years	9 (22,5%)	1 (2,5%)	
- 10-18 years	7 (17,5%)	15 (37,5%)	
<b>Laboratory Parameters</b>			
- Hb (g/dL)	9,68 ± 1,12	7,05 ± 2,05	<0,001 <sup>a</sup>
- RBC (10 <sup>6</sup> /uL)	4,81 ± 0,78	3,62 ± 0,94	<0,001 <sup>a</sup>
- MCV (fL)	59,00 (53,00-87,40)	62,55 (41,30-94,60)	0,637 <sup>b</sup>
- MCH (pg)	18,95 (17,40-28,30)	19,25 (11,80-31,20)	0,397 <sup>b</sup>
- RDW (%)	17,40 (11,80-28,90)	17,75 (12,90-31,80)	0,331 <sup>b</sup>
- HbA <sub>2</sub> (%)	5,05 (3,60-21,4)	-	-
- TIBC (µg/dL)	-	368,00 ± 98,52	-
- Serum Iron (µg/dL)	-	16,00 (6,00-29,00)	-

Notes: Hb = hemoglobin, RBC = Red Blood Cell Count, MCV = Mean Corpuscular Volume, MCH = Mean Corpuscular Haemoglobin, RDW = Red Cell Distribution Width, TIBC = Total Iron Binding Capacity, <sup>a</sup>Independent T-test, <sup>b</sup>Mann-Whitney Test

Based on sex distribution, the beta-thalassemia minor group consisted of 13 male subjects (32.5%) and 27 female subjects (67.5%), whereas the iron deficiency anemia (IDA) group included 15 males (37.5%) and 25 females (62.5%). No significant difference in sex distribution was observed between the two groups ( $p = 0.639$ ).

Age distribution showed a statistically significant difference between groups ( $p = 0.004$ ). In the beta-thalassemia minor group, the highest proportion of subjects was in the 0–4 years age group (45.0%), followed by 7–9 years (22.5%), 10–18 years (17.5%), and 5–6 years (15.0%). In contrast, the IDA group was predominantly represented by subjects aged 0–4 years (57.5%) and 10–18 years (37.5%), followed by those aged 5–6 years and 7–9 years (2.5% each).

Regarding laboratory parameters, hemoglobin levels were significantly higher in the beta-thalassemia minor group compared with the IDA group, with mean values of  $9.68 \pm 1.12$  g/dL and  $7.05 \pm 2.05$  g/dL, respectively ( $p < 0.001$ ). Similarly, the red blood cell (RBC) count was significantly higher in the beta-thalassemia minor group than in the IDA group ( $4.81 \pm 0.78 \times 10^6/\mu\text{L}$  vs.  $3.62 \pm 0.94 \times 10^6/\mu\text{L}$ ;  $p < 0.001$ ). Both groups demonstrated microcytic anemia based on Mean Corpuscular Volume (MCV) values, with median values of 59.00 fL (range 53.00–87.40) in the beta-thalassemia minor group and 62.55 fL (range 41.30–94.60) in the IDA group. The median Mean Corpuscular Hemoglobin (MCH) was 18.95 pg (IQR 17.40–28.30) in the beta-thalassemia minor group and 19.25 pg (IQR 11.80–31.20) in the IDA group, with no statistically significant difference ( $p = 0.397$ ). Red Cell Distribution Width (RDW) tended to be higher in the IDA group compared with the beta-thalassemia minor group, with median values of 17.75% (IQR 12.90–31.80) and 17.40% (IQR 11.80–28.90), respectively.

Additional investigations in the beta-thalassemia minor group showed a median HbA<sub>2</sub> level of 5.05% (IQR 3.60–21.40). In the IDA group, iron status assessment revealed

a mean Total Iron Binding Capacity (TIBC) of  $368.0 \pm 98.52$   $\mu\text{g/dL}$  and a median serum iron level of  $16.0$   $\mu\text{g/dL}$  (IQR 6.00–29.00).

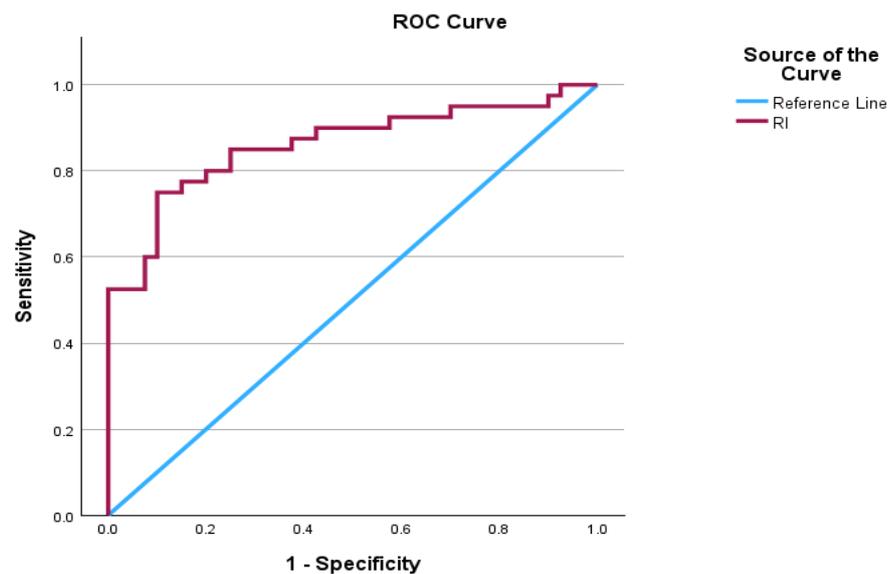


Figure 2. Receiver Operating Characteristic (ROC) Curve of the Ricerca Index

The optimal cut-off value was determined through sensitivity and specificity analysis. The newly identified cut-off value in this study was 4.3, which is slightly lower than the conventional Ricerca index cut-off value of 4.4. The Area Under the Curve (AUC) derived from the ROC analysis was 0.861 (95% CI: 0.776–0.945), indicating good discriminative ability of the Ricerca index, with an overall diagnostic accuracy of 86.1% in differentiating beta-thalassemia minor from iron deficiency anemia. The p-value ( $<0.001$ ) demonstrates that the result was statistically significant.

Table 2. Diagnostic Performance of the Ricerca Index for Identifying Beta-thalassemia Minor Against Iron Deficiency Anemia

	Beta-thalassemia Minor	Iron Deficiency Anemia	Total
Indeks Ricerca < 4,3	31	8	39
> 4,3	9	32	41
Total	40	40	

Table 3. Comparison of the Mean Ricerca Index Between Study Groups

	Ricerca Index Values	$P^*$ CI 95% (0,776-0,945)
Beta-thalassemia Minor	3,33 (2,65 – 4,23)	<0,001
Iron Deficiency Anemia	5,39 (4,30 – 9,43)	

$P^*$  Mann-Whitney Test  $p$ -value  $< 0,05$

Overall, of the total 80 study subjects, 63 were correctly classified, while misclassification occurred in 17 subjects. These findings indicate that the Ricerca Index demonstrates good performance in identifying beta-thalassemia minor and iron deficiency anemia within the study population. The comparison of Ricerca Index values between the

beta-thalassemia minor and iron deficiency anemia groups is presented in Table 3. The median Ricerca Index value in the beta-thalassemia minor group was 3.33 (range: 2.65–4.23) with a standard deviation of 0.38. In contrast, the iron deficiency anemia group showed a median value of 5.79 (range: 4.30–9.43) with a standard deviation of (1.53.)

Statistical analysis demonstrated a significant difference in the mean Ricerca Index between the two groups ( $p < 0.001$ ). These findings indicate that the mean Ricerca Index was significantly higher in the iron deficiency anemia group compared to the beta-thalassemia minor group.

Table 4. Diagnostic Performance of the Ricerca Index

	<i>Cut-off</i>	Sn (%)	Sp (%)	PPV (%)	NPV (%)	YI
4.3	Beta-thalassemia Minor	77,50	80,00	79,49	78,05	0,58
	Iron Deficiency Anemia	80,00	77,50	78,05	79,49	
4.4	Beta-thalassemia Minor	77,50	75,00	75,61	76,92	0,53
	Iron Deficiency Anemia	75,00	77,50	76,92	75,61	

The calculation of the Ricerca Index (RI) at a cut-off value of 4.3 demonstrated a sensitivity of 77.5%, specificity of 80%, positive predictive value (PPV) of 79.49%, and negative predictive value (NPV) of 78.05%. For the identification of iron deficiency anemia, the sensitivity was 80%, specificity 77.5%, PPV 78.05%, and NPV 79.49% (YI = 0.58). When the RI was calculated using the conventional cut-off value of 4.4, a decline in diagnostic performance was observed compared to the 4.3 cut-off. Identification of beta-thalassemia minor showed the same sensitivity (77.5%) but a decrease in specificity to 75%, with PPV of 75.61% and NPV of 76.92%. Meanwhile, for the identification of iron deficiency anemia, sensitivity was 75%, specificity 77.5%, PPV 76.92%, and NPV 75.61% (YI = 0.53).

This study demonstrated a significant difference in Ricerca Index (RI) values between the beta-thalassemia minor and iron deficiency anemia groups ( $p < 0.001$ ). The significant difference in RI values between the two groups can be explained by differences in the pathophysiology of erythropoiesis. Beta-thalassemia minor is a genetic disorder caused by gene mutations leading to erythrocyte membrane damage and ineffective erythropoiesis (Rujito, 2019; Paloma, 2023). As a compensatory mechanism, the bone marrow increases erythrocyte production, resulting in a high RBC count with relatively uniform cell size, thereby producing normal or slightly elevated RDW values. In iron deficiency anemia, iron depletion disrupts hemoglobin synthesis, leading to decreased erythrocyte production and smaller, more variable erythrocyte size, resulting in increased RDW and decreased RBC count (Ningrum et al., 2023; Hidayat et al., 2023). This mechanism underlies the RDW/RBC ratio used in the Ricerca Index. A low RI value (<4.3) indicates a high erythrocyte count with minimal size variation, as seen in beta-thalassemia minor, whereas a high RI value (>4.3) reflects a lower erythrocyte count with greater size variability, as observed in iron deficiency anemia (Jameel et al., 2017).

The findings of this study differ from those of other studies. Rabbani et al. (2021) reported that the Mentzer index had the highest sensitivity (92.5%), whereas the Ricerca Index demonstrated the highest specificity (94.2%) in differentiating beta-thalassemia minor from iron deficiency anemia. Setiawan et al. (2021) in Ciamis Regency reported very high sensitivity of the Ricerca Index (98.7%) but low specificity (7.03%). Meanwhile, Hidayat et al. (2023) in Lampung concluded that the Mentzer index had a sensitivity of only 21.4% and specificity of 78.6%, and was considered less accurate compared to the Ricerca Index. Differences among studies may be attributed to several factors, including

variations in laboratory instruments, differences in age and ethnic populations, and underlying clinical conditions (Astrand et al., 2024). The Banyumas population included in this study also has a distinct genetic background, in which the *XmnI*, *BCL11A*, and *HBS1L-MYB* genes have been reported to contribute to clinical variation among thalassemia patients in the region (Siswandari et al., 2019).

The results of this study strengthen the potential use of the Ricerca Index as a simple hematological screening method in primary healthcare facilities. Complete blood count testing is a routine, relatively inexpensive, and widely available examination, allowing index calculation to guide diagnosis before confirmatory tests such as hemoglobin electrophoresis or iron status assessment are performed (Bhargava et al., 2020; Munkongdee et al., 2020). The use of the Ricerca Index may help prevent therapeutic errors resulting from misdiagnosis. Administration of iron supplementation in patients with beta-thalassemia minor may lead to unnecessary treatment (Javed et al., 2025). Therefore, early screening using a simple method such as the Ricerca Index offers particular advantages, especially in primary healthcare settings that lack advanced diagnostic facilities.

The limitations of this study include the use of a cross-sectional design, which does not allow assessment of causal relationships, and a sample derived from a single healthcare center. In addition, this study did not control for other factors that may influence RDW values, such as nutritional status, inflammation, or chronic diseases that may not have been detected in secondary data (Loprinzi & Hall, 2015). Nevertheless, this study provides an important contribution by establishing a local Ricerca Index cut-off value (4.3) in a pediatric population in Banyumas, which has rarely been reported previously. These findings are expected to serve as a basis for developing an initial screening algorithm for microcytic hypochromic anemia in Indonesia.

## CONCLUSION

This study demonstrates that the Ricerca Index has good diagnostic capability in differentiating beta-thalassemia minor from iron deficiency anemia (IDA), with a sensitivity of 77.5% and specificity of 80%. The optimal cut-off value of 4.3 yielded a diagnostic accuracy of 86.1%, indicating that this index can be considered a reliable and simple hematological screening tool in primary healthcare settings. These findings may serve as a foundation for the development of screening strategies for microcytic hypochromic anemia in Indonesia. However, external validation through multicenter studies is required to strengthen the generalizability of these results to broader populations.

## REFERENCES

- Astrand, A., Wingren, C., Walton, C., Mattsson, J., Agrawal, K., Lindqvist, M., et al. 2024. A comparative study of blood cell count in four automated hematology analyzers: An evaluation of the impact of preanalytical factors. *Plos one*. 19(5): 1-19.
- Bahraen, R. 2021. Penentuan Cut-off Indeks Diskriminasi Diagnosis Pada Anemia Defisiensi Besi Dan Beta Thalassemia Minor. *Jurnal Kedokteran*. 10(1): 400-404.
- Bhargava, M., Kumar, V., Pandey, H., Singh, V., Misra, V., Gupta, P. 2020. Role of Hematological Indices as a Screening Tool of Beta Thalassemia Trait in Eastern Uttar Pradesh: An Institutional Study. *Indian journal of hematology & blood transfusion*. 36(4): 719-724.

- Hidayat, H., Triwahyuni, T. T., Kurniati, M., Florentina, C. 2023. Perbandingan Sensitivitas dan Spesifisitas Indeks Mentzer pada Anemia Defisiensi Besi dan Talasemia di RSUD Dr. H. Abdul Moeloek Provinsi Lampung. *SEHAT: Jurnal Kesehatan*. 2(3): 181-188.
- Jameel, T., Baig, M., Ahmed, I., Hussain, M.B., Alkhamaly, M.B.D. 2017. Differentiation of beta thalassemia trait from iron deficiency anemia by hematological indices. *Pakistan Journal of Medical Sciences*. 33(3): 665-669.
- Javed, H., Wahid, S., Latif, A., Qureshi, M. A., Hussain, I., Zafar, A. 2025. Diagnostic Accuracy of Hematological Indices for Differentiation of Beta Thalassemia Trait and Iron Deficiency Anemia—A Cross Sectional Study. *The Research of Medical Science Review*. 3(1): 1296-1303.
- Loprinzi, P. D., Hall, M. E. 2015. Physical activity and dietary behavior with red blood cell distribution width. *Physiology & behaviour*. 149(1): 35-38.
- Munkongdee, T., Chen, P., Winichagoon, P., Fucharoen, S., Paiboonsukwong, K. 2020. Update in Laboratory Diagnosis of Thalassemia. *Frontiers*. 7(74): 1-12.
- Ningrum, N., Setiadi, D., Sari, M. 2023. Diagnosis dan Tatalaksana Anemia Defisiensi Besi pada Anak Usia 0–18. *Jurnal Penelitian dan Karya Ilmiah Lembaga Penelitian Universitas Trisakti*. 8(1): 99-111.
- Paloma, I. D. A. N. C. 2023. Talasemia: sebuah Tinjauan Pustaka. *Biocity Journal of Pharmacy Bioscience and Clinical Community*. 1(2): 89-100.
- Rabbani, S., Farooq, M., Naeem, S., Uddin, N., Naeem, M. A., Jabeen, S. 2021. Diagnostic efficacy of red blood cell indices in diagnosis of beta thalassemia trait taking haemoglobin electrophoresis as gold standard. *PAFMJ*. 71(3): 1006-10.
- Rashwan, N. I., Ahmed, A. E. A., Hassan, M. H., Mohammed, M. E., Bakri, A. H. 2022. Hematological indices in differentiation between iron deficiency anemia and beta-thalassemia trait. *International Journal of Pediatrics*. 10(1): 15285-15295.
- Rujito, L. 2019. *Talasemia: Genetik Dasar dan Pengelolaan Terkini*. Universitas Jenderal Soedirman, Purwokerto.
- Setiawan, D., Setiawan, H., Nurmalasari, A. 2021. Indeks Formula Eritrosit Untuk Uji Skrining Talasemia Beta Minor. *Jurnal Analisis Medika Biosains*. 8(2): 114-120.
- Siswandari, W., Rujito, L., Indriani, V., Djatmiko, W. 2019. Mentzer index diagnostic value in predicting thalassemia diagnosis. *IOP Conference Series*. 255(1): 1-7.
- Sulistiyowati, E. H., Grehastuti, W., Faiza, D., Novia, D. E., Suprihatin, S., Purwoko, A., Aminah, S. 2024. Penggalangan Komitmen Banyumas Dalam Mencegah Talasemia Menuju Banyumas Goes to Zero Talasemia 2030. *Jurnal Linggamas*. 2(1): 1-6.
- World Health Organization. 2024. *Guideline on haemoglobin cutoffs to define anaemia in individuals and populations*. World Health Organization Regional Office for South-East Asia, Geneva.