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Correlation between malondialdehyde levels, ferritin levels, and transfusion duration in transfusion-dependent pediatric thalassemia patients

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Abstract

Thalassemia is a genetic disorder that causes chronic anemia and requires regular blood transfusion therapy. Indonesia is one of the countries with the highest thalassemia traits; there are 10,531 thalassemia patients, and it is estimated 2,500 newborns experience thalassaemia. Long-term transfusions can cause increase iron levels in the body's, which is characterized by increased serum ferritin levels. Excess iron forms Reactive Oxygen Species (ROS), which damages the lipid membrane causing cell damage. One of the ROS products is malondialdehyde, which is produced by secondary lipid peroxidation, and is a biomarker for examining oxidative stress in thalassemia. Purpose this study analysed the relationship between malondialdehyde and ferritin levels with transfusion duration in transfusion-dependent pediatric thalassaemia patients. Methods: a cross-sectional design involved 34 transfusion-dependent pediatric thalassemia patients at Dr. Soetomo Surabaya Hospital in July-August 2025. The research variables included malondialdehyde, ferritin, and how long they had undergone blood transfusions. Measurement of malondialdehyde levels using the HPLC method, ferritin examination using the CMIA method, and length of transfusion using survey and questionnaire methods. Data analysis was carried out by Spearman correlation test ($p<0.05$). The results obtained were the value of the malondialdehyde coefficient with ferritin ($rs = 0.130$; $p = 0.465$) had a weak positive correlation, malondialdehyde with the length of time to receive transfusions ($rs = -0.115$; $p= 0.519$), showing a negative correlation means weak. The conclusion reached was that there was no association between malondialdehyde levels and ferritin with the length of time they received blood transfusions in thalassemia patients.

Keywords Thalassemia dependent transfusion, Malondialdehyde, Ferritin, Long transfusion.

Introduction

A genetic mutation in the globin-alpha or beta gene causes thalassemia, a condition characterized by decreased or absent production of one or more hemoglobin tetramer chains.1 This can lead to inefficient erythropoiesis, hemolysis, and clinical symptoms include anemia, bone abnormalities, and iron excess.2 The World Health Organization (WHO) in 2020 stated that the carriers of thalassemia in the world reached 7% and reached 40% in Asian countries. Indonesia is one of the countries with the highest carrier of traits, there are 10,531 thalassemia patients and in newborns, it is estimated that as many as 2,500 have thalassemia.3 Thalassemia patients have chronic anemia that requires regular blood transfusions lifetime.4 The maturity of physiological development in children dependent on blood transfusions worsens the host's response to the transfused cells, changes the type or severity of the clinical resulting in increased morbidity and premature death.5

Patients with Transfusion Dependent Thalassemia (TDT) requires a transfusion of red blood cells or Packed Red Cells (PRC) to maintain hemoglobin levels between 9.0-10.5 g/dl.6 The length of time the patient was diagnosed with thalassemia and the first time a patient received a blood transfusion until evaluation within a certain time.7 Blood transfusions can affect a patient's clinical condition through a variety of mechanisms, including iron accumulation, oxidative stress, and organ damage.8

Markers of oxidative stress that can be measured through harmful compounds from lipid peroxidation products.9,10 Lipid peroxidation produces Reactive Oxygen Species (ROS) will attack the cell membrane producing some products for example malondialdehyde, 4-hydroxy-2-nonenal (4-HNE),

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DNA damage, protein oxidation, thrombosis, pulmonary hypertension, serosis.11 Malondialdehyde (MDA) is the end result of the peroxidation of polyunsaturated fatty acids in cells, Increased MDA is a marker of oxidative stress 12. Due to increased oxidants compared to antioxidant levels, it can cause cell damage,13 MDA also has mutagenic properties.14 Blood transfusions have an effect of increasing levels of malondialdehyde and ferritin in the blood that result in organ damage and complications 15, 34,36. Therefore, it is important to conduct research to prove the correlation of levels malondialdeyide, with ferritin levels and long-term blood transfusions in transfusion-dependent pediatric thalassemia patients.

Materials and Methods

Cross-sectional observational analytical research design. Samples were obtained from the Pediatric Hematology-Oncology Polyclinic Installation and from the Clinical Pathology Laboratory of Dr. Soetomo Hospital, Surabaya, East Java, Indonesia. With ethical approval from the Ethics Committee under number 1357/KEPK/VI/2025 on June 30, 2025.

Sample

A total of 34 pediatric patients who were diagnosed with thalassemia and had undergone transfusions more than 10 times meet the research criteria and are willing to participate in informed consent.

Malondialdehyde (MDA) analysis

A sample of 300µL was added with 30µL KOH 3M, then vortexed and incubated for 1 hour at a temperature of 60°C. Then 600 µL diluent 1 was added, which is a mixture of (TCA 20% in H2S04 0.2M), after that the vortexed for 1 minute and centrifugation for 10 minutes at a speed of 14000 rpm. Supernatant is pipetted as much as 500 µL, and 250 µL diluent 2 (TBA 0.355%) was added. The mixture is incubated for 40 minutes at 90°C. Next, it is incubated at a cold temperature for 5 minutes, followed by centrifugation for 10 minutes at a speed of 14000 rpm. Supernatant is pipetted as much as 20µL and transferred to an HPLC sample vial for analysis.

Chromatography separation used a 4.6 x150mm Eclipse XDB-C18 (5µm) with (Methanol) mobile phase and Phospat buffer (18.9 µM, pH=6.0) mobile phase B. Elution used isocratic with a composition of 55% (A) and 45% (B), injection volume of 20ul, flow rate of 1 ml/min with an analysis time of 3 minutes. The temperature of the examination column is 40°C MDA readings were obtained using a 532nm wavelength DAD detector on the Agilent 1200 series HPLC equipment.16

Ferritin analysis

A serum sample of 25µL was put into a cuvette, and then 100µL (Reagent Lite) and 450µL (Solid phase) were added in incubation for 7.5 minutes at a temperature of 370C. Dispense 300 µL of acid reagents and alkaline reagents each to initiate the chemiluminescent reaction. It is further measured using CMIA (Chemiluminescent Microparticle Immunoassay) the SIEMENS ADVIA Centaur XPT Immunoassay System.17

Data Analysis

Data analysis of correlation malondialdehyde levels, ferritin levels, and duration transfusion was analyzed using IBM SPSS Statistics 24 with normalization tests using the Shapiro-Wilk test to test the normality of data distribution and correlation tests using the Spearman test correlation.

Results

Screening of research subjects

The initial research was screened on 38 patients, and 34 patients were found to be included in the inclusion criteria, followed by completing using questionnaires and supporting secondary data. It can be seen in Table 1.

Table 1. General Characteristics of Research Participants

Features	Frequency N = 34	Percentage (%)
Gender		
Male	24	70,6
Women	10	29,4
Age (years)		
0 – 6 Years	2	5,9
7 – 12 Years	19	55,9
13 – 18 Years	13	38,2
Iron Sailor		
Deferasirox	15	41,7
Deferiprone	17	47,2
Combination Deferasirox & Deferiprone	1	2,8
Do Not Consume	1	2,8
Folic Acid		
Consuming Folic Acid	33	91,7
Not Consuming Folic Acid	1	2,8
Classification		
Beta thalassemia	33	97,1
Thalassemia	1	2,9

Remarks: Characteristics of Research Subjects

Pediatric thalassemia patients who met the inclusion criteria were found to be male as many as 70.6% and female 29.4% at an average age of 12 years. This study is in line with a review conducted by Tuo 2024 of thalassemia sufferers in Asia, in boys under the age of five years higher than in girls, although, there are deviations in high-income Asian regions there is no gender difference.18

With iron chelation therapy, the iron consumed are deferasirox and deferipron, where deferipron is consumed as much as 47.2% and deferasirox as many as 41.7%. In a previous study by Rochman (2019) it was stated that the use of the same iron chelation to lower ferritin levels. Antioxidant defenses in the body include catalase, superoxide dismutase, glutathione peroxidase, and glutathione so that the formation of ROS can be suppressed. Thalassemia patients receive iron chelation treatment (deferasirox, deferiprone or a combination of both drugs) to lower circulating levels of free iron to prevent ROS. The serum ferritin target in thalassemia major patients was <1000ng/ml, but the use of both drugs did not show a decrease in ferritin levels.19 However, Deferasirox is more effective than Deferiprone in reducing complications related to melatonin drugs, iron excess, notably in transfusion-dependent thalassemia patients.20 In addition to iron chelation, patients also receive folic acid as a supportive therapy that ensures the process of red blood cell formation remains optimal, lowers homocysteine and maintains the endogenous oxidant system (GSH), to strengthen cells against ROS even if it does not directly reduce iron reserves.21 Vitamin E is also an antioxidant that is sometimes used for additional therapy, which has the efficacy of increasing the effectiveness of deferasirox as an iron chelating agent in transfusion-dependent thalassemia.22, 35, 35,37.

Measurement Compete Blood Count (CBC)

Complete hematological examination or Complete Blood Count (CBC) is often used as the first screening test to mark possible thalassemia 23. This study showed the results of a decrease in several parameters, see Table 2.

Table 2. Characteristics of Research Supporting Examinations

Features	n (%)	Mean ±SD	Median	Range
Hemoglobin (Hb)				
5,0 – 10,0 g/dl	31 (91,2)	8,3706±1,1010	8,4	5,7-10,5
10,1 – 15,0 g/dl	3 (8,8)			
Erythrocyte				
< 4x106/uL	24 (70,6)	3,5541± 0,5524	3,55	2,21 – 4,48
>4x106/uL	10 (29,4)			
Leukosit				
3,000-10,000/µL	31 (86,1)	6,7311±2,40339	6,185	3,84 – 15,05
>10.000/µL	3 (8,3)			
Thrombosit				
<150.000/µl	4 (11,1)	287,4412±148,49	264.500	114.00-884.00
150,000-450,000/µl	25 (69,4)			

Features	n (%)	Mean ±SD	Median	Range
>150.000/µl	5 (13,9)			
MCV				
<80 fL	30 (88,2)	72,618±7,3411	72,2	61,3-89,3
>80 fL	4 (11,8)			
MCH				
<26 pg	26 (76,5)	23,858±2,8577	23.8	18.9-30.0
>26 pg	8 (23,5)			
MCHC				
<32 g/dL	8 (23,5)	32.8±1.586	32,6	30,5-38,3
>32 g/dL	26 (76,5)			
Hematocrit				
<35%	34 (100)	25.588±3.068	25.85	16.4-31.7

Description: Complete haematology or Competitive Blood Count (CBC)

Hemoglobin levels are at the mean value 8,37 g/dl This shows that (91.2%) of thalassemia pediatric patients come with anemia. Patients with chronic anemia are 100% in line with the research of Fatchurrozak (2019), which states that thalassemia patients experience severe anemia due to excessive erythrocyte breakdown, so in patients experience chronic anemia.24 The number of erythrocytes is less than 4x106/uL as much as 70.6%. This shows that the patient has chronic anemia and microcytosis, so that it is not efficient in transporting oxygen. The number of leukocytes (86.1%) decreased with a median of 6.18/uL, which means the patient did not have an infection. The number of platelets with a median of 264,500/uL. MCV levels of more than 80 fL (88.2%) mean the average volume of erythrocytes, so that small erythrocytes occur (Microcytosis). At MCH less than 26g/dL (76.5%), the Hb content in erythrocytes is slight, so erythrocytes are pale (hypochrome). MCHC levels greater than 32g/dL (23.5%) indicate a low concentration of hemoglobin in erythrocytes. A hematocrit examination showed a 100% decrease in levels, which was less than 35%. This indicates that the patient is anemic and will increase after receiving a blood transfusion.25 In addition to increasing hematocrit, regular blood transfusions in people with hypertension attempt to minimize symptoms of anemia and overcome difficulties caused by inadequate erythropoiesis.26

Results of Measurement of MDA, Ferritin and Transfusion Duration

The measurement result of malondialdehyde levels, ferritin levels, and the length of time receiving the transfusion see Table 3.

Table 3. Measurement of malondialdehyde (MDA), Ferritin, and Long received Transfusion

Features	n (%)	Mean ±SD	Median	Range
MDA Thalassemia Patients	34	1,0456±0, 28418	1,03	0,56 – 1,78
Ferritin in Thalassemia Patients	34	2536,0±12 93,55	2342,75	783,9 - 6510,2
How long it took to receive a transfusion	34	97,676±39 ,7886	98	24 - 168

Descriptive analysis of rates of malondialdehyde (MDA) thalassemia patients at a median of 1.03 µmol/L with a range between 0.56 µmol/L to 1.78 µmol/L, this value indicates that MDA levels are within normal limits, where the normal MDA value is 0.55 – 2.27 µmol/L meaning that the results of the study show that there has been no oxidative stress in the patient's blood sample. MDA results within normal limits give meaning even if they occur in high iron load due to receiving blood transfusions, but no significant increase in malondialdehyde. This is likely due to regular administration of antioxidant supplements and iron chelation therapy.13 Increased anti-oxidant enzymes capture radical molecules thereby neutralizing ROS before lipids undergo significant peroxidation.27

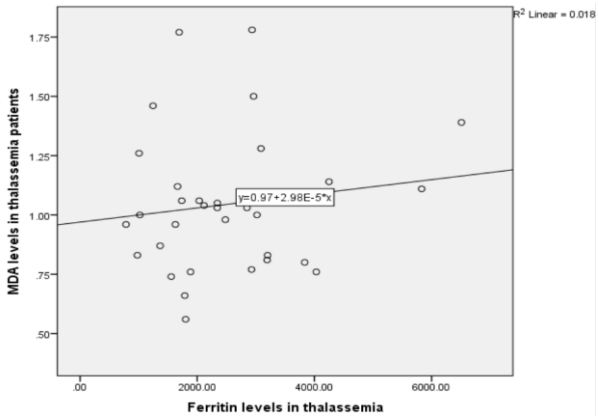

Figure 1. Plot Scatter MDA Rate vs Ferritin Rate

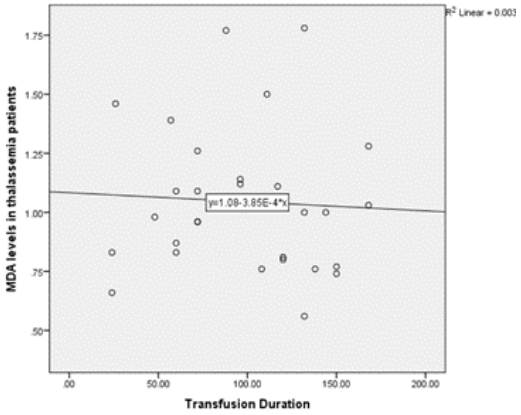

Figure 2. Scatter Plots MDA Rate with Transfusion Duration

The relationship of malondialdehyde (MDA) with ferritin levels using the Spearman have a correlation coefficient value (rs)= 0.130 with p = 0.465. The results showed no relationship between malondialdehyde with ferritin levels in thalassemia patients. This means that an increase in ferritin levels does not always result in an increase in MDA in thalassemia patients. Previous investigations have found no significant change in MDA levels between TDT and NTDT patients, with median levels of 0.45 µmol/L and minimum and maximum levels of 0.14 µmol/L and 1.49 µmol/L.3

The results of the study obtained a median value of 2342.75 ng/ml with a value range of 783.9 ng/ml to 6510.2 ng/ml. This value shows an increase above the normal value (10-200 ng/mL), which indicates that the patient has iron accumulation (iron over-load). Meanwhile, the average length of time to receive a transfusion in patients was 97.67 ± 39.78 months or about 8 years. This illustrates that most patients have undergone blood transfusions for a long time, so there is a buildup of iron in their bodies. Regular blood transfusions increase the danger of iron accumulation in the heart, liver, and endocrine system. Each blood transfusion contains 200-250mg of iron (1ml of erythrocytes contains 1mg of iron) that cannot be removed. In line with the research of Widyastuti (2024), which states that routine blood transfusions cause an increase in ferritin in the body.28 In patients with thalassemia, serum ferritin levels are significantly increased, not only reflecting iron reserves, but also acting as an acute phase protein that increases when inflammation occurs.29

The length of time to undergo a transfusion varies between 24 and 168 months, according to the first diagnosis of thalassemia. Meanwhile, the average length of time to receive a transfusion in patients was 97.67 ± 39.78 months or about 8 years. This illustrates that most patients have undergone blood transfusions for a long time, so that there is a buildup of iron in their bodies. Blood transfusions are carried out due to the body's inability to produce hemoglobin optimally, so patients need routine blood transfusion therapy for life. This is consistent with Irdawati findings, which claim that the longer it takes to undergo a transfusion is related to the amount of blood iron is received by the patient receives.30 Excess iron can stimulate lipid oxidation and reduce antioxidants in the body, so that an imbalance occurs and causes ROS.31,32 The amount of iron released from the breakdown of hemoglobin will stimulate ROS products, which will increase free radicals in erythrocytes and affect body tissues.33

The relationship between variables is said to be meaningful if the obtained p-value exceeds the significance rate of 5% (>0.05). In this study, it was found that rs=-0.115 with p=0.519. These findings indicated that there was no meaningful correlation between the rate of malondialdehyde (MDA) has long received blood transfusions in thalassemia patients. This happens because the body stores iron in the form of proteins such as ferritin or hemosiderin, thus free iron triggers the formation of free radicals relatively little, so oxidative stress and lipid peroxidation do not increase sharply.3

Conclusion

The study found no significant correlation between malondialdehyde (MDA) levels with serum ferritin and transfusion duration in pediatric patients with transfusion-dependent thalassemia (TDT). The association showed that increased iron and length of transfusion were reflected in ferritin levels, but did not contribute to increased oxidative stress on malondialdehyde assay if iron therapy was adequate. The increase in MDA is transient; this study has not considered the exact sampling time.

References

1. Meri, M. A., Al-hakeem, A. H., & Al-abeadi, R. S. (2022). Overview on thalassemia: a review article. Medical Science, 3(1), 26–32. https://doi.org/10.46966/msjar.v3i1.36
2. Sadiq, I. Z., Abubakar, F. S., Usman, H. S., & Abdullahi, A. D. (2024). Thalassemia: Pathophysiology, diagnosis, and advances in treatment. Thalassemia Reports, 14(4), 81–102. https://doi.org/10.3390/thalassrep14040010
3. Atmakusuma, T. D., Nasution, I. R., & Sutandyo, N. (2021). Oxidative stress (Malondialdehyde) in adults beta-thalassemia major and intermedia: Comparison between before and after blood transfusion and its correlation with iron overload. International Journal of General Medicine, 14, 6455–6462. https://doi.org/10.2147/IJGM.S336805
4. Salih, M. M., Al-Ziaydi, A. G., & Alzamili, A. H. H. (2023). The Effect of Ferritin Level and Gene Expression of β-globin Promoter with β-thalassemia Patients in Al-Qadisiyah Governorate, Iraq. Journal of Applied Hematology, 14(4), 257–262. https://doi.org/10.4103/joah.joah_98_23
5. Tzounakas, V. L., Valsami, S. I., Kriebardis, A. G., Papassideri, I. S., Seghatchian, J., & Antonelou, M. H. (2018). Transfusion and Apheresis Science Red cell transfusion in paediatric patients with thalassaemia and sickle cell disease : Current status , challenges and perspectives. Transfusion and Apheresis Science, 57(3), 347–357. https://doi.org/10.1016/j.transci.2018.05.018
6. Rachmayani. (2015). Ministry of Health of the Republic of Indonesia. Pocket book on thalassemia for sufferers and their families. Jakarta, Directorate General of Disease Prevention and Control, Ministry of Health of the Republic of Indonesia. 2022;(01):37. 6.
7. Galanello, R. (2014). Beta thalassemia - a review. Journal of Pathology of Nepal, 4(8), 663–671. https://doi.org/10.3126/jpn.v4i8.11609
8. Huang, Y., Lei, Y., Liu, R., Liu, J., Yang, G., Xiang, Z., Liang, Y., & Lai, Y. (2019). Imbalance of erythropoiesis and iron metabolism in patients with thalassemia. International Journal of Medical Sciences, 16(2), 302–310. https://doi.org/10.7150/ijms.27829
9. Fibach, E., & Rachmilewitz, E. A. (2017). Pathophysiology and treatment of patients with beta-thalassemia–an update. F1000Research, 20(6), 2156. https://doi.org/10.12688/f1000research.12688.1
10. Nielsen, Flemming, Mikkelsen, Borg, Nielsen, B., Bo, Jesper, Andersen, Raun, H., Grandjean, & Philippe. (1997). Plasma malondialdehyde as biomarker for oxidative stress: Reference interval and effects of life-style factors. Clinical Chemistry, 43(7), 1209–1214. https://doi.org/10.1093/clinchem/43.7.1209
11. Rismayanti, L., Yulistiani, Y., Andarsini, M. R., & Qibtiyah, M. (2017). Analysis of Dl-Alfa-Tocopherol As Antioxidant on Malondialdehyde Level in Pediatric Patients With Beta-Thalassemia Major. Folia Medica Indonesiana, 53(1), 49. https://doi.org/10.20473/fmi.v53i1.5490
12. Mulianto, N. (2020). Malondialdehid sebagai Penanda Stres Oksidatif pada Berbagai Penyakit Kulit. Cermin Dunia Kedokteran, 47(1), 39–44. https://doi.org/10.55175/cdk.v47i1.13
13. Nasseri, E., Mohammadi, E., Tamaddoni, A., Qujeq, D., Zayeri, F., & Zand, H. (2017). Benefits of Curcumin Supplementation on Antioxidant Status in β-Thalassemia Major Patients : A Double-Blind Randomized Controlled Clinical Trial. Annals of Nutrition

and Metabolism, 71(3–4), 136–144. https://doi.org/10.1159/000479634
14. Esterbauer, H., Eckl, P., & Ortner, A. (1990). Possible mutagens derived from lipids and lipid precursors. Mutation Research/Reviews in Genetic Toxicology, 238(3), 223–233. https://doi.org/10.1016/0165-1110(90)90014-3
15. Torti,F.M., & Toti, S. V. (2022). (2002). Regulation of ferritin genes and protein. Blood, 99(10), 3505–3516. https://doi.org/https://doi.org/10.1182/blood.V99.10.3505
16. Guide, A. 1200 S. H. U., & Instrument, 2025. (2025). Agilent 1200 Series HPLC User Guide Instrument. March, 1–12.
17. Siemens Healthineers. (2023). ADVIA Centaur XPT Immunoassay System. Https://Www.Siemens-Healthineers.Com/. https://www.siemens-healthineers.com/en-us/laboratory-diagnostics/clinical-chemistry-and-immunoassay-systems/advia-centaur-xpt
18. Tuo, Y., Li, Y., Li, Y., Ma, J., Yang, X., Wu, S., Jin, J., & He, Z. (2024). Global, regional, and national burden of thalassemia, 1990–2021: a systematic analysis for the global burden of disease study 2021. EClinicalMedicine, 72(May), 102619. https://doi.org/10.1016/j.eclinm.2024.102619
19. Sutrisnaningsih, E. S., Suharjono, S., & Sudarmanto, B. (2017). Analysis of deferasirox and deferipron use in children with pediatric ï¢-thalassemia major. Folia Medica Indonesiana, 52(1), 1–6. https://doi.org/10.20473/fmi.v52i1.5207
20. Tripathy, I., Panja, A., Dolai, T. K., & Mallick, A. K. (2021). Comparative Efficacy and Safety Between Deferiprone and Deferasirox with Special Reference to Serum Ferritin Level and Cardiac Function in Bengali β-Thalassemia Major Children. Hemoglobin, 45(5), 296–302. https://doi.org/10.1080/03630269.2021.1999258
21. Premawardhena, A., Wanasinghe, S., Perera, C., Wijethilaka, M. N., Rajakaruna, R. H. M. G., Samarasinghe, R. A. N. K. K., Williams, S., & Mettananda, S. (2024). Deferoxamine, deferasirox, and deferiprone triple iron chelator combination therapy for transfusion-dependent β-thalassaemia with very high iron overload: a randomised clinical trial. The Lancet Regional Health - Southeast Asia, 30, 100495. https://doi.org/10.1016/j.lansea.2024.100495
22. ElLaboudy, M. A., Saber, M. M., Adly, A. A., Ismail, E. A., Ibrahim, F. A., & Elalfy, O. M. (2025). Oxidative stress markers and tissue iron overload after 12-months vitamin E supplementation for children with transfusion-dependent β-thalassemia on different iron chelators: A randomized placebo-controlled trial. Clinical Nutrition (Edinburgh, Scotland), 50, 154–163. https://doi.org/10.1016/j.clnu.2025.05.003
23. Patel, D. (2019). Complete Blood Cell Count Interpretation for Hypoproliferative Anemias. Physician Assistant Clinics, 4(3), 637–647. https://doi.org/10.1016/j.cpha.2019.02.011
24. Rochman, F., Mulyantari, N. K., & Sutirtayasa, I. W. (2019). Hubungan Jumlah Transfusi Darah dan Penggunaan Kelasi Besi dengan Kadar Feritin pada Pasien Talasemia. E-Jurnal Medika Udayana, 8(9), 1–6.
25. Brancaleoni, V., Di Pierro, E., Motta, I., & Cappellini, M. D. (2016). Laboratory diagnosis of thalassemia. International Journal of Laboratory Hematology, 38, 32–40. https://doi.org/10.1111/ijlh.12527
26. Pramatarova, T., Yarakova, N., Sluncheva, B., Hitrova, S., Radulova, P., & Emilova, Z. (2013). Blood transfusions suppress erythropoiesis in anemia of prematurity. Akusherstvo i ginekologiia, 52(5), 42–46.
27. Anwar, S., Alrumaihi, F., Sarwar, T., Babiker, A. Y., Khan, A. A., Prabhu, S. V., & Rahmani, A. H. (2024). Exploring Therapeutic Potential of Catalase : Strategies in Disease Prevention and Management.
28. Widyastuti, E., Notopuro, P. B., Ratwita, M., Rahman, A. A., Soneta, M., & Rochmi, S. E. (2024). Correlation between Serum Ferritin level and Immature Reticulocyte Fraction (IRF) in Children with Beta Thalassemia Major. Research Journal of Pharmacy and Technology, 17(9), 4194–4198. https://doi.org/10.52711/0974-

360X.2024.00648
29. Kremastinos, D. T., & Farmakis, D. (2011). Contemporary Reviews in Cardiovascular Medicine Iron Overload Cardiomyopathy in Clinical Practice. 2253–2263. https://doi.org/10.1161/CIRCULATIONAHA.111.050773
30. Irdawati, I., Syaiful, A. A., & Haryani, A. (2021). Hubungan Usia Anak Penderita Thalasemia Dengan Frekuensi Transfusi. Jurnal Berita Ilmu Keperawatan, 14(2), 73–79.
31. Rahayu, K., Rahmawati, A., & Susiloningtyas, I. (2023). The Relationship Between Family Income and the Nutritional Status of Pregnant Mothers at Ampel 1 Primary Health Care Center in Boyolali Regency. PHARMACOLOGY, MEDICAL REPORTS, ORTHOPEDIC, AND ILLNESS DETAILS, 2(2), 55–66. https://doi.org/10.55047/comorbid.v2i2.820
32. Zahro, S., Yulinda, R., & Sauqina. (2022). Optimization of Moringa Oleifera Leaf Tea Administration for Increasing Hemoglobin (HB) Levels in Anemic Patients. TRANSPUBLIKA INTERNATIONAL RESEARCH IN EXACT SCIENCES, 1(4), 44–52. https://doi.org/10.55047/tires.v1i4.884
33. Torti, F. M., & Torti, S. V. (2002). Regulation of ferritin genes and protein. Blood, 99(10), 3505–3516. https://doi.org/10.1182/blood.V99.10.3505
34. Bano, A., Hamzah, S. H., & Hafiz, E. B. (2025). Interplay Between Gender & and Influencing Factors to Determine Physical Activity of School Children. Journal of Management Practices, Humanities and Social Sciences, 9(2), 120-135.
35. Kahil, B. (2025). Pathways to success: Exploring the mediating roles of affective learning and intellectual engagement in academic achievement. Journal of Advanced Research in Social Sciences and Humanities, 27-38.
36. Tanriverdi, S., Berkarda, Ö. Ö., & Özer, E. A. (2025). Post-immunization evaluation in infants of hepatitis b carrier mothers. Perinatal Journal, 33(1), 1-4.
37. Shamsuddin, N., & Raza, S. (2025). Analyzing Peace Narratives: Content Analysis of Pakistan Studies Curricula and Textbooks at Secondary and Higher Secondary Levels. Journal of Management Practices, Humanities and Social Sciences, 9(1), 45-57.