JHeS (Journal of Health Studies)
Vol. 7, No. 2 (2023), pp. 82-89
e-ISSN 2549-3353
p-ISSN 2549-3345
10.31101/jhes.3199

Original Research Paper

Nutritional status, anemia status and application of the Mentzer index on complete blood examination results of students

Yanasta Yudo Pratama[1,2,3*], Tri Ratnaningsih[4], Desi Arijadi[5], Muhammad Luthfi Adnan[6], Vita Widyasari[7], Annisa Tristifany[6], Griselda Elisse Santoso[5,2], Muhammad Alvin Ramadhan Usman[5,2], Rofifah Miftahurrahmi[8]

[1]Department of Physiology, Faculty of Medicine, Universitas Islam Indonesia, Jalan Kaliurang KM 14,5, Umbulmartani, Sleman, Daerah Istimewa Yogyakarta, Indonesia 55584
[2]Universitas Gadjah Mada Academic Hospital, Jl. Kabupaten, Kranggahan I, Trihanggo, Gamping, Sleman, Daerah Istimewa
Yogyakarta Indonesia 55291
[3]Department of Nursing, Universitas 'Aisyiyah Yogyakarta, Jl. Siliwangi Jl. Ringroad Barat No.63, Area Sawah, Nogotirto, Gamping, Sleman, Daerah Istimewa Yogyakarta Indonesia 55592
[4]Department of Clinical Pathology, Faculty of Medicine, Public Health and Nursing, Universitas Gadjah Mada, Jl. Farmako, Sekip Utara, Depok, Sleman, Daerah Istimewa Yogyakarta Indonesia 55281
[5]Moyudan Health Center, Ngentak, Area Sawah, Sumberagung, Moyudan, Sleman, Daerah Istimewa Yogyakarta Indonesia 55563
[6]Faculty of Medicine, Universitas Islam Indonesia Jl. Kaliurang KM. 14,5, Krawitan, Umbulmartani, Ngemplak, Sleman, Daerah Istimewa Yogyakarta Indonesia 55584
[7]Department of Public Health, Faculty of Medicine, Universitas Islam Indonesia, Jalan Kaliurang KM 14,5, Umbulmartani, Sleman, Daerah Istimewa Yogyakarta, Indonesia 55584
[8]Master of Science Students, Postgraduate School, Universitas Gadjah Mada Jln. Nusantara, Kampus UGM, Bulaksumur, Yogyakarta Indonesia 55281
yanasta_yudo@uii.ac.id

Submitted: August 7, 2023 Revised: September 15, 2023 Accepted: September 22, 2023

Abstract

Thalassemia is a disease that attacks the hemoglobin gene, causing disturbances in erythropoiesis. Anemia is a condition in which the hemoglobin (Hb) concentration and the number of erythrocytes are below normal limits. The high number of anemia and thalassemia causes the need for early detection in order to prevent adverse effects in the future. Research objectives: to determine nutritional status, anemia status, and application of the Mentzer Index for SMK Muhammadiyah II Moyudan students. Methods: This study is a descriptive study with a cross-sectional design. The research subjects were first graders at SMK Muhammadiyah 2 Moyudan. Venous blood samples were examined at the Clinical Pathology Laboratory of FK-KMK UGM using the Sysmex XN-1000 tool on November 25, 2021. Data analysis used IBM SPSS Version 26 and Microsoft Office 365. Results: A total of 53 subjects participated in this study. A total of 47 (89%) respondents had normal hemoglobin values, and 6 (11%) respondents suffered from anemia. 31 (58.5%) respondents have normal nutrition, 15 (28%) respondents have less nutrition, 7 (13%) have excess nutrition, and 29 (54.7%) respondents have normal status. A total of 2 (3.8%) respondents showed Thalassemia. Conclusion: There are two students of SMK Muhammadiyah 2 Moyudan diagnosed with thalassemia and five students diagnosed with anemia. No statistically significant difference exists between Anemia Status in Adolescents at SMK Muhammadiyah 2 Moyudan and Nutritional Status. Further study is needed in wider and more diverse populations to analyze the influence of nutritional conditions on anemia in adolescents.

Keywords: anemia; mentzer index; nutritional status; thalasemia

1. Introduction

Thalassemia is a hemoglobin gene disorder that causes abnormality in erythropoiesis (Bajwa & Basit, 2021). Thalassemia is humans' most common form of hemoglobinopathies caused by various pathogenic variants (Gao et al., 2022). This abnormality can lead to impaired protein synthesis,

resulting in an imbalance of globin chains (Gao et al., 2022). Alpha thalassemia is caused by abnormalities in the production process of alpha-globin chains (Harewood & Azevedo, 2021). This is related to genetic mutations of more than 15 different genes (Harewood & Azevedo, 2021). Beta thalassemia is also caused by various mutations, especially deletions in the beta-globin gene (HbH) on chromosome 11 (Needs et al., 2021). Indonesia is one of the countries with a high frequency of thalassemia genes. The number of people with thalassemia has increased from 4,896 people in 2012 to 9,028 people in 2018. In 2019, there were more than 10,531 thalassemia patients and 2,500 newborns each year suffer from thalassemia (Kementerian Kesehatan Republik Indonesia, 2019)**.**

Anemia is a condition when the concentration of hemoglobin (Hb) and the number of erythrocytes are below normal limits, which is also defined as an absolute decrease in the number of erythrocytes in circulation or a condition in which the number of erythrocytes cannot meet physiological needs (Chaparro & Suchdev, 2019). The normal range of hemoglobin levels is generally in the range of 13-16 g/dL in men, 12-15 g/dL in women, 11-16 g/dL in children, and varies in pregnant women depending on the trimester of pregnancy (generally > 10 g/dL) (Turner et al., 2021). Anemia is differentiated according to the mean corpuscular volume, namely microcytic anemia (MCV < 80 fl), normocytic anemia (MCV 80 – 100 fl), and macrocytic anemia (MCV > 100 fl) (Turner et al., 2021).

The World Health Organization (WHO) reports the highest prevalence of anemia in children (42.6%) and the lowest in non-pregnant women (29.0%) (Turawa et al., 2021). The 2013 Indonesian National Health Survey showed that the prevalence of anemia in children aged 1-4 years, 5-14 years, and 15-24 years, respectively, was 28.1%, 26.4%, and 18.4% (Kementerian Kesehatan Republik Indonesia, 2018). Iron deficiency anemia (IDA) is the most common anemia type WHO estimates that nearly two billion people or 25% of the world's population, have IDA (Mantadakis, 2020). A study of the prevalence of IDA in Indonesian school-age children (6-12 years) found a prevalence of IDA of 32%. In contrast, a retrospective study involving 709 laboratory records of Indonesian children and adolescents showed a prevalence of IDA of 16% in Indonesia. Age group 5–11.9 years and 15.2% in the age group 12–18 years (Andriastuti et al., 2020).

Nearly half (43%) of cases of anemia in children are caused by iron deficiency (Mantadakis, 2020). Published risk factors for IDA include race, poverty, education, low iron intake, heavy menstruation, parity, and history of IDA based on all women of reproductive age, varying between 12 and 49 years (Sekhar et al., 2016). Deficiency can result from inadequate iron intake, malabsorption of iron, increased iron requirements during rapid growth in children, and chronic blood loss (Gebreweld et al., 2019). Other causes of anemia include folate deficiency and vitamins B12 and A, malaria, intestinal helminths, viral infections, chronic disease, hemoglobinopathies, hemolysis, and bone marrow disorders, which cause disturbance in the development of children's physical and mental health, and social interactions which can be seen in short and long-term outcomes (Gebreweld et al., 2019).

Thalassemia and iron deficiency anemia are clinically difficult to distinguish. Therefore, special methods are needed to differentiate these two diseases. One of the most commonly used methods is the Mentzer index. The calculation of the Mentzer index (mean blood cell volume divided by the number of red blood cells) was found to be useful. A Mentzer score lower than 13 indicates that the patient has thalassemia, and an index of more than 13 indicates that the patient is anemic due to iron deficiency (Bajwa & Basit, 2021). The easy-to-use Mentzer index can help detect the differences between anemia and thalassemia early and prevent future adverse effects and complications of both disorders. This study aims to determine nutritional and anemia status by applying the Mentzer index among SMK Muhammadiyah II Moyudan students.

2. Research Method

This research method uses a descriptive quantitative research design with a cross-sectional approach. The population in this study were first-grade students at SMK Muhammadiyah 2 Moyudan who were registered in the 2020/2021 academic year with a total population of 53 people. Sampling was carried out according to the inclusion criteria, namely first-grade high school students who did not know the status of Thalassemia or Anemia and were willing to take part in this study in writing, evidenced by the signatures of the respondent's parents and respondents on the Informed Consent sheet. Exclusion criteria were respondents whose informed consent form was signed by themselves without the signature of a parent or guardian, as well as lysed or damaged blood specimens.

The study was conducted in November 2021 with one venous blood sampling, and anthropometric measurements (body weight and height) were carried out. After taking blood samples, respondents were given time to rest for 10 minutes. Respondents were allowed to enter their respective classes and participate in teaching and learning activities if there were no complaints. Blood sampling from research respondents used 3.0 mL of EDTA (Ethylenediaminetetraacetic acid) blood by Technological Experts in the medical laboratory of the Faculty of Medicine, Public Health and Nursing, Universitas Gadjah Mada who have been trained by the Standard Operational procedures that have been carried out. The Clinical Pathology Laboratory, Faculty of Medicine, Public Health and Nursing, Gadjah Mada University examined venous blood samples. Hematology examinations carried out were Hemoglobin, MCV, MCH, MCHC, RDW, and Hematocrit examinations using a hematology analyzer.

After the blood analysis results came out, a calculation was performed using the Mentzer index. One study of the Mentzer index showed the sensitivity of the Mentzer index was 0.36 with a specificity of 0.81 while the PPV was 0.44 and the NPV was 0.75 (Siswandari et al., 2019). Presentation of data using Bar charts and Pie charts. The examination results data were analyzed in both Univariate and Bivariate analysis using IBM SPSS version 26 data processing program and using Microsoft Excel, which is part of Microsoft Office 365.

This research has obtained permission from the Health Office of Sleman Regency by using an ethical license from the Faculty of Medicine, Public Health and Nursing, Gadjah Mada University – Dr. Central General Hospital. Sardjito with the number KE-FK-1255-EC-2021. All of this research has obtained approval from the respondent and the respondent's parents or guardians to take blood anthropometric measurements. The results of each research will be given to each individual. Diagnosis of anemia is confirmed if the hemoglobin value is less than 12 g/dL (Turner et al., 2021). Nutritional status is taken from body mass index (BMI) with normal status in the range of 18 kg/m2 – 23 kg/m2, undernutrition if the respondent in this study has a BMI <18 kg/m2, and overweight if the respondent in this study has a BMI > 23 kg/m2 (Satyarsa & Putra, 2021). The Mentzer index is calculated using the MCV/RBC formula. The Mentzer index can be used to diagnose beta thalassemia minor, where a Mentzer Index value of less than 13 is diagnosed as beta thalassemia minor and more than 13 is iron deficiency anemia (Siswandari et al., 2019). Research data from each individual was provided in the form of anthropometric data, results of blood tests, and recommendations from the Faculty of Medicine, Public Health, and Nursing, Universitas Gadjah Mada.

3. Results and Discussion

3.1.Results

3.1.1. Overview of Research Results

This research was conducted at SMK Muhammadiyah 2 Moyudan with 53 respondents. All respondents are aged between 16-17 years and are female.

3.1.2. Overview of Hemoglobin Value

Figure 1 shows that as many as 47 people (89%) of respondents had normal hemoglobin values. A total of 6 people (11%) of respondents had a hemoglobin value below the normal cut-off value.

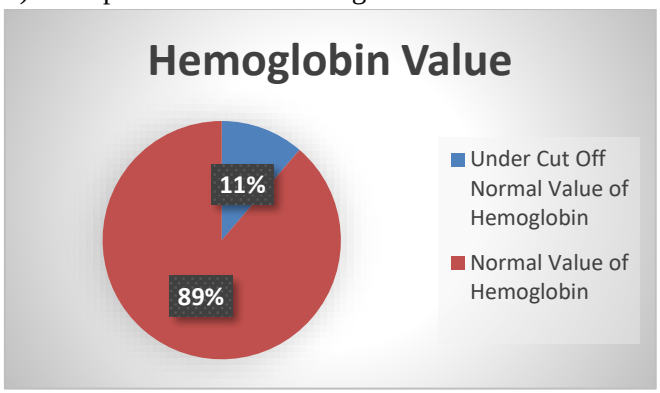

Figure 1. Hemoglobin Value

3.1.3. Overview of Nutritional Status on Participants

Figure 2 shows that 31 (58.5%) participants had normal nutrition, 15 (28%) participants had undernutrition, and 7 (13%) had overnutrition.

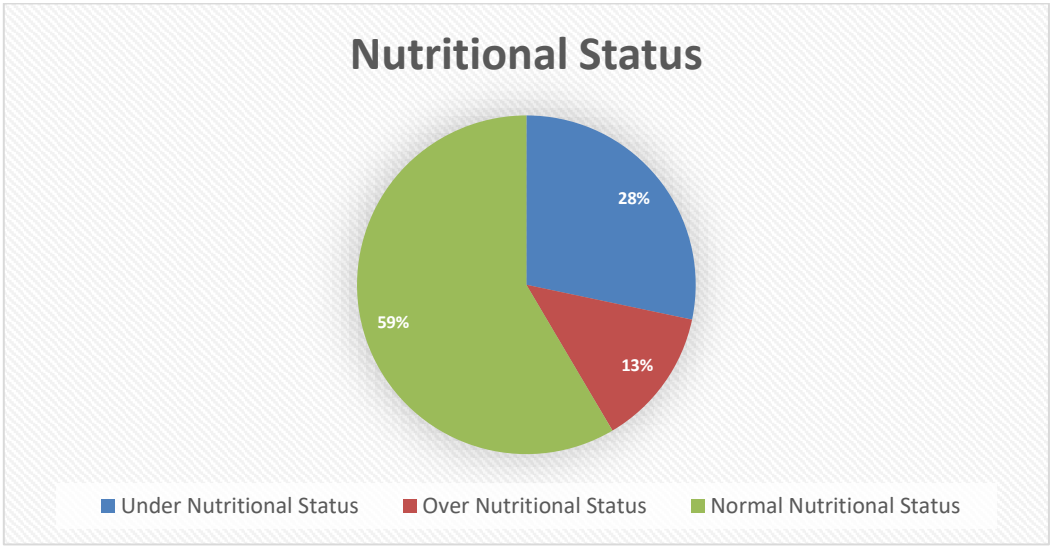

Figure 2. Nutritional Status Based on BMI of Participants

3.1.4. Overview of the Distribution of Participants Diagnosis Based on Mentzer's Values

Figure 3 shows that 2 (4%) respondents have thalassemia based on calculations using the Mentzer Index, and the remaining 51 (96%) respondents are diagnosed with thalassemia based on calculations using the Mentzer Index.

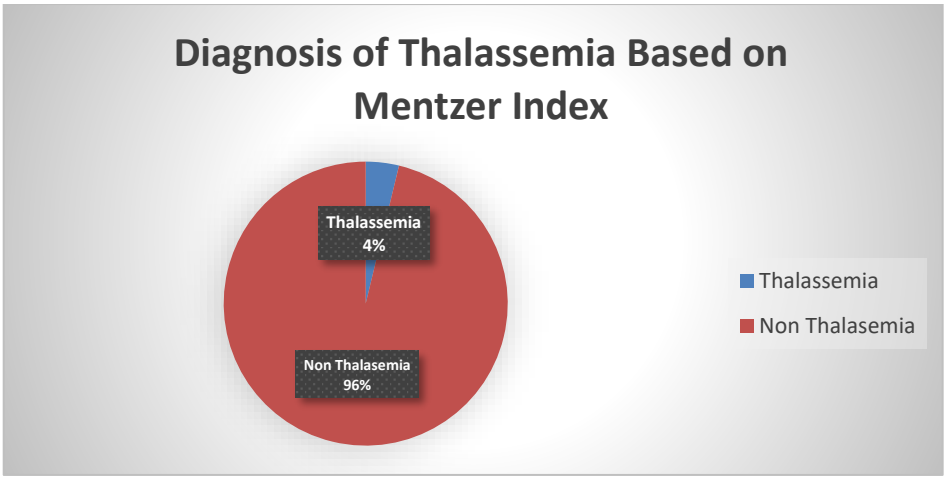

Figure 3. Percentage of Patients with Thalassemia and Not Thalassemia Based on Mentzer Index

After data analysis using Chi-Square in Table 1, the results obtained a p-value of 0.607. This shows no statistically significant difference between anemia and the nutritional status of subjects.

Table 1. Analysis of the Relationship between Anemia Status and Nutritional Status

Variable	Sig (P value)
Anemia Status Nutritional Status	0,607

3.2.Discussion

The diagnosis of thalassemia is carried out by conducting a preliminary examination, physical, and laboratory tests. The final laboratory examination includes an examination of HbA2, HbF, and DNA analysis to determine the type of mutation that occurred. Screening examinations to identify thalassemia carriers in Indonesia generally are based on the MCV value of 80 fl, MCH 27 pg, and Hb examination (Siswandari et al., 2019). In our study of 53 subjects, it was found that 13 (24.5%) participants were suspected of having iron deficiency anemia, while 2 (3.8%) were diagnosed with thalassemia. In this study most of the subjects (54.7%) were within normal limits. This interpretation is obtained through calculations using the Mentzer index.

In our study, 3 (5.7%) participants were diagnosed with iron deficiency anemia and 2 (3.8%) had iron deficiency. Another similar study of 562 patients found that 333 respondents had iron deficiency and 98 patients had beta thalassemia minor with iron deficiency (Amid et al., 2015). In a study conducted by Amid et al. (2015), the authors analyzed the correlation between HbA2 and ferritin. The results found that lower ferritin levels were associated with lower HbA2 levels ($p = 0.007$). Under normal conditions, there is a relative balance of α and β globin chains in erythroblasts (Amid et al., 2015). In healthy individuals, HbA is formed in preference to HbA2 due to the more favorable stoichiometric properties of HbA and the lower expression and relative instability of δ-globin mRNA. In patients with iron deficiency who are not carriers of thalassemia, excess HbA formation occurs, leading to a decrease in HbA2 (Vehapoglu et al., 2014).

A total of 31 (58.5%) participants had normal nutritional status, while 15 (28.3%) were undernutrition, and 7 (13.2%) participants were detected as overnutrition. In our study, there was no anemia in overnutrition subjects. The results between nutritional status and anemia status concluded that there was no relationship between the two ($p = 0.607$). This is similar to a cross-sectional study of 256 women aged 20-35 years in Iran, which concluded no significant differences in ferritin, serum iron, and TIBC levels between the obese group with normal BMI (Rad et al., 2019). Another cross-sectional study of 206 obese nutritional status patients and 45 normal nutritional status patients found

that there was no significant relationship between ferritin levels and the degree of obesity, ferritin was found to be higher in the normal nutritional status group (Altunoğlu et al., 2014).

However, our results differ from a cross-sectional study showing that BMI is inversely correlated with iron absorption ($r = -0.148$; $p < 0.01$) (Mujica-Coopman et al., 2015). Based on an analysis of 318 women with an average age of 40 years, it was found that iron absorption was lower in obese women than in the overweight and normal groups with serum iron and Hb concentrations were also found to be significantly higher (Mujica-Coopman et al., 2015). This relationship is thought to be related to inflammation, obese individuals show an increase in pro-inflammatory molecules such as IL-6 and hepcidin (Mujica-Coopman et al., 2015). Increased hepcidin may decrease iron absorption by reducing DMT-1 expression and iron release via ferroportin sequestration (Alshwaiyat et al., 2021).

Hepcidin regulates plasma iron levels by binding to ferroportin, leading to internalization and degradation via blockage of iron transport in cell (20). As a result, the absorption of dietary iron from the small intestine is decreased, and thus, the serum iron concentration is decreased (Alshwaiyat et al., 2021). Hepcidin also reduces iron release rate, which recycles from macrophages to the periphery and transports iron stores from the liver or spleen (Alshwaiyat et al., 2021). In our study, there was no anemia status in the obese participants which may be due to the limited number of study subjects and duration of the study.

Our study found that 3 out of 28 participants with a normal BMI and 2 of 13 participants with undernutrition had anemia. A cross-sectional study on a population of female adolescents in India concluded that 208/418 (49.76%) underweight subjects had several anemia-related factors, namely food intake patterns such as a vegetarian diet, irregular eating, eating less than three times a day, and reduce fruit and vegetable consumption (<1 time per week) (Singh et al., 2021). In multivariable logistic regression analysis, household mean monthly income, household family size, duration of menstrual flow per each cycle, history of intestinal parasitic infection, and BMI for age were significantly associated with anemia. Adolescent girls with a BMI for age < -2 SD were 3.2 times [AOR = 3.2, 95% CI (1.43, 7.05) were more likely to be anemic compared with a BMI for age -2 SD (Singh et al., 2021).

Anemia in young women occurs due to increased nutritional needs due to physical growth, reproductive maturation, and cognitive transformation in the life cycle that are not met with nutrient intake (Engidaw et al., 2018). The most common type of anemia in adolescents is iron deficiency, which causes fatigue and decreased physical performance (Mengistu et al., 2019). Anemia conditions can increase the risk of maternal and child mortality, cognitive decline, and physical development of children and have an impact on adult physical performance (Capanema et al., 2022; Qin et al., 2013). The trend of low iron intake among adolescents increased over time, with a significant peak in those aged 15 and 17 years (Krishnan et al., 2021). Management of anemia can be more effective with treatment management focusing on the cause of anemia. Although clinically, anemia and thalassemia are difficult to distinguish, efforts can be made to establish a diagnosis using various methods. This also helps detect these disorders so that they can reduce the prevalence of anemia and thalassemia in adolescents in Indonesia.

4. Conclusion

There are two students of SMK Muhammadiyah 2 Moyudan diagnosed with thalassemia and five students diagnosed with anemia. No statistically significant difference exists between Anemia Status in Adolescents at SMK Muhammadiyah 2 Moyudan and Nutritional Status. We found that anemia status was unrelated to populations with normal nutritional status or overnutrition. This study is still limited to a single location, so more population samples are needed to assess the effect of nutritional

status on anemia. Further studies are needed in a wider and more diverse population with prospective analysis to determine the influence of nutritional status on anemia and thalassemia and its long-term implications.

Acknowledgments

Thank you to Mrs. Titin and Ms. Rima as the Person in Charge of the Nutrition Program at the Moyudan Health Center, who have assisted in the anthropometric measurements of the respondents. Thanks to Dr. dr. Tri Ratnaningsih, M.Kes., Sp.PK (K) and the Clinical Pathology team from the Faculty of Medicine, Public Health, and Nursing who have assisted in taking blood samples for research data. Thanks also to the Sleman Health Office for granting permission related to this research. Thank you to the Principal of SMK Muhamamdiyah 2 Moyudan who has helped smooth the implementation of this research.

References

Alshwaiyat, N., Ahmad, A., Wan Hassan, W. M. R., & Al-jamal, H. (2021). Association between obesity and iron deficiency (Review). *Experimental and Therapeutic Medicine*, *22*(5), 1268. https://doi.org/10.3892/etm.2021.10703

Altunoğlu, E., Müderrisoğlu, C., Erdenen, F., Ülgen, E., & Ar, M. C. (2014). The Impact of Obesity and Insulin Resistance on Iron and Red Blood Cell Parameters: A Single Center, Cross-Sectional Study. *Turkish Journal of Hematology*, *31*(1), 61–67. https://doi.org/10.4274/Tjh.2012.0187

Amid, A., Haghi-Ashtiani, B., Kirby-Allen, M., & Haghi-Ashtiani, M. T. (2015). Screening for Thalassemia Carriers in Populations with a High Rate of Iron Deficiency: Revisiting the Applicability of the Mentzer Index and the Effect of Iron Deficiency on Hb A $_2$ Levels. *Hemoglobin*, *39*(2), 141–143. https://doi.org/10.3109/03630269.2015.1024321

Andriastuti, M., Ilmana, G., Nawangwulan, S. A., & Kosasih, K. A. (2020). Prevalence of anemia and iron profile among children and adolescent with low socio-economic status. *International Journal of Pediatrics and Adolescent Medicine*, *7*(2), 88–92. https://doi.org/10.1016/j.ijpam.2019.11.001

Bajwa, H., & Basit, H. (2021). *Thalassemia*.

Capanema, F. D., Lamounier, J. A., Ribeiro, J. G. L., Lima, C. O. V., Paiva, A. R. de A., Quadros, P. R., Ferreira, N. S. K., Almeida, T. S. de, & Santos, N. C. M. (2022). Anemia and nutritional aspects in adolescent athletes: a cross-sectional study in a reference sport organization. *Revista Paulista de Pediatria*, *40*. https://doi.org/10.1590/1984-0462/2022/40/2020350

Chaparro, C. M., & Suchdev, P. S. (2019). Anemia epidemiology, pathophysiology, and etiology in low- and middle-income countries. *Annals of the New York Academy of Sciences*, nyas.14092. https://doi.org/10.1111/nyas.14092

Engidaw, M. T., Wassie, M. M., & Teferra, A. S. (2018). Anemia and associated factors among adolescent girls living in Aw-Barre refugee camp, Somali regional state, Southeast Ethiopia. *PLOS ONE*, *13*(10), e0205381. https://doi.org/10.1371/journal.pone.0205381

Gao, S., Wang, X., Meng, L. B., Zhang, Y. M., Luo, Y., Gong, T., Liu, D. P., Chen, Z. G., & Li, Y. J. (2022). Recent Progress of Chronic Stress in the Development of Atherosclerosis. In *Oxidative Medicine and Cellular Longevity* (Vol. 2022). Hindawi Limited. https://doi.org/10.1155/2022/4121173

Gebreweld, A., Ali, N., Ali, R., & Fisha, T. (2019). Prevalence of anemia and its associated factors among children under five years of age attending at Guguftu health center, South Wollo, Northeast Ethiopia. *PLOS ONE*, *14*(7), e0218961. https://doi.org/10.1371/journal.pone.0218961

Harewood, J., & Azevedo, A. M. (2023). Alpha Thalassemia. In *StatPearls*. StatPearls Publishing.

Kementerian Kesehatan Republik Indonesia. (2019). *Angka Pembawa Sifat Thalasemia Tergolong Tinggi*. https://www.kemkes.go.id/article/view/19052100003/angka-pembawa-sifat-talasemia-tergolong-tinggi.html

Kementerian Kesehatan Republik Indonesia. (2018). Riset Kesehatan Dasar (Riskesdas) 2018. Badan Penelitian dan Pengembangan Kesehatan Kementerian RI tahun 2018.

Krishnan, V., Zaki, R. A., Nahar, A. M., Jalaludin, M. Y., & Majid, H. A. (2021). The longitudinal relationship between nutritional status and anaemia among Malaysian adolescents. *The Lancet Regional Health - Western Pacific*, *15*, 100228. https://doi.org/10.1016/j.lanwpc.2021.100228

Mantadakis, E. (2020). Iron Deficiency Anemia in Children Residing in High and Low-Income Countries: Risk Factors, Prevention, Diagnosis and Therapy. *Mediterranean Journal of Hematology and Infectious Diseases*, *12*(1), e2020041. https://doi.org/10.4084/mjhid.2020.041

Mengistu, G., Azage, M., & Gutema, H. (2019). Iron Deficiency Anemia among In-School Adolescent Girls in Rural Area of Bahir Dar City Administration, North West Ethiopia. *Anemia*, *2019*, 1–8. https://doi.org/10.1155/2019/1097547

Mujica-Coopman, M. F., Brito, A., López de Romaña, D., Pizarro, F., & Olivares, M. (2015). Body mass index, iron absorption and iron status in childbearing age women. *Journal of Trace Elements in Medicine and Biology*, *30*, 215–219. https://doi.org/10.1016/j.jtemb.2014.03.008

Needs, T., Gonzalez-Mosquera, L. F., & Lynch, D. T. (2023). Beta Thalassemia. In *StatPearls*. StatPearls

Qin, Y., Melse-Boonstra, A., Pan, X., Yuan, B., Dai, Y., Zhao, J., Zimmermann, M. B., Kok, F. J., Zhou, M., & Shi, Z. (2013). Anemia in relation to body mass index and waist circumference among chinese women. *Nutrition Journal*, *12*(1), 10. https://doi.org/10.1186/1475-2891-12-10

Rad, H. A., Sefidgar, S. A. A., Tamadoni, A., Sedaghat, S., Binjani, A., Bakouei, F., & Omidvar, S. (2019). Obesity and iron-deficiency anemia in women of reproductive age in northern Iran. *Journal of Education and Health Promotion*, *8*, 1–5. https://doi.org/10.4103/jehp.jehp_371_18

Satyarsa, A. B. S., & Putra, D. K. A. (2021). Penurunan Indeks Massa Tubuh (IMT) Berhubungan Status Kognisi Buruk Pada Lansia. *Al-Iqra Medical Journal: Jurnal Berkala Ilmiah Kedokteran*, *4*(1), 23–28.

Sekhar, D. L., Murray-Kolb, L. E., Kunselman, A. R., Weisman, C. S., & Paul, I. M. (2016). Differences in Risk Factors for Anemia Between Adolescent and Adult Women. *Journal of Women's Health*, *25*(5), 505–513. https://doi.org/10.1089/jwh.2015.5449

Singh, J. K., Acharya, D., Rani, D., Gautam, S., Thapa Bajgain, K., Bajgain, B. B., Park, J.-H., Yoo, S.-J., Poder, T. G., Lewin, A., & Lee, K. (2021). Underweight and Associated Factors Among Teenage Adolescent Girls in Resource-poor Settings: A Cross-sectional Study. *Risk Management and Healthcare Policy*, *Volume 14*, 9–19. https://doi.org/10.2147/RMHP.S280499

Siswandari, W., Rujito, L., Indriani, V., & Djatmiko, W. (2019). Mentzer Index Diagnostic Value in Predicting Thalassemia Diagnosis. *IOP Conference Series: Earth and Environmental Science*, *255*, 012004. https://doi.org/10.1088/1755-1315/255/1/012004

Turawa, E., Awotiwon, O., Dhansay, M. A., Cois, A., Labadarios, D., Bradshaw, D., & Pillay-van Wyk, V. (2021). Prevalence of Anaemia, Iron Deficiency, and Iron Deficiency Anaemia in Women of Reproductive Age and Children under 5 Years of Age in South Africa (1997-2021): A Systematic Review. *International journal of environmental research and public health*, *18*(23), 12799. https://doi.org/10.3390/ijerph182312799

Turner, J., Parsi, M., & Badireddy, M. (2023). Anemia. In *StatPearls*. StatPearls Publishing.

Vehapoglu, A., Ozgurhan, G., Demir, A. D., Uzuner, S., Nursoy, M. A., Turkmen, S., & Kacan, A. (2014). Hematological Indices for Differential Diagnosis of Beta Thalassemia Trait and Iron Deficiency Anemia. *Anemia*, *2014*, 1–7. https://doi.org/10.1155/2014/576738