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EVALUATION OF HEMOGLOBIN LEVELS, ERYTHROCYTE INDEX, AND MENTZER INDEX FOR EARLY DETECTION OF ANEMIA AND THALASSEMIA MINOR IN JUNIOR HIGH SCHOOL

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ABSTRACT

Introduction: Thalassemia and iron deficiency anemia (IDA) are two of the most common causes of microcytic anemia worldwide, particularly in developing countries. This study was conducted to analyze hematological parameters and apply the Mentzer Index among junior high school students in Pontianak, Indonesia, in order to identify suspected cases of thalassemia trait and IDA, and to assess the feasibility of using Mentzer Index as a preliminary screening tool in this setting.

Methods: A cross-sectional study was conducted involving 50 students (aged 13-17 years) who underwent complete blood count (CBC) testing. Parameters included hemoglobin (Hb), erythrocyte count, MCV, MCH, MCHC, RDW and Mentzer Index. An MI <13 was interpreted as suggestive of thalassemia trait, while MI ≥ 13 indicated possible IDA or normal findings

Results: Among the participants, 6 students (11,5%) had MI < 13, consistent with suspected thalassemia minor. Several others showed anemia with MI ≥ 13 and elevated RDW, suggestive of IDA. Girls were more frequently affected by anemia-related abnormalities. Overall, microcytosis (MCV < 80 fL), hypochromia (MCH <27 pg) and high RDW were commonly observed

Conclusion: A notable proportion of students screened exhibited hematological indicators of thalassemia trait and IDA. The Mentzer Index, combined with CBC parameters, proved effective in initial differentiation. Early school-based screening is essential for timely diagnosis, management, and genetic counseling in at-risk populations.

KEYWORDS:
Thalassemia Trait, Iron Deficiency Anemia, Mentzer Index, School Screening

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INTRODUCTION

Anemia represents a widespread public health issue that impacts populations in both low- and high-income countries. The World Health Organization (WHO) reported that in 2019, approximately 1.74 billion people were affected by anemia, with the highest prevalence observed among children and women of reproductive age.[1] In Indonesia, the Basic Health Research (Riskesdas) 2018 documented that the prevalence of anemia among adolescents aged 15-24 years reached 32% while the estimated prevalence of thalassemia carriers is around 6-10% of the population.[2] Anemia and thalassemia minor are two common hematological conditions that can significantly impact adolescent health, especially during the critical period of physical and cognitive development. objectives.[3] One of the key approaches to identifying anemia and thalassemia minor is through the evaluation of hematological parameters such as hemoglobin levels and red blood cell indices, including Mean Cospuscular Volume (MCV), Mean Corpuscular Hemoglobin (MCH), and Mean Corpuscular Hemoglobin Concentration (MCHC).[4] These indices provide insight into the size

and hemoglobin content of red blood cells, allowing differentiation between types of anemia-particularly microcytic anemia, which is commonly caused by iron deficiency or thalassemia minor.[5,6] The conclusive diagnosis of thalassemia involves hemoglobin analysis and DNA testing. However, erythrocyte indices like MCV and MCH are commonly used for screening purposes because they are quick and cost-effective. [7]

The Mentzer Index, calculated by dividing the MCV by the red blood cell count (RBC), is a simple and cost-effective screening tool that helps distinguish iron deficiency anemia from thalassemia minor. A Mentzer Index greater than 13 typically suggests iron deficiency anemia, while a value less than 13 is more indicative of thalassemia minor.[8]

This study focuses on evaluating hemoglobin levels, erythrocyte indices, and the Mentzer Index among Junior High School students in Pontianak. As this demographic represents a critical stage in physical development, early identification of hematological abnormalities is essential. The findings from this research aim to support school-based health screening programs and inform public health interventions that can improve adolescent health outcomes in the region.

METHODS

This study employed a cross-sectional descriptive design to evaluate hemoglobin levels, erythrocyte indices, and Mentzer Index as tools for early detection of anemia and thalassemia minor among junior high school students. This research was conducted across five public junior high schools in Pontianak. A stratified random sampling technique was used to ensure proportional representation from different schools and grade levels. First, the participating public junior high school in Pontianak were categorized into strata based on grade (7^{th}, 8^{th},9^{th} grade). Within each stratum, the number of students selected was proportional to the the total number of students enrolled in that grade, thereby preventing over-or-under- representation of any academic level. From each stratum, participants were randomly selected using the student attandenace list. as the sampling frame. This approach increased the representatives of any academic level. Participants who met the inclusion criteria and provided informed consent (along with parental consent) were included in the study. Inclusion criteria: students enrolled in SMP Negeri in Kota Pontianak, both boys and girls aged between 12-15 years in accordance with the adolescent group targeted in this study and willing to participate with parental consent. Exclusion criteria: students with known chronic diseases, and students currently undergoing treatment for anemia or thalassemia.

A total of 50 students who met the inclusion criteria and agreed to participate (with parental consent) were finally enrolled.

Data collection took place from September 2024 to January 2025. Blood samples were collected from all participants by trained medical professionals under aseptic conditions. Hematological examinations were conducted in collaboration with Prodia Laboratory, using standard automated hematology analyzer. Although the hematology analyzer provided a full panel of hematological paramaters, this study focused specifically on red cell indices (Hemoglobin (Hb) concentration, Mean Corpuscular Volume (MCV), Mean Corpuscular Hemoglobin (MCH) and Mean Corpuscular Hemoglobin Concentration (MCHC) and RDW and the Mentzer Index. From the hematological data, the Mentzer Index was calculated using the formula: Mentzer Index = MCV/RBC count. Other parameters, such as leukocyte and platelet counts were recorded but not included in the analysis, since they are not directly related to the study objectives.

The diagnosis of anemia is established according to the World Health Organization (WHO) criteria, which define anemia as hemoglobin concentration below specific cut-off values adjusted for age, sex, and physiological status (e.g.,pregnancy). years, the cut-off values differ: 13 g/dL for males and 12 g/dL for females. In this study, we adopted these criteria to classify anemia status among participants According to WHO, adolescents age 12-14 years, regardless of sex, are considered anemic if Hb <12 g/dL. For those aged ≥ 15. A Mentzer Index < 13 was suggestive of thalassemia minor, while a value >13 was indicative of Iron deficiency anemia (IDA).[8]

The collected data were analyzed using SPSS 25 Version. Descriptive statistics (mean, standard deviation, and frequency) were used to summarize the hematological parameters. Interpretation of findings was made in accordance with established clinical hematology guidelines.

This study has been approved by the Research Ethics Committee, as evidenced by the ethical clearance letter No. 4437/UN22.9/PG/2024.

RESULT AND DISCUSSION

Among the 50 students examined, hemoglobin distribution showed sex-related differences. In the male group (n=13), the mean hemoglobin concentration was 13.24±1.13 g/dL, with values ranging from 10.7 to 15.0 g/dL. Based on WHO criteria for adolescents, 2 boys (16,7%) were classified as anemic (Hb <13 g/dL), while the remaining 10 boys (83,3%) had normal hemoglobin levels. In the female group (n=37), the mean hemoglobin concentration was slightly lower at 12.66 ± 1.15 g/dL (range 9.5-14.6 g/dL). Nine girls (24,3%) were classified as anemic (Hb<12 g/dL), whereas 28 (75,7%) had normal hemoglobin concentrations. Overall, anemia was more frequent among girls than boys, both in terms of absolute number and proportion.

Table 1. Descriptive Hematology Parameters

Parameter	Sex	Mean	SD	Min	Max	n
Hb (g/dL)	Male	13.24	1.13	10.7	15	13
	Female	12.66	1.15	9.5	14.6	37

Parameter	Sex	Mean	SD	Min	Max	n
MCV (fL)	Male	78.83	5.97	66.7	89.1	13
	Female	80.13	7.19	58.8	89.7	37
MCHC (g/dL)	Male	33.58	1.54	30.1	36.7	13
	Female	32.84	1.41	29.7	36.3	37
RDW (%)	Male	13.85	2.18	11.1	18.3	13
	Female	14.2	1.74	12	19.7	37
Mentzer Index	Male	15.85	2.13	12.54	19.76	13
	Female	16.77	2.6	9.8	24.31	37

This aligns with common patterns seen in general populations, particularly among school-aged children and adolescents, where nutritional deficiencies such as iron, folate, or vitamin B12 may contribute to anemia.[9] However given the focus on thalassemia screening, the possibility of hereditary causes like thalassemia minor must also be considered.

The mean MCV in boys was 78.8 ± 6.0 fL (range 66.7-89.1 fL), while in girls it was 80.1 ± 7.2 fL (range 58.8-89.7 fL). Microcytosis (MCV <80 fL) was more frequently observed among boys compared to girls, indicating higher proportion of thalassemia trait or iron deficiency anemia in this group. Microcytosis is a hallmark of both iron deficiency anemia (IDA) and thalassemia trait, but differentiation between the two is essential due the different management approaches.[10] The absence of macrocytosis (MCV ≥100 fL) suggests that vitamin B12 or folate deficiency is not a major contributing factor in this group.[11]

The Mentzer Index helps differentiate between IDA and thalassemia minor. A value <13 typically suggests thalassemia trait, while ≥13 leans toward iron deficiency. In this study, the Mentzer Index was 15.8 ± 2.1 (range 12.5-19.8) in boys and 16.8 ± 2.6 (range 9.8-24.3) in girls. A Mentzer Index <13, suggesting of thalassemia trait, was observed in a small proportion of students, whereas the majority had value ≥ 13 which are more consistent with iron deficiency anemia.

Regarding RDW, boys had a mean value of 13.9 ± 2.2% (range 11.1 – 18.3%), while girls had a mean of 13.7 ± 1.7% (range 12.0-19.7%). Elevated RDW values were identified in a subset of participants, more commonly among girls, which is consistent with iron deficiency anemia. In contrast, thalassemia trait is typically associated with normal RDW despite microcytosis. RDW (Red Cell Distribution Width) is another parameter that aids in distinguishing types of anemia. In IDA, RDW is usually elevated due to mixed populations of small and normal-sized red cells.[10, 13]

The interpretation is further supported by the finding that most of these students exhibited microcytosis with normal RDW values. This pattern is typical for thalassemia trait, where the red cell population is uniformly small, in contrast to IDA, which usually demonstrates increased RDW due to heterogeneous cell size. Therefore, combining Mentzer with RDW enhances diagnostic accuracy in differentiating thalassemia carriers from the iron deficiency anemia. Although the percentage is small, it is clinically significant and highlights the importance of targeted follow-up testing in these

individuals. Techniques for early detection, like Hb-electrophoresis and DNA testing, continue to be considered the gold standards, even though they tend to be more expensive and not as widely accessible.[12]

Overall, the findings indicate that while anemia prevalence was relatively modest, microcytosis and abnormal Mentzer Index values point to a possible hidden burden of thalassemia trait alongside iron deficiency anemia in this adolescent population. Identifying thalassemia carriers is crucial for early genetic counseling (premarital genetic counseling) and preventing the birth of children with thalassemia major through informed reproductive decisions (prenatal diagnosis).[14,15] Multilevel screening serves as an effective and efficient alternative to population-wide screening in countries with limited healthcare resources and funding.[16,17] The number of registered patients continues to rise, with 10.555 cases reported in 2019. From an economic perspective, thalassemia ranks as the fifth-highest contributor to healthcare expenditure among non-communicable disease, with the national health insurance (BPJS) spending around IDR 2.78 trillion (=USD 185 million) in 2020 for its management.[18] Given its relatively high incidence and burden of Thalassemia, Indonesia should begin implementing screening programs to help lower the number of new cases.[18] Moreover, distinguishing thalassemia trait from iron deficiency prevents unnecessary iron supplementation, which can be harmful in thalassemia.[19]

This study has several limitations. First, the sample size was relatively small, no formal sample size estimation was performed for this study. The research was designed as a preliminary, school-based screening project aimed at exploring the feasibility of using complete blood count indices and the Mentzer Index for early detection of thalassemia carriers among adolescents. Secondly, the cross-sectional design of the study precludes the assessment of longitudinal outcomes or the effectiveness of potential interventions. Third, although a peripheral blood smear (PBS) is a valuable tool for identifying morphological features characteristic of thalassemia trait-such as taget cells, microcytosis, and anisopoikilocytosis- it was not included in this study, because this study was focus on cost-effective and easily standardized hematological parameters (CBC and Mentzer Index), which are more feasible for large-scale-school-based screening programs.

CONCLUSION

The findings indicate a relatively low prevalence of anemia; however, the high rate of microcytosis suggests a potential silent burden of thalassemia trait in the studied population. This study highlights the importance of early identification of thalassemia carriers to enable timely genetic counseling and informed reproductive decisions, ultimately helping

to prevent the birth of children with thalassemia major. Future large-scale studies should include an a priori sample size calculation to ensure adequate statistical power and generalizability. To confirm suspected cases, referral for diagnostic tests such as peripheral blood smear (PBS), hemoglobin electrophoresis and genetic testing is essential. Furthermore, accurately distinguishing thalassemia trait from iron deficiency anemia is crucial to avoid inappropriate iron supplementation, which can be harmful in individuals with thalassemia.

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