Original Research Article

DIAGNOSTIC ACCURACY OF MENTZER INDEX AS A SCREENING TOOL FOR THE DIAGNOSIS OF IRON DEFICIENCY ANEMIA BY TAKING IRON PROFILE AS GOLD STANDARD IN PATIENTS PRESENTING WITH HYPOCHROMIC MICROCYTIC ANEMIA AT TERTIARY CARE HOSPITAL, KARACHI

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Abstract: *Anemia is the most prevalent haematological condition in newborns and children. A deficiency of iron necessary for synthesizing haemoglobin causes it. This study used the iron profile as the gold standard for patients with hypochromic microcytic anemia at a tertiary care hospital in Karachi to assess the Mentzer index's diagnostic accuracy for iron-deficient anemia. From January 2021 to December 2022, a cross-sectional descriptive study was conducted in the Department of Pediatrics, NICH, Karachi. With the patient's explicit consent, data was prospectively collected. Those who satisfied the diagnostic requirements totaled 163 patients. While frequency and percentages were used to represent qualitative factors, simple descriptive statistics with mean and standard deviation were used to convey quantitative data. The following metrics were calculated: diagnostic accuracy, sensitivity, specificity, positive and negative predictive values, and a significance level set at p-value ≤0.05. A total of 163 patients with hypochromic microcytic anemia were included in the study; their mean age was 8.23±3.57 years. 78 (47.9 percent) and 85 (52.1 percent) were female. For the diagnosis of iron deficiency anemia, the Mentzer index's sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy were determined to be, respectively, 90.1 percent, 90.1 percent, 93.8 percent, 84.6 percent, and 90.8 percent. According to the study's findings, cell-count-based indices—in particular, the Mentzer index—are trustworthy, widely accessible techniques that have a high degree of discrimination power for identifying iron deficiency anemia.*

Keywords: Iron Deficiency Anemia, Beta Thalassemia, Mentzer Index, and Iron Profile

Introduction

According to the World Health Organization, anemia is characterized by a hemoglobin level of less than 11 g/dl. The main cause of anemia in children is a dietary deficiency. According to WHO estimates, anemia affects 42% of children under the age of five worldwide, with iron deficiency accounting for half of these cases (Who, 2001). Of young children, 51 percent suffer from nutritional anemia, a condition that is more common in low- and middle-income countries and has a higher prevalence in South Asia and Africa. Within the undernourished kid population in Pakistan, nutritional anemia has become the most prevalent kind. 53.7 percent of people in Pakistan had nutritional anemia in 2018, up from 38 percent in 1977, according to the National Nutritional Survey of Pakistan (EKRAM et al., 2018). Pakistan's public health is still seriously concerned about iron deficiency anemia (IDA) in youngsters. The prevalence of the under-five age group varies between 40 and 70 percent. Nevertheless, according to the 2018 National Nutritional Survey, the incidence of IDA is 28.6%, with males in urban areas accounting for 29.1% of cases and rural regions accounting for 28.9% (Ullah et al., 2016).

Concerning disability-adjusted life years, IDA is the 13th most important risk factor and the third most common cause of impairment worldwide (Sherali et al., 2023). IDA has been linked to low birth rates in Pakistan (Akhtar et al., 2017), delayed brain development in under-five children, and reduced growth and intellectual capacities. A condition known as iron deficiency anemia, which mostly affects newborns and children, is caused by insufficient hemoglobin synthesis from iron deficiency and affects about 30% of the world's population. Comparing developing to industrialized nations, the former has a higher prevalence of this dietary deficiency. Age is a significant factor in the prevalence of IDA. IDA and anemia are sometimes used synonymously; nevertheless, in certain instances, IDA has been shown to induce tissue damage on its own. Stages from inadequate iron intake to decreased iron storage and hemoglobin synthesis are typically involved in IDA (Sherali et al., 2023).

Its sensitivity and specificity make the Mentzer Index stand out among the many other used indices. Mean corpuscular volume and red blood cell count are the two hematological parameters that this index, which was first introduced by Mentzer in 1973, is based on. Across a range of age groups and conditions, its efficacy has been observed 8. 98.7% Sensitivity and 82.3 % Specificity were shown in a study that focused on children to differentiate between IDA and thalassemia. Using the Mentzer Index9, another study found that the sensitivity was 91% and the specificity was 83%. International research emphasizes its discriminative power in children, even though the validation statistics may differ. It has been applied in many parts of the world due to its widespread acceptance (Awais et al., 2022).

By using an iron profile as the gold standard for patients presenting with hypochromic microcytic anemia at Tertiary Care Hospital, Karachi, the study aimed to ascertain the diagnostic accuracy of the Mentzer index as a screening tool for diagnosing iron deficient anemia.

Methodology

From May 27 to May 23, a descriptive cross-sectional study was carried out in the Department of Paediatrics, NICH, Karachi. The sample size was determined by factoring in a 9 percent margin of error for sensitivity, a 7 percent margin for specificity, an 85 percent confidence interval, and a 93 percent specificity. Based on the prevalence of 37.5 percent for hypochromic microcytic anemia, a minimum of 163 patients were projected to be in the sample.

Non-probability sequential sampling was the method of sampling that was applied. The study included patients aged 1-16 years, independent of gender, who had hypochromic microcytic anemia for more than a week. Exclusions from the trial were patients with congenital heart disease, cerebral palsy, pneumonia, asthma, tuberculosis, refusal to consent, hospitalization within the preceding 14 days, and recent surgical procedures.

This study was carried out with permission from the College of Physicians and Surgeons Pakistan. Children from the Department of Pediatrics at NICH, Karachi, who met the study's inclusion criteria and consented were enrolled. The parents of every patient gave their informed consent before their child was included in the study or had any of their data used for research purposes. The mother was questioned briefly about the length of her illness. After collecting it sterilely, the researcher sent the blood sample to the same facility for an iron profile and comprehensive blood picture. The operational definition of iron deficiency anemia is defined as hemoglobin ≤ 11.5 g/dl, mean corpuscular volume (MCV) ≤ 77 fL, mean corpuscular hemoglobin (MCH) ≤ 25 pg, transferrin saturation < 12 percent, and Mentzer index (MCV/RBC) ≥ 13. The patient's hemoglobin, mean corpuscular volume, mean corpuscular hemoglobin, iron, TIBC, and ferritin level were recorded, and the patient's transferring saturation was computed by dividing their serum/TIBC. The results of the quantitative factors (age, hemoglobin, and anemia duration) and qualitative variables (anemia duration, gender, family monthly income, mother's educational status, and prior anemia history) were recorded in the proforma that was provided as an appendix.

Data analysis was done with SPSS Version 16. Age, hemoglobin level, and length of anemia were examples of continuous variables for which mean and standard deviation were computed. Gender, family monthly income, mother's educational status, prior history of anemia, IDA by iron profile (yes/no), and Mentzer index (yes/no) were all calculated in terms of frequency and percentages. Calculations were made for sensitivity, specificity, positive and negative predictive values, and diagnostic accuracy. Effect modifiers were managed by stratifying based on age, gender, length of anemia, family monthly income, mother's educational background, and prior anemia history. Sensitivity, specificity, positive and negative predictive values, and diagnostic accuracy were computed.

Results

This study comprised 163 patients who visited the Department of Paediatrics at the NICH in Karachi and satisfied the inclusion and exclusion criteria. The lowest and greatest ages of the 163 patients were 2 and 15, respectively. Our study's average age was 8.23 years, with a standard deviation of ± 3.57. In our study, the mean hemoglobin and duration of anemia were 8.04 ± 1.78 g/dl and 5.08 ± 2.51 weeks, respectively (Table 1). Out of 163 patients, the frequency distribution of iron profile revealed that 102 (62.6 percent) and 61 (37.3 percent) had iron deficiency anemia and did not, respectively (Table 2). The Mentzer index frequency distribution revealed that, of the 163 patients, 98 (60.1%) and 65 (39.9%) had iron deficiency anemia and did not, respectively. The age distribution frequency distribution of the 163 patients revealed that 92 (56.4%) and 71 (43.6%) belonged to the 1–8 and 9–16 age groups, respectively. Out of 163 patients, the gender frequency distribution revealed that 85 (52.1%) were men and 78 (47.9%) were women. The anemia duration frequency distribution revealed that, of the 163 patients, 98 (60.1%) and 65 (39.9%) had durations of less than or equal to four weeks and more than four weeks, respectively. The study examined the frequency distribution of the mother's educational status. Of the 163 patients, 16 (9.8%), 34 (20.9%), 41 (25.2%), and 72 (44.2%) belonged to the educational groups of the illiterate, primary, secondary, and higher groups, respectively (Table 3). The family income group frequency distribution for the 163 patients revealed that, of those, 07 (4.3 percent), 39 (23.9 percent), 35 (21.5 percent), 54 (33.1 percent), and 28 (17.2 percent) belonged to the lower income, lower middle income, middle income, upper middle income, and upper-income groups, respectively. Out of 163 patients, the frequency distribution of previous anemia history revealed that 34 (20.9%) and 129 (79.1%) had and did not have prior anemia history, respectively. The Mentzer index's sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy were determined to be 90.1%, 90.1%, 93.8 percent, 84.6 percent, and 90.8%, respectively, out of 163 patients when using the iron profile as the gold standard for the diagnosis of iron deficiency anemia. Age-based stratification was found to be 90.3 percent, 90 percent, 92.1 percent, 87.8 percent, and 90.2 percent, respectively, regarding sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy of the Mentzer index for the diagnosis of iron deficiency anemia by using the iron profile as the gold standard in the age group of 1 to 8 years. Furthermore, it was shown that 90 percent, 90 percent, 95.7%, 79.1%, and 90.1% of those in the 9–16 age group, respectively. 88.8 percent, 90 percent, 90.9 percent, 87.8 percent, and 89.4 percent, respectively, were the results of the gender stratification concerning sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy of the Mentzer index for diagnosis of iron deficiency anemia by using the iron profile

as the gold standard in the male group. Additionally, it was discovered that 91.2 percent, 96.4 percent, 96.2 percent, 79.1 percent, and 91 percent of the female group. Using the iron profile as the gold standard duration < 4-week group, the stratification for anemia duration was found to be 91.3 percent, 90 percent, 92.9 percent, 87.8 percent, and 90.8 percent, respectively, in terms of sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy of the Menzer index for iron deficiency anemia diagnosis. Furthermore, 88.6 percent, 90.4 percent, 95.1 percent, 79.1 percent, and 89.2 percent were discovered in the group with a length of more than four weeks. The stratification for educational status was found to be 80 percent, 83.3 percent, 88.8 percent, 71.4 percent, and 81.2 percent, respectively, concerning sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy of the Mentzer index for the diagnosis of iron deficiency anemia by using the iron profile as the gold standard illiterate group. Additionally, it was discovered that 92.3 percent, 87.5 percent, 96 percent, 77.7 percent, and 91.1 percent, respectively, were in the primary group. Additionally, it was discovered that 88.2 percent, 91.6 percent, 88.2 percent, 91.6 percent, and 90.2 percent, respectively, were in the secondary group. Ultimately, the percentages in the higher group were 91.8 percent, 91.3 percent, 95.7 percent, 84 percent, and 95.8 percent, in that

order. The stratification for family monthly income status was found to be 50 percent, 66.6 percent, 66.6 percent, 50 percent, and 57.1 percent, respectively, concerning sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy of the Mentzer index for the diagnosis of iron deficiency anemia by using the iron profile as the gold standard lower income group.
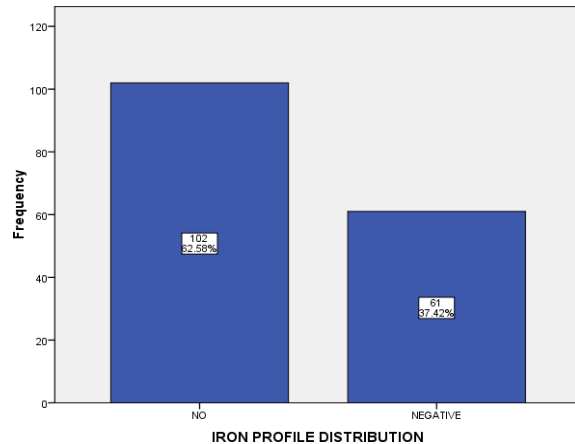

Figure 1: Mentzer index ≥ 13 distribution

Table 1 Descriptive statistics

VARIABLE	MEAN	STANDARD DEVIATION	MIN-MAX
Age (years)	8.23	±3.57	2-15
Hemoglobin (g/dl)	8.04	±1.78	7-11
Duration of anemia (weeks)	5.08	±2.51	3-8

Table 2 Diagnostic accuracy of Mentzer index for diagnosis of iron deficiency anemia by taking iron profile as the gold standard

MENTZER INDEX > 13	IRON PROFILE		TOTAL
	YES	NO	
YES	92(TP)	06(FP)	98
NO	10(FN)	55(TN)	65
TOTAL	102	61	163

Table 3 Diagnostic accuracy, sensitivity, specificity, positive predictive value, and negative predictive value of Mentzer index for diagnosis of iron deficiency anemia by taking iron profile as the gold standard

SENSITIVITY	TP/TP+FN x 100	90.1%
SPECIFICITY	TN/TN+FP x 100	90.1%
POSITIVE PREDICTIVE VALUE	TP/TP+FP x 100	93.8%
NEGATIVE PREDICTIVE VALUE	TN/FN+TN x 100	4.6%
DIAGNOSTIC ACCURACY	TP + TN/TOTAL PATIENTS x 100	90.8%

Table 4 Diagnostic accuracy of Mentzer index for diagnosis of iron deficiency anemia by taking iron profile as gold standard according to previous history of anemia.

PREVIOUS H/O ANEMIA	MENTZER INDEX > 13	IRON PROFILE		TOTAL		
		YES	NO			
YES					SEN	50%
	YES	05(TP)	04(FP)	09	SPE	83.3%
	NO	05(FN)	20(TN)	25	PPV	55.5%
					NPV	80%
	TOTAL	10	24	34	DA	73.5%
NO						
					SEN	94.5%
	YES	87(TP)	02(FP)	89	SPE	94.5%
	NO	05(FN)	35(TN)	40	PPV	97.7%
					NPV	87.5%
	TOTAL	**92**	**37**	**129**	DA	94.8%

Discussion

The most frequent causes of microcytic hypochromic anemias are beta thalassemia trait (βTT) and iron deficiency anemia (IDA). Several indices based on blood cell count factors have been proposed (Shaha et al., 2023) to distinguish between the two. Medical practitioners usually use tests such as complete blood count, serum iron, total iron-binding capacity, and serum ferritin levels to diagnose iron deficiency anemia (IDA) (Idrees et al., 2023). Low hemoglobin levels, microcytic and hypochromic red cells in peripheral smears, and elevated hemoglobin levels after two months of iron therapy are all signs of IDA in resource-poor environments. These tests aren't always accessible, though, and they can be expensive (Düzenli Kar et al., 2020). On the other hand, a red cell distribution width >14 percent and a Mentzer index >13 percent are further indicators that point to IDA. The Mentzer index (MI), determined as the ratio between mean corpuscular volume and red cell count (red blood cells per million per microliter), is a simple method for identifying possible IDA cases in children (Oltean and Chincesan, 2020). The existence of IDA is strongly indicated by an MI > 13. The MI is unique because of its high sensitivity and specificity, even in the face of other tests like the England-Fraser, Shine and Lal, Shrivastava index, and Youden index. The reported sensitivity and specificity ranges for MI in IDA indications are 85–90% and 80–93%, respectively (Rashwan et al., 2022). Three indices' dependability was assessed in this study. Red blood cell count and mean corpuscular volume compute the Mentzer's index. It is considered that iron deficiency anemia is more likely if the ratio of RBC count (millions per microliter) to MCV(fl) is higher than 13. Our investigation revealed that 163 patients in all had hypochromic microcytic anemia. The average age was 3.57±2.83 years. There were 78 (47.9%) females and 85 (52.1%) males (Gupta et al.). In addition, the Mentzer index's sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy were determined to be 90.1 percent, 90.1 percent, 93.8 percent, 84.6 percent, and 90.8 percent, respectively, for the diagnosis of iron deficiency anemia in 163 patients (Boonrusmee et al., 2022). The Rahim et al. study included three hundred twenty-three participants with microcytic anemia (173 children and 150 adults). For patients above the age of ten, none of the indices demonstrated 100% sensitivity and specificity; for patients under ten, only the Shine & Lal index demonstrated 100% specificity and sensitivity in the range of 90% to 100%. For the diagnosis of iron deficiency anemia, the Mentzer index's sensitivity, specificity, PPV, and NPV were determined to be 85.5 percent, 93.3 percent, 96.6 percent, and 76.6 percent (Sharma et al., 2020) (Ringoringo et al., 2022) (BALCI et al., 2021).

Conclusion

Iron deficiency anemia and thalassemia trait are the most prevalent microcytic and hypochromic anemias. In the clinical routine, it would be helpful to construct an index with good diagnostic accuracy based only on factors generated from the blood cell count measured with basic counters. The Mentzer index performs exceptionally well and could be helpful in the screening of patients with microcytic anemias. Frequent utilization of the index yielded excellent diagnostic precision and might significantly influence the selection of confirmatory laboratory tests, ultimately leading to an accurate diagnosis and course of therapy. The health system would save a lot of money, which is particularly helpful in emerging and impoverished nations with tight budgets.

Declarations

Data Availability statement
All data generated or analyzed during the study are included in the manuscript.
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Conflict of interest

The authors declared absence of conflict of interest.

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