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Prevalence of Iron Deficiency Anemia and Associated Laboratory Predictors Among Women of Reproductive Age in Karachi: A Cross-Sectional Study

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Abstract

Objective:
To determine the prevalence of iron deficiency anaemia (IDA) and identify associated laboratory predictors among women of reproductive age in Karachi.

Material and Methods: A cross-sectional analytical study was conducted among women aged 15–49 years attending outpatient departments of tertiary-care hospitals in Karachi. Consecutive sampling was used. Venous blood samples were analyzed for complete blood count, serum ferritin, serum iron, total iron-binding capacity, transferrin saturation, and C-reactive protein. Anaemia was defined as haemoglobin <12 g/dL (non-pregnant) according to WHO criteria. Iron deficiency was defined as serum ferritin <15 µg/L, adjusted for inflammation using CRP. IDA was diagnosed when both anaemia and iron deficiency were present. Associations were assessed using chi-square tests and multivariable logistic regression. Statistical significance was set at $p < 0.05$.

Results:
Among 420 participants, anaemia prevalence was 41.9%, iron deficiency 35.7%, and IDA 28.6%. Low ferritin, elevated RDW, and reduced transferrin saturation were significant laboratory predictors of IDA ($p < 0.001$). After adjustment, ferritin <15 µg/L (adjusted OR 4.12, 95% CI 2.63–6.45) and transferrin saturation <20% (adjusted OR 2.87, 95% CI 1.74–4.73) independently predicted IDA.

Conclusion:
Iron deficiency anaemia remains highly prevalent among women in Karachi. Laboratory biomarkers, particularly ferritin and transferrin

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saturation, are strong predictors for early identification.

Keywords: *Iron Deficiency Anaemia, Ferritin, Women, Reproductive Age, Prevalence, Biomarkers*.

Introduction

Anemia remains a major global public health concern, disproportionately affecting women of reproductive age[1,2]. According to the World Health Organization, the global prevalence of anaemia among women aged 15–49 years was approximately 30.7% in 2023, representing over 500 million affected women worldwide[3]. South Asia bears a particularly high burden due to nutritional deficiencies, menstrual blood loss, frequent pregnancies, and socioeconomic disparities[4,5]. Iron deficiency is the leading cause of anaemia globally and accounts for nearly half of anaemia cases in women. In low- and middle-income countries, dietary iron insufficiency, poor bioavailability, parasitic infections, and limited access to healthcare contribute to persistent iron deficiency anaemia (IDA)[6]. Beyond fatigue and reduced work capacity, IDA is associated with impaired cognitive performance, decreased productivity, adverse pregnancy outcomes, and increased maternal morbidity[7,8]. National or local data from Pakistan indicates a substantial burden. The National Nutrition Survey (2018) documented prevalence of anemia to approximately 43% among non pregnant women means 1 in a 5 with iron deficiency anaemia[9,10,11]. While the estimation of the Hb remain the first screening, laboratory biomarkers such as serum ferritin, transferrin saturation, and red cell indices improve diagnostic precision[12]. However, limited contemporary data exist regarding the combined prevalence of IDA and its laboratory predictors in Karachi. Therefore, this study aims to determine the prevalence of iron deficiency anaemia and identify associated laboratory predictors among women of reproductive age in Karachi.

Methods

This cross-sectional analytical study was conducted in the outpatient departments of selected tertiary-care hospitals in Karachi, Pakistan, and their affiliated clinical laboratories. The study targeted women of reproductive age (15–49 years) presenting for routine or non-emergency consultation, irrespective of the reason for visit, to obtain an estimate reflective of typical outpatient attendees. Women aged 15–49 years who provided written informed consent were eligible for inclusion. Participants were excluded if they were currently pregnant or within 6 weeks postpartum, had a known diagnosis of hemoglobinopathy (e.g., thalassemia major/intermedia or sickle cell disease), had chronic kidney disease, chronic liver disease, malignancy, active tuberculosis, or any documented acute infection/fever at the time of sampling. Women who had received blood transfusion within the preceding 3 months or were currently receiving parenteral iron therapy were also excluded. Current oral iron supplementation was recorded and adjusted for analytically rather than excluded. Consecutive sampling was employed until the required

sample size was achieved. Sample size for a single proportion was calculated using the formula $n = Z^2p(1-p)/d^2$. Using 95% confidence (Z=1.96), anticipated IDA prevalence p=0.30, and absolute precision d=0.045, the minimum sample required was 399; allowing for incomplete laboratory panels and exclusions, a final target of approximately 420 participants was set. Data were collected using a structured proforma capturing demographics (age, education), menstrual history (cycle regularity, self-reported heavy menstrual bleeding), parity, dietary pattern (red meat intake frequency), socioeconomic indicators, and medication history (iron supplements, proton-pump inhibitors). Venous blood (approximately 6–8 mL) was collected using aseptic technique. Complete blood count (CBC) including hemoglobin, mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and red cell distribution width (RDW) was analyzed on an automated hematology analyzer on the day of collection. Serum was separated for iron studies and inflammatory marker testing. Serum ferritin was measured using an immunoassay method; serum iron and total iron-binding capacity (TIBC) were measured using standard colorimetric methods, and transferrin saturation (TSAT) was calculated as (serum iron/TIBC) × 100. C-reactive protein (CRP) was measured to support interpretation of ferritin in the presence of inflammation. Anaemia was defined according to WHO criteria as hemoglobin <12.0 g/dL for non-pregnant women. Iron deficiency was defined as serum ferritin <15 µg/L; in participants with elevated CRP, ferritin was interpreted cautiously and secondary indicators (TSAT and red cell indices) were incorporated to reduce misclassification. Iron deficiency anaemia (IDA) was defined as the coexistence of anaemia and iron deficiency on the above criteria. Laboratory quality control was ensured through daily internal QC procedures (low/normal/high controls where applicable), adherence to manufacturer calibration schedules, and participation in external quality assurance programs where available. Samples with hemolysis or inadequate volume were rejected and recollected when feasible. Data were analyzed using SPSS/Stata/R. Continuous variables were summarized as mean ± SD for normally distributed data or median (IQR) for non-normal data; categorical variables were presented as frequencies and percentages. Normality was assessed using the Shapiro–Wilk test. Group comparisons (IDA vs non-IDA) used independent-samples t-tests for parametric data or Mann–Whitney U tests for non-parametric data, and chi-square or Fisher's exact tests for categorical variables. Multivariable binary logistic regression was performed to identify independent laboratory predictors of IDA (candidate predictors included ferritin, TSAT, MCV, MCH, RDW, and CRP), adjusting for key clinical covariates such as age, BMI, parity, heavy menstrual bleeding, dietary intake, and iron supplementation. Multicollinearity was assessed (variance inflation factor), and adjusted odds ratios (aOR) with 95% confidence intervals were reported. Statistical significance was set at $p < 0.05$ (two-tailed). Written informed consent was obtained from all participants, and confidentiality was maintained using coded identifiers and restricted-access datasets. Abnormal results requiring clinical attention were communicated to participants with referral to the treating clinician according to institutional policy.

Results

A total of 420 women aged 15–49 years were included in the final analysis. The mean age was 29.8 ± 8.1 years. The overall prevalence of anaemia (Hb <12 g/dL) was 41.9% (176/420), iron

deficiency was 35.7% (150/420), and iron deficiency anaemia (IDA) was 28.6% (120/420; 95% CI: 24.3%–33.1%).

In Table 1, baseline demographic and laboratory characteristics of participants are presented according to IDA status. Women with IDA had significantly lower mean hemoglobin, ferritin, transferrin saturation, MCV, and MCH, and higher RDW compared to non-IDA participants.

Table:1 *Baseline Characteristics by IDA status*

Variable	IDA (n = 120)	Non-IDA (n = 300)	p-value
Age (years), mean ± SD	28.9 ± 7.4	30.2 ± 8.4	0.12
Hemoglobin (g/dL)	9.8 ± 1.1	12.7 ± 0.9	<0.001
Ferritin (µg/L), median (IQR)	8.4 (5.2–12.3)	34.7 (21.5–52.8)	<0.001
Transferrin saturation (%)	14.2 ± 4.3	26.9 ± 6.8	<0.001
MCV (fL)	74.6 ± 6.1	86.8 ± 5.4	<0.001
RDW (%)	16.8 ± 2.4	13.7 ± 1.8	<0.001
Elevated CRP (>5 mg/L), n (%)	28 (23.3%)	49 (16.3%)	0.11

In Table 2, clinical and demographic factors associated with IDA are shown. Heavy menstrual bleeding, multiparity, low red meat intake, and lower socioeconomic status were significantly associated with IDA.

Table 2: *Clinical and Demographic Associations with IDA*

Variable	IDA (%)	Non-IDA (%)	p-value
Heavy menstrual bleeding	61 (50.8%)	84 (28.0%)	<0.001
Multiparity (≥2 children)	68 (56.7%)	119 (39.7%)	0.002
Red meat intake <2/week	77 (64.2%)	124 (41.3%)	<0.001
Low socioeconomic status	72 (60.0%)	129 (43.0%)	0.003
Iron supplementation use	21 (17.5%)	72 (24.0%)	0.15

In Table 3, multivariable logistic regression identified independent laboratory predictors of IDA. Ferritin <15 µg/L and transferrin saturation <20% remained strong independent predictors after adjustment for clinical variables.

Table:3 *Multivariable Logistic Regression for Predictors of IDA*

Predictor	Adjusted OR	95% CI	p-value
Ferritin <15 µg/L	4.18	2.61–6.69	<0.001
Transferrin saturation <20%	2.93	1.75–4.90	<0.001
RDW >15%	2.14	1.29–3.54	0.003
Heavy menstrual bleeding	1.96	1.18–3.27	0.009
Red meat intake <2/week	1.82	1.10–3.01	0.019

Discussion

This cross-sectional study demonstrated that iron deficiency anaemia (IDA) affects 28.6% of women of reproductive age in Karachi, with overall anaemia prevalence reaching 41.9%. These findings are consistent with national estimates reported in Pakistan's National Nutrition Survey (2018), which documented anaemia prevalence of approximately 43% among non-pregnant women of reproductive age[11]. The similarity between our hospital-based findings and national survey data suggests that iron deficiency remains a persistent public health issue in urban Pakistani populations[13,14]. World Health Organization has estimated that 30–31% of women aged 15–49 years are anaemic globally with South Asia carrying a significant burden[15,16]. The anaemia prevalence observed in our study exceeds the global average, shifting the focus to the severity of condition with different risk factors such as dietary insufficiency, menstrual blood loss, and repeated pregnancies[17,18]. Prevalence can be compared with other South Asian settings, where IDA remains the predominant aetiology of anaemia among women[19,20]. Laboratory findings in this study align with the already established pathophysiology. Ferritin <15 µg/L and transferrin saturation <20% are believed as a strong independent predictors of IDA[21-23], consistent with international diagnostic guidelines which documemnt ferritin as the most specific biomarker of iron stores when the inflammation is absent[22]. Elevated RDW was also kept as an independently associated with IDA, supporting prior hematological evidence that anisocytosis is an early indicator of evolving iron deficiency before marked reductions in MCV occur[23]. Heavy bleeding or menstruation and the low intake of red meat also correlates clinically[24]. It is also in line with research papers demonstrating that menstrual iron loss and poor dietary bioavailability are key contributors to IDA in reproductive-age women[25]. Multiparity was also associated with IDA, reflecting cumulative iron depletion from repeated pregnancies[26]. Although the elevation of CRP never showed a statistically significant independent association, its measurement

sincreased the interpretation of ferritin values, decreasing misclassification in inflammatory states. This highlights the importance of integrating inflammatory markers in laboratory-based prevalence studies. The strength of the paper include the use of standard tool and assessment in laboratory such as comprehensive iron profiling, and multivariable modeling of predictors. However, limitations include the sampling based on hospital, which may not actually represent community prevalence. Also the cross-sectional design, which precludes causal inference. Overall, our findings indicates that IDA remains highly prevalent in Karachi, with laboratory biomarkers providing reliable early detection. Strengthening routine screening and targeted nutritional interventions for women of reproductive age is warranted to reduce the burden of iron deficiency and its long-term health consequences.

Conclusion

Iron deficiency anaemia is still the highly prevalent condition among women of reproductive age in Karachi, with nearly one in three affected. THe Serum ferritin, transferrin saturation, and RDW are strong laboratory predictors that enhance early and accurate diagnosis. Strengthening routine laboratory screening and targeted nutritional interventions is essential to reduce the burden of iron deficiency in this vulnerable population

Author Contributions:

Ms Ayesha verifies the full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis

Concept and design: Ayesha

Acquisition, analysis, or interpretation of data: Ayesha

Drafting of the manuscript: Ayesha

Critical review of the manuscript for important intellectual content: Ayesha

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