

Original Article

Prevalence of Iron Deficiency Anemia in Type 2 Diabetes: A Descriptive Cross-Sectional Study

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Abstract

Objective: This study aimed to establish the prevalence of IDA in T2DM patients and explore its relationship with glycaemic control.

Methodology: The study design employed for this research was a descriptive cross-sectional study that was carried out at Holy Family Hospital, Rawalpindi, for a period of one year (April 2025 to April 2026). A sample size of 225 patients with adult T2DM aged between 25 and 70 years was selected for the study employing a consecutive non-probability sampling technique. Data were gathered from medical records and laboratory reports. Diagnosis of IDA was made using the WHO criteria based on haemoglobin and serum ferritin levels. Glycaemic control was categorised as controlled (HbA1c<7%) or uncontrolled (HbA1c>7%).

Results: The total prevalence of IDA was 19.6% (44/225 patients). The mean age of the participants was 56.4 (13.9) years, and 81.8% (184/225) had uncontrolled serum glucose levels. According to the bivariate analysis, there was no significant correlation between IDA and controlled glycaemia ($p=0.669$), sex ($p=0.241$), socioeconomic status ($p=0.279$), and education level ($p=0.623$). Furthermore, binary logistic regression analysis revealed that age ($p=0.262$), sex ($p=0.180$), HbA1c ($p=0.489$), and duration of T2DM ($p=0.661$) were not statistically significant independent predictors of IDA.

Conclusion: IDA was present in one of every five patients in this tertiary care centre in relation to the T2DM population. Although age and increased HbA1c levels were not significant factors for IDA in the adjusted model, the overall prevalence of 19.6% indicates the clinical importance of IDA screening among patients with diabetes to prevent possible confusion with HbA1c measurements.

Keywords: Iron deficiency anemia, type 2 diabetes mellitus, HbA1c, glycemic control, prevalence, Pakistan

Introduction

Diabetes mellitus is caused by absolute or relative insulin insufficiency. Insulin deficiency causes improper carbohydrate metabolism.¹ There are two types of diabetes mellitus (DM). Type 2 diabetes, which typically affects adults, accounts for more than 85% of all diabetes cases.² Diabetes mellitus affects over 537 million people aged 20–79 years. Four out of five adults are from low- and middle-income countries.³ Diabetes mellitus cases are increasing worldwide, with an estimated 8.4% of the population affected in 2017 and 9.9% by 2045.⁴ According to the International Diabetes Federation (IDF), 72.9 million people in India suffer from diabetes. India is the world's second-most affected country after China.⁵

Anaemia is a condition in which the number and size of red blood cells or the concentration of haemoglobin falls below normal levels, resulting in a lack of oxygenation of the human body's tissues.⁶ Anaemia is defined as a haemoglobin concentration below the WHO criterion, which is < 13.0 g/dL in men, < 12.0 g/dL in non-pregnant women, and < 11.0 g/dL in pregnant women.^{7,8} Anaemia is estimated to affect half a billion women aged 15–49 years and 269 million children aged 6–59 months. Anaemia primarily affects the African and Asian regions, with 106 million women and 103 million children in Africa and 244 million women and 83 million children in

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Data Availability Statement: The anonymised raw dataset generated and analysed in the current study has been deposited in the Mendeley Data repository and is publicly accessible via the following DOI: 10.17632/hkgr9fc52v.1.

Institutional Review Board

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Southeast Asia.⁹ Anaemia can be caused by various factors, including iron, vitamin B12, and folate deficiencies.¹⁰ Iron deficiency anaemia arises from insufficient iron storage, nutritional shortage, impaired iron utilisation, or excessive loss from the body.¹¹ It accounts for one-third of all instances of anaemia in underdeveloped countries. Severe IDA can lead to nervous system dysfunction and disability. Anaemia is a risk factor for cardiovascular and end-stage renal diseases in patients with diabetes.¹²

IDA is a prevalent comorbidity in patients with T2DM, with an estimated frequency of over 30%.¹³ This is clinically significant because undiagnosed IDA can result in false HbA1c levels, thus masking actual glycaemic control. Different studies have shown that HbA1c values change in patients with iron-deficient anaemia.¹⁴ Because hemoglobin glycosylation is an irreversible process, RBCs (red blood cells) in IDA have longer survival times, resulting in higher levels of HbA1c than those who do not have IDA. Malondialdehyde, which increases with IDA, also promotes haemoglobin glycosylation.¹⁵ However, some studies suggest that IDA is related to lower HbA1c levels due to immature haemoglobin formation.¹⁶

IDA is a prevalent but often overlooked complication in individuals with T2DM, with the potential to skew HbA1c readings and impair the evaluation of glycaemic control.¹⁷ This study aimed to determine the frequency of IDA among T2DM patients and to examine how it varies between well-managed and poorly controlled glycaemic levels. Identifying IDA in patients with diabetes is critical for correct HbA1c interpretation, optimal disease monitoring, and prevention of long-term consequences.

Methodology

A descriptive cross-sectional study was conducted at the Holy Family Hospital in Rawalpindi, a large public tertiary care facility with significant geographic coverage, including the Rawalpindi-Islamabad metropolitan area. Data were collected throughout the year from April 2025 to April 2026, with the approval of the Rawalpindi Medical University and Allied Hospitals' Institutional Ethical Review Boards. Written informed consent was obtained from all participants before enrolment and clinical evaluation.

The study population comprised adult patients who were actively treated for T2DM in a hospital. The number of patients required for the study was calculated using the WHO Sample Size Calculator. The target sample size was determined using the World Health Organization (WHO) Sample Size Calculator. Assuming an expected prevalence of iron deficiency anaemia of 17.9% among adult patients with diabetes based on recent regional literature,¹⁸ alongside a 95% confidence level and a 5% margin of error, the minimum required sample size was calculated to be 226. To make the study feasible and reduce selection bias, a non-probability consecutive sampling method was used. All participants who met the inclusion criteria were included in the study. One record was omitted during the data collection process due to the presence of missing laboratory values; this exclusion was executed via complete-case analysis under the assumption that the data were Missing Completely At Random (MCAR), bringing the total number of analysed patients to 225.

The internal validity of this study was ensured by the selection of participants using stringent inclusion criteria centred on adult patients between 25 and 70 years of age who had been diagnosed with T2DM for one year. Participants were excluded if they were pregnant or had been pregnant in the past year, had known haemoglobinopathies, or were administered haematinic supplements. Moreover, to avoid any confounding of the haematological data collected, participants were excluded if they had experienced any recent blood loss, had active infections such as malaria, dengue, or hepatitis, or were undergoing treatment that may affect iron or haemoglobin levels.

Data were gathered systematically by examining the patients' clinical charts and laboratory results in the hospital. Biological samples were not collected from the patients for this study; rather, the parameters were extracted from the patients' laboratory reports.

The haematological parameters of the participants were obtained from the laboratory reports of their complete blood counts (CBC). The diagnoses and classifications of anaemia were based on reports using the reference standards set by the World Health Organization (WHO). If peripheral blood smear and reticulocyte counts were reported in the participants' medical charts, these reports were also examined to determine the condition of the red blood cells.

Biochemical measures, such as serum ferritin and serum iron, were employed to determine the level of iron in the body of the participants, while glycaemic status was determined by HbA1c and blood glucose levels.

This observational cross-sectional study was conducted in strict adherence to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines. Initial data entry was performed using Microsoft Excel, and all subsequent statistical analyses were performed using IBM SPSS Statistics for Windows, Version 27.0. (IBM Corp., Armonk, NY, USA; RRID: SCR_019096). Descriptive statistics were used to determine the demographic and clinicobiological features of the samples. Before selecting statistical tests, continuous variables (such as age, haemoglobin, and HbA1c levels) were formally assessed for normal distribution using the Shapiro-Wilk test.

Continuous variables are represented by the mean and standard deviation, and categorical variables by frequency and percentage. Anaemia was defined based on the current medical standards as haemoglobin levels < 12 g/dL in women and < 13 g/dL in men. Iron deficiency was defined as serum ferritin levels below 30 ng/mL in men and below 15 ng/mL in women.¹⁹ IDA was diagnosed in patients who met both criteria. Poor glycaemic control was defined as an HbA1c level above 7%.¹¹

Pearson's chi-square test was used to ascertain the relationship between categorical factors, including ex, glycaemic status, and IDA. Independent t-tests were performed to assess the differences in continuous variables between the groups. Binary logistic regression analysis was conducted to determine the independent risk factors for IDA. Multicollinearity was ruled out by assessing the variance inflation factor (VIF) values. Model calibration was tested using the Hosmer-Lemeshow test. Statistical significance was defined as a p-value of less than 0.05.

Results

The research participants included 110 females and 115 males, accounting for 48.9% and 51.1% of the total number of participants, respectively. The average age of the participants was 56.4 (13.9) years. In terms of IDA, 44 subjects were diagnosed with the condition, while 181 subjects were not, as shown in Figure 1. The average HbA1c level for all participants was 9.1 (2.0) %

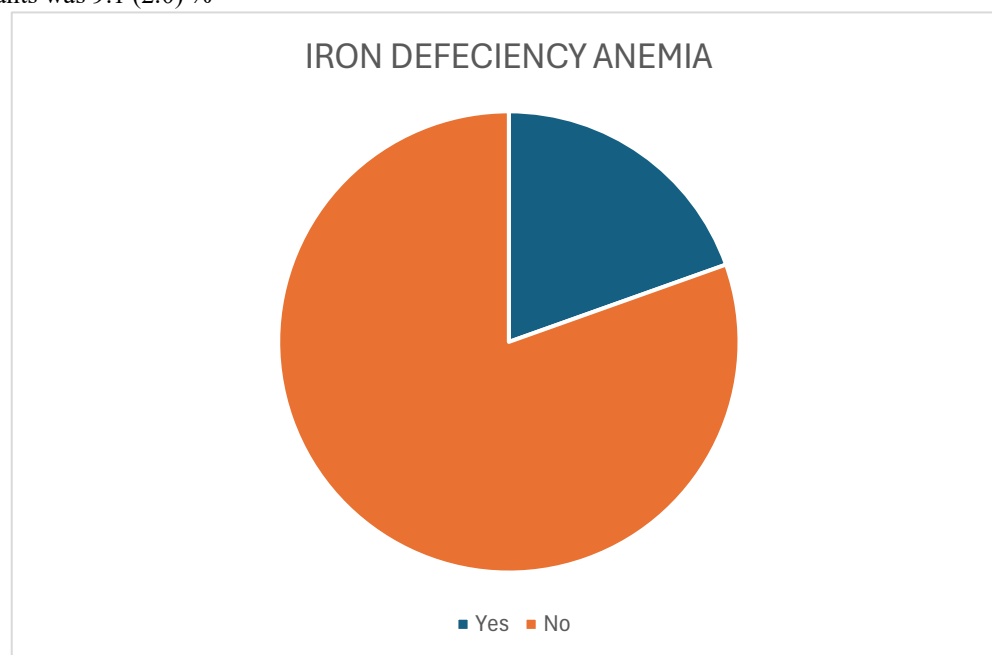


Figure 1: Prevalence of Iron Deficiency Anemia in the Study Population

Distribution of the Study Population: Based on sociodemographic and clinical characteristics

The educational backgrounds of the participants varied, with 51 (22.7%) being illiterate, 53 (23.6%) having a primary education, 59 (26.2%) having completed secondary education, and 62 (27.6%) being graduates. The socioeconomic distribution showed that the majority of patients belonged to the low class (99 patients, 44.0%), followed by the middle class (67 patients, 29.8%), and the high class (59 patients, 26.2%).

Clinically, the mean duration of T2DM was 7.7 (SD 4.3) years. The mean duration of taking T2DM medicine was 7.8 (4.0) years. Glycaemic control was suboptimal in the majority of the cohort; 81.8% of patients had uncontrolled glycaemic levels ($\geq 7.0\%$), whereas 41 patients (18.2%) maintained controlled levels ($< 7.0\%$), as shown in Table 1.

Biological Data and Hematological Profile

Analysis of the haematological parameters measured continuously within the whole population showed that the average haemoglobin (Hb) concentration was 11.8 (2.3) g/dL. The average corpuscular volume (MCV) measured from the red blood cells was 80.7 (8.2) fL, with a mean corpuscular haemoglobin (MCH) and mean corpuscular

haemoglobin concentration (MCHC) of 26.4 (3.7) pg and 32.3 (2.5) g/dL, respectively. Lastly, the mean serum ferritin level was 80.4 (46.4) ng/mL.

Table 1: Sociodemographic and Baseline Clinical Characteristics of the Study Population

Abbreviation: T2DM; Type 2 Diabetes Mellitus, SD; Standard Deviation, HbA1c; Haemoglobin A1C

Characteristics of the patients	n	Percentage (%)
Age “Mean (SD)”	56.4 (13.9)	
Gender		
Female	110	48.9
Male	115	51.1
Education		
Illiterate	51	22.7
Primary	53	23.6
Secondary	59	26.2
Graduate	62	27.6
Socioeconomic Class		
Low	99	44.0
Middle	67	29.8
High	59	26.2
HbA1c (%) “Mean (SD).”	9.1 (2.0)	
Glycaemic Control		
Controlled (<7.0%)	41	18.2
Uncontrolled (≥7.0%)	184	81.8
Duration of T2DM in years “Mean (SD).”	7.7 (4.3)	
Duration of T2DM Medicine in years “Mean (SD).”	7.8 (4.0)	

Biological Data and Hematological Profile: Analysis of the haematological parameters measured continuously within the whole population showed that the average haemoglobin (Hb) concentration was 11.8 (2.3) g/dL. The average corpuscular volume (MCV) measured from the red blood cells was 80.7 (8.2) fL, with a mean corpuscular haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC) of 26.4 (3.7) pg and 32.3 (2.5) g/dL, respectively. Lastly, the mean serum ferritin level was 80.4 (46.4) ng/mL.

Table 2: Descriptive Statistics of the Hematological Profile and Iron Parameters

Abbreviation: Hb; Haemoglobin, MCV; mean cell volume, MCH; mean corpuscular haemoglobin, MCHC; mean corpuscular haemoglobin concentration

	Mean	Standard Deviation
Hb (g/dL)	11.8	2.3
MCV (fL)	80.8	8.2
MCH (pg)	26.4	3.7
MCHC (g/dL)	32.3	2.5
Serum Ferritin (ng/mL)	80.4	46.4

Factors Associated with IDA: A comparative analysis of categorical variables between patients with and without IDA showed no statistically significant differences (**Table 3**). Gender distribution ($p=0.241$), socioeconomic position ($p=0.279$), and educational background ($p=0.623$) did not substantially differ according to the presence or absence of IDA. Furthermore, a chi-square test of independence was performed to examine the association between IDA and glycaemic control. The analysis revealed no statistically significant relationship between IDA and glycaemic control, $\chi^2(1) = 0.183$, $p=0.669$, as illustrated in Figure 2.

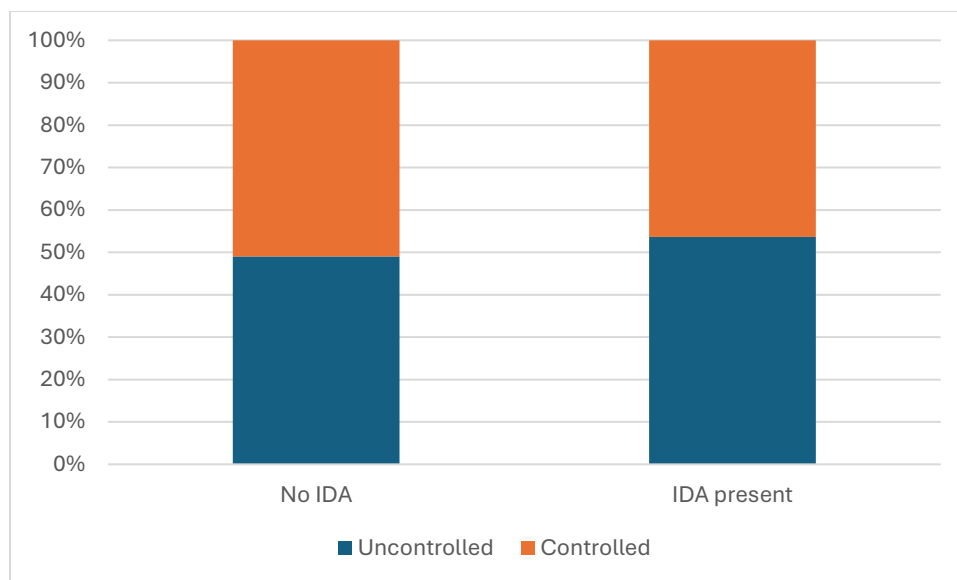


Figure 2: Distribution of Glycaemic Control Among Diabetic Patients

When analyzing continuous variables, the mean age was 58.4 (13.0) vs 55.9 (14.0) years, $p=0.277$, and HbA1c levels (9.3 (2.0) vs. 9.0 (2.0) %, $p=0.397$) were not significantly different between the IDA present and IDA absent groups. However, patients presenting with IDA had significantly lower Hb levels (10.2 (1.4) g/dL) compared to those without IDA (12.9 (2.3) g/dL), yielding a highly significant difference ($p=0.001$).

Table 3: Association of Sociodemographic and Clinical Factors with Iron Deficiency Anemia Status

Abbreviation: IDA; Iron Deficiency Anaemia

Variables	IDA Absent (n=181)	IDA Present (n=44)	p-value
Categorical Variables			
Gender			
Male	96 (83.5%)	19 (16.5%)	0.241
Female	85 (77.3%)	25 (22.7%)	
Socioeconomic Status			
Low	75 (75.8%)	24 (24.2%)	0.279
Middle	57 (85.1%)	10 (14.9%)	
High	49 (83.1%)	10 (16.9%)	
Education			
Illiterate	42 (82.4%)	9 (17.6%)	0.623
Primary	44 (83.0%)	9 (17.0%)	
Secondary	44 (74.6%)	15 (25.4%)	
Graduate	51 (82.3%)	11 (17.7%)	
Glycaemic Control			
Controlled (<7.0%)	32 (78.0%)	9 (22.0%)	0.669
Uncontrolled (≥7.0%)	149 (81.0%)	35 (19.0%)	

Predictors of IDA: A binary logistic regression was conducted to assess the association of age, sex, HbA1c level, and duration of T2DM with IDA (**Table 4**). The overall model was significant ($\chi^2(4) = 70.801$, $p < .001$). The model

explained 1.6% of the variance according to Cox and Snell R^2 and 2.6% according to Nagelkerke R^2 , with an overall accuracy of 80.4%.

Age insignificantly predicted IDA status, $B = .015$, $SE = .013$, $Wald = 1.261$, $p = .262$, $OR = 1.015$, 95% CI (0.989 – 1.041). Gender insignificantly predicted IDA status, $B = .462$, $SE = .345$, $Wald = 1.800$, $p = .180$, $OR = 1.588$, 95% CI (0.808 – 3.120). HbA1c value insignificantly predicted IDA status ($B = .062$, $SE = .089$, $Wald = .479$, $p = .489$, $OR = 1.063$, 95% CI: 0.893 – 1.266). T2DM duration insignificantly predicted IDA status ($B = .001$, $SE = .003$, $Wald = .192$, $p = .661$, $OR = 1.001$, 95% CI: 0.995 – 1.008).

Table 4: Binary Logistic Regression Analysis for Predictors of Iron Deficiency Anaemia

Abbreviation: T2DM; Type 2 Diabetes Mellitus, B; Unstandardized Regression Coefficient, SE; Standard Error, CI; Confidence Interval, OR; Odds Ratio

Variables	B	S.E.	Wald	Sig.	OR	95% CI Lower	95% CI Upper
Age	.015	.013	1.261	.262	1.015	.989	1.041
Sex	.462	.345	1.800	.180	1.588	.808	3.120
HbA1c Value (%)	.062	.089	.479	.489	1.063	.893	1.266
Duration of T2DM in years	.001	.003	.192	.661	1.001	.995	1.008

Discussion

This descriptive cross-sectional study investigated the prevalence and clinical correlates of IDA in patients with T2DM at a well-known tertiary care hospital in Rawalpindi-Islamabad. Our results indicate that the prevalence of IDA among our group of patients with diabetes was 19.55% (44 out of 225 patients). These results are consistent with the increasing evidence available in the regional and global literature, suggesting that IDA is a common but underdiagnosed condition among patients with diabetes.²⁰

The prevalence noted is in line with the figures reported in the regional literature. Studies performed in similarly structured tertiary care setups in Pakistan, in patients studied at the Pakistan Institute of Medical Sciences (PIMS), and among Pakistan armed forces personnel, have reported a variable baseline incidence of anaemia, depending on local diets and socioeconomic background.²¹⁻²³ In addition, broader regional data, including studies conducted among Indians and Bangladeshis, have reported the prevalence of anaemia among patients with T2DM to be between 15% and above 30%.^{3,15} The prevalence of 19.55% in our study highlights that iron deficiency is a problem in this region, further exacerbated by inflammation caused by T2DM.²⁴

One of the primary objectives of this study was to determine the relationship between IDA and glycaemic control. In the beginning, bivariate analysis indicated that the HbA1c level did not differ significantly between the presence and absence of IDA ($p=0.397$), nor was there any significant relationship between the classification of glycaemic control and IDA ($p=0.669$).²⁵ However, after conducting the test for binary logistic regression, HbA1c was not a statistically significant predictor of IDA ($p=0.489$).²⁶

Several sources reviewed here have mentioned that absolute iron deficiency might cause an erroneous increase in HbA1c levels.²⁷ This behaviour is due to the irreversible nature of haemoglobin glycosylation and its time-dependency. The increased erythrocyte lifespan in iron-deficiency conditions facilitates glycosylation, irrespective of blood plasma glucose levels.²⁸ As such, the independent predictive power of HbA1c for IDA found in our regression analysis might be explained by the same mechanism, where undiagnosed IDA causes a false increase in glucose metabolism indices.²⁹

No significant relationship was found between IDA and sex ($P=0.241$), socioeconomic status ($P=0.279$), or education level ($P=0.623$). In contrast to population studies indicating that women have a higher risk of anaemia before menopause, there was no sex bias in terms of IDA incidence in our study sample, as most of the females had already undergone menopause, which means they did not have a physiologic loss of iron.³⁰ In addition, IDA was not positively predicted by age, even when adjusted for other factors in the regression model ($p=0.262$).³¹ This finding supports the current literature, indicating an increased probability of developing nutritional and chronic disease-related anaemia in elderly patients.³²

The absence of an association with socioeconomic status and education level could indicate the nature of the patient demographics at Holy Family Hospital.³³ Since it is a busy public tertiary care hospital, it is possible that there is a certain similarity among the nutrition-related backgrounds of the patients, despite any slight differences in education and income levels.

Limitation

This study had several limitations. First, the cross-sectional design did not allow us to draw any conclusions about the temporality or causation between T2DM and IDA. Second, the use of a single-centre population could affect our results in relation to their applicability to people in rural areas who have access to nutrition. Lastly, we selected participants who were not receiving haematinic treatment or experiencing bleeding; however, we do not know the exact dietary iron intake and BMI.

Conclusions

In summary, iron deficiency anaemia is widespread in approximately 19.6% of patients with T2DM in this population group. Age and HbA1c levels are important factors contributing to iron deficiency anaemia. Consequently, it is imperative to focus on screening elderly individuals and diabetic patients with poorly controlled blood glucose levels. It is crucial to manage iron deficiency in such patients to improve their haematological parameters and ensure reliable HbA1c testing.

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All authors approved the final version to be published & agreed to be accountable for all aspects of the work.

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