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Prevalence & Predictors of Anaemia in Relation to Glycaemic Status & Mean Corpuscular Volume: A Hospital-Based Observational Study

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HIGHLIGHTS

- Anaemia affected half the participants.
- Females had higher anaemia prevalence.
- Anaemia correlated with lower HbA1c.
- Male sex lowered anaemia odds.
- MCV lacked independent predictive value.

Key Words:

Anaemia; Haemoglobin
HbA1c
Mean corpuscular volume
Glycaemic status

ABSTRACT

Introduction: Anaemia is a common haematological disorder influenced by demographic, nutritional, metabolic and systemic factors. Alterations in erythrocyte morphology and turnover may also affect interpretation of glycated haemoglobin (HbA1c), making evaluation of the relationship between anaemia, glycaemic status and red-cell indices clinically relevant. **Aim & Objective:** To evaluate the prevalence of anaemia and assess its association with demographic characteristics, HbA1c levels, and erythrocyte indices, particularly MCV. **Material & Methods:** This hospital-based observational study included 150 participants. Age, sex, haemoglobin, HbA1c and mean corpuscular volume (MCV) were assessed. Anaemia was defined as haemoglobin <13 g/dL in males and <12 g/dL in females. HbA1c was categorized as <7% and ≥7%, while MCV was classified as microcytic, normocytic or macrocytic. Associations were evaluated using appropriate comparative tests and multivariable logistic regression. **Results:** The mean age was 44.97 ± 15.69 years, and 56.7% were females. Anaemia was present in 77 participants (51.3%) and was significantly more common among females than males (61.2% vs 38.5%; p=0.010). Anaemia prevalence did not differ significantly across age groups (p=0.489), HbA1c categories (p=0.076) or MCV categories (p=0.564). However, mean HbA1c was significantly lower in anaemic than non-anaemic participants (6.54 ± 1.88% vs 7.37 ± 2.73%; p=0.031). On multivariable analysis, male sex (adjusted OR 0.34, 95% CI 0.17–0.69; p=0.003) and increasing HbA1c (adjusted OR 0.83, 95% CI 0.72–0.97; p=0.020) were independently associated with lower odds of anaemia, whereas age and MCV were not independent predictors. **Conclusion:** Anaemia affected more than half of the study population and was significantly more common among females. Higher HbA1c was independently associated with lower odds of anaemia, while MCV was not an independent predictor.

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INTRODUCTION

Anaemia is a major haematological and public-health problem, characterized by a reduction in circulating haemoglobin sufficient to impair the oxygen-carrying capacity of blood. Its occurrence reflects a wide spectrum of nutritional, inflammatory, metabolic, renal, haematological and systemic disorders. The World Health Organization recommends haemoglobin-based thresholds for identifying anaemia and emphasizes appropriate interpretation according to sex, age and physiological status [1]. In India, anaemia continues to affect a substantial proportion of the population, with considerable variation according to sex, age, nutritional status and geographical region [2]. Population-based data have consistently demonstrated a greater burden among women, although anaemia among adult and elderly men is also increasingly recognized as an important health concern [3].

Apart from haemoglobin concentration, red-cell indices are important for the initial morphological assessment of anaemia. Mean corpuscular volume (MCV), representing average erythrocyte volume, permits classification into microcytic, normocytic and macrocytic patterns and can guide subsequent investigation of possible aetiologies [4]. Microcytosis is frequently associated with iron deficiency or haemoglobin disorders, whereas macrocytosis may be associated with vitamin B12 or folate deficiency, alcohol exposure and disturbances of erythrocyte maturation. Normocytic anaemia is commonly encountered with chronic inflammatory, renal and systemic diseases [5]. However, MCV is primarily a morphological indicator and should be interpreted together with clinical findings and other laboratory investigations rather than as an isolated marker of aetiology [6].

The relationship between anaemia and glycaemic status is particularly relevant because glycated haemoglobin (HbA1c) is extensively used for assessment of long-term glycaemia. HbA1c reflects glucose exposure during the lifespan of circulating erythrocytes; consequently, conditions that alter haemoglobin concentration, erythrocyte survival or red-cell turnover may affect its interpretation [7]. Current diabetes guidelines therefore recommend caution when HbA1c is interpreted in patients with anaemia or other conditions associated with altered erythrocyte kinetics [8]. Iron deficiency has received particular attention, as several studies have reported changes in HbA1c independent of actual plasma glucose concentration, although the magnitude and direction of this effect have varied between populations [9].

Figure 1: Mechanisms by which iron deficiency, vitamin B12/ folate deficiency, & chronic inflammation affect HbA1c levels and glycaemic classification.

Recent evidence further suggests that correction of iron deficiency may alter HbA1c values, highlighting the possibility of glycaemic misclassification when haematological abnormalities coexist [10]. An understanding of the interrelationship between haemoglobin, red-cell morphology and HbA1c is therefore clinically important, particularly in populations where both anaemia and abnormalities of glucose metabolism are common. The present study was undertaken to determine the prevalence of anaemia and its association with age, sex, HbA1c and MCV, to compare laboratory parameters between anaemic and non-anaemic participants, and to identify independent predictors of anaemia in the study population.

MATERIALS & METHODS

This hospital-based observational study included a total of 150 participants. Demographic characteristics, including age and sex, were recorded for all participants. Laboratory evaluation included haemoglobin concentration, glycated haemoglobin (HbA1c), and mean corpuscular volume (MCV). Anaemia was

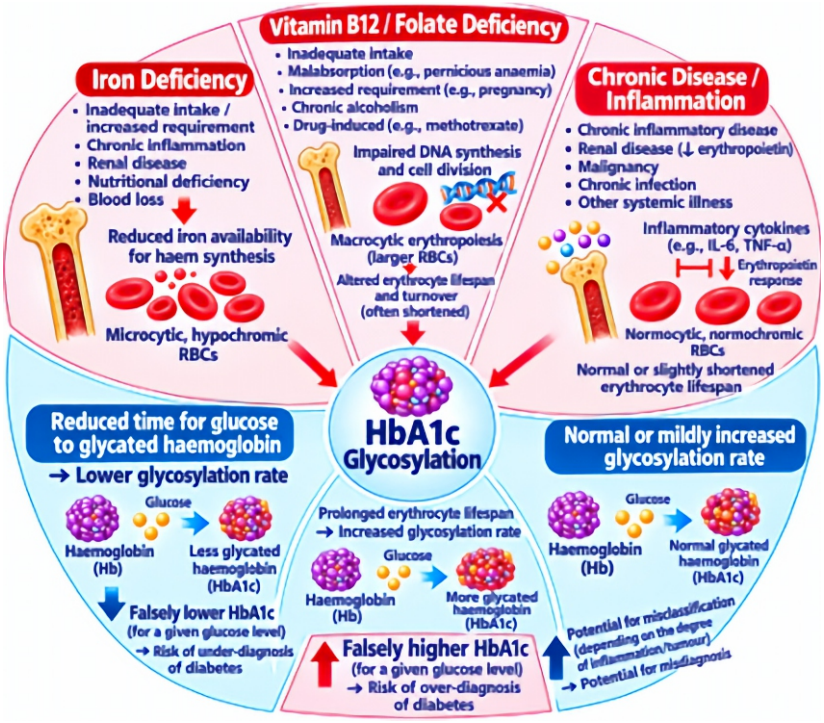


Figure 1: Effects of anaemia and inflammation on HbA1c levels.

defined using sex-specific haemoglobin cut-offs of <13 g/dL in males and <12 g/dL in females. Participants were subsequently classified as anaemic or non-anaemic for comparative analysis. For further assessment, HbA1c values were categorized as <7% and ≥7%, while MCV was classified as microcytic (<80 fL), normocytic (80–100 fL), and macrocytic (>100 fL). Age was grouped as <40 years, 40–59 years, and ≥60 years. The prevalence of anaemia was assessed across these demographic and laboratory categories, and differences in age, HbA1c, and MCV were compared between anaemic and non-anaemic participants.

Continuous variables were summarized as mean ± standard deviation, with median and range where appropriate, while categorical variables were expressed as frequencies and percentages. The independent-samples t-test was used for comparison of continuous variables and the Chi-square test for categorical variables. Multivariable binary logistic regression was performed to identify independent predictors of anaemia using age, sex, HbA1c, and MCV. Results were expressed as adjusted odds ratios with 95% confidence intervals, and a p value <0.05 was considered statistically significant.

RESULTS

A total of 150 participants were included in the analysis. Participants were assessed for the presence of anaemia using sex-specific haemoglobin cut-offs, and the distribution of anaemia was further examined according to demographic characteristics, glycaemic status and MCV category. Continuous variables were summarized using mean ± standard deviation, median and range, while categorical variables were expressed as frequencies and percentages. Appropriate comparative and multivariable statistical analyses were performed, with p<0.05 considered statistically significant. **Table 1** summarizes the demographic and haematological chara-cteristics of the study population. The mean age was 44.97 ± 15.69 years, and the largest proportion of participants belonged to the 40–59-year age group (40.0%). Females constituted 56.7% of the cohort, while males accounted for 43.3%. The mean haemoglobin concentration was 12.12 ± 1.95 g/dL, with values ranging from 6.8 to 17.4 g/dL. Overall, 77 participants (51.3%) fulfilled the criteria for anaemia. As shown in **Figure 2**, anaemia was more frequent among females (61.2%) than males (38.5%), & the difference was statistically significant (p= 0.010). **Table 2** presents the principal laboratory findings. The mean HbA1c was 6.94 ± 2.36%, with a median of 6.60% & a range of 3.4–15.3%, while the mean MCV was 96.74 ± 24.94 fL. Overall, 96 participants (64.0%) had HbA1c <7%, whereas 54 (36.0%) had HbA1c ≥7%. Based on MCV, 34.0% of participants had microcytic indices, 20.7% had normocytic indices & 45.3% had macrocytic indices.

Figure 3 demonstrates anaemia preval-ence across age groups, which was highest among participants aged 40–59 years (56.7%), followed by those aged ≥60 years (51.5%) and <40 years (45.6%); however, this variation was not statistically significant (p=0.489). **Table 3** demonstrates a significant association between sex and anaemia. Anaemia was identified in 52 of 85 females (61.2%), compared with 25 of 65 males (38.5%), giving a statistically significant difference (χ^2=6.73, p=0.010). In contrast, the prevalence of anaemia did not vary significantly according to age category. Anaemia was present in 45.6% of participants aged <40 years, 56.7% of those aged 40–59 years and 51.5% of participants aged ≥60 years. Although the highest prevalence was observed in the 40–59-year group, the overall association between age category and anaemia was not statistically significant (χ^2=1.43, p=0.489).

Table 4 compares the principal continuous variables between anaemic and non-anaemic participants. The mean age was slightly higher among participants with anaemia (46.12 ± 16.41 years) than among those without anaemia (43.77 ± 14.93 years), although the difference was not statistically significant (p= 0.360). Mean HbA1c was significantly lower in the anaemic group (6.54 ± 1.88%) than in the non-anaemic group (7.37 ± 2.73%; t=−2.18, p=0.031). Mean MCV remained comparable between the two groups (97.75 ± 24.28 vs 95.67 ± 25.75 fL; p=0.612). **Figure 4** illustrates anaemia prevalence according to MCV category. Anaemia was present in 49.0% of participants with microcytic indices, 45.2% of those with normocytic indices and 55.9% of those with macrocytic indices. Although anaemia was numeri-cally most frequent in the macrocytic group, the overall differe-nce across the three MCV categories was not statistically signifi-cant (p=0.564). **Table 5** evaluates the relationship of glycaemic status and MCV pattern with anaemia and identifies independent predictors on multivariable logistic regression. Anaemia was observed in 55 of 96 participants (57.3%) with HbA1c <7% compared with 22 of 54 participants (40.7%) with HbA1c ≥7%. This categorical association did not reach statistical significance (χ^2=3.16, p=0.076). Similarly, anaemia prevalence did not differ signifi-cantly across microcytic, normocytic and macrocytic MCV categories (p=0.564). After adjustment for age, sex, HbA1c and MCV, male sex remained independently associated with lower odds of anaemia compared with female sex (adjusted OR 0.34, 95% CI 0.17–0.69; p=0.003). Increasing HbA1c was also independently associated with lower odds of anaemia (adjusted OR 0.83 per 1% increase, 95% CI 0.72–0.97; p=0.020), whereas age (p=0.103) and MCV (p=0.686) were not independent predictors.

Overall, anaemia was present in 51.3% of the 150 participants and was significantly more common among females. Neither age category, HbA1c category nor MCV category showed a statistically significant unadjusted categorical association with anaemia. However, mean HbA1c was significantly lower among anaemic participants, and multivariable analysis identified both sex and HbA1c as independent predictors: males and participants with higher HbA1c had lower odds of anaemia. Age and MCV did not retain statistically significant independent associations.

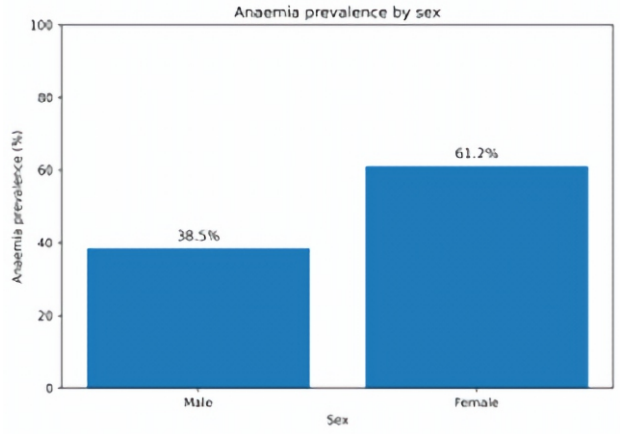


Figure 2. Distribution of anaemia prevalence according to sex among the study participants.

Table 2. Laboratory profile and distribution of HbA1c and MCV (n=150)

Parameter	Mean ± SD	Median	Range
Haemoglobin (g/dL)	12.12 ± 1.95	12.25	6.8–17.4
HbA1c (%)	6.94 ± 2.36	6.60	3.4–15.3
MCV (fL)	96.74 ± 24.94	97.50	52–139
Category	n (%)		
HbA1c <7%	96 (64.0%)		
HbA1c ≥7%	54 (36.0%)		
Microcytic, MCV <80 fL	51 (34.0%)		
Normocytic, MCV 80 –100 fL	31 (20.7%)		
Macrocytic, MCV >100 fL	68 (45.3%)		

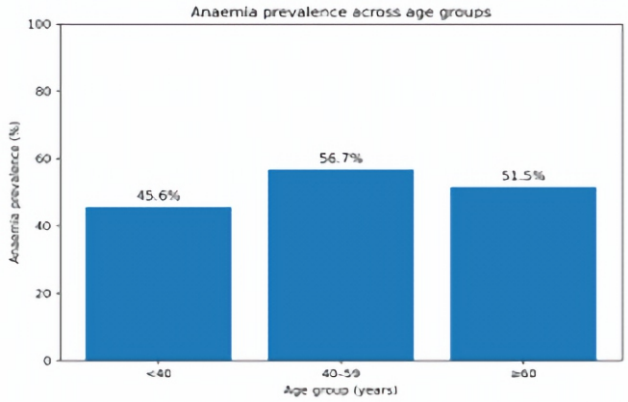


Figure 3. Distribution of anaemia prevalence across different age groups in the study population.

Table 3. Association of anaemia with sex and age group

Variable	Anaemia n (%)	No anaemia n (%)	χ^2	p value
Sex			6.73	0.010
Male (n=65)	25 (38.5%)	40 (61.5%)		
Female (n=85)	52 (61.2%)	33 (38.8%)		
Age group			1.43	0.489
<40 years (n=57)	26 (45.6%)	31 (54.4%)		
40–59 years (n=60)	34 (56.7%)	26 (43.3%)		
≥60 years (n=33)	17 (51.5%)	16 (48.5%)		

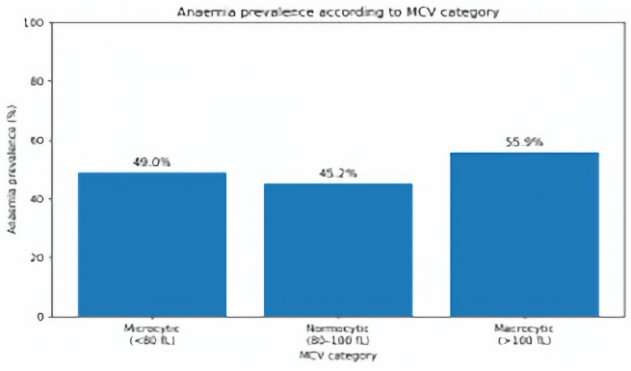


Figure 4. Distribution of anaemia prevalence among microcytic, normocytic and macrocytic MCV categories.

Table 4. Comparison of age, HbA1c and MCV according to anaemia status

Parameter	Anaemia (n=77), Mean ± SD	No anaemia (n=73), Mean ± SD	Test statistic	p value
Age (years)	46.12 ± 16.41	43.77 ± 14.93	t=0.92	0.360
HbA1c (%)	6.54 ± 1.88	7.37 ± 2.73	t=−2.18	0.031
MCV (fL)	97.75 ± 24.28	95.67 ± 25.75	t=0.51	0.612

Table 5. Association of HbA1c and MCV categories with anaemia and multivariable predictors

Variable	Anaemia n (%)	No anaemia n (%)	Statistic / Adjusted OR (95% CI)	p value
HbA1c category			χ^2=3.16	0.076
<7% (n=96)	55 (57.3%)	41 (42.7%)		
≥7% (n=54)	22 (40.7%)	32 (59.3%)		
MCV category			χ^2=1.15	0.564
Microcytic, <80 fL (n=51)	25 (49.0%)	26 (51.0%)		
Normocytic, 80 –100 fL (n=31)	14 (45.2%)	17 (54.8%)		
Macrocytic, >100 fL (n=68)	38 (55.9%)	30 (44.1%)		
Multivariable logistic regression				
Age, per year	-	-	1.02 (1.00 –1.04)	0.103
Male sex vs female	-	-	0.34 (0.17 –0.69)	0.003
HbA1c, per 1% increase	-	-	0.83 (0.72 –0.97)	0.020
MCV, per 1 fL increase	-	-	1.00 (0.99 –1.02)	0.686

DISCUSSION

The present study demonstrated a high prevalence of anaemia, affecting **51.3%** of the 150 participants. This finding is comparable with recent Indian population-based estimates. **Dutta et al.** reported that anaemia prevalence among Indian women increased from **51.4% in NFHS-4 to 56.2% in NFHS-5** [11]. Similarly, **Gnanasekaran et al.** reported an anaemia prevalence of approximately **57% among women of reproductive age** using NFHS-5 data [12]. These findings indicate that anaemia continues to represent a substantial health burden in India, although differences in age distribution, sex composition and clinical characteristics may influence prevalence across studies.

A significant association between sex and anaemia was observed in the present study. Anaemia was detected in **61.2% of females compared with 38.5% of males**, and male sex remained independently associated with lower odds of anaemia on multivariable analysis. This pattern is consistent with the findings of **Didzun et al.**, who reported a lower overall prevalence of anaemia among Indian men compared with the high burden documented among women [13]. **Ghosh et al.** similarly observed a greater prevalence of anaemia among females across different adult age groups in an Indian multicentre survey [14]. Higher iron requirements, menstrual blood loss, pregnancy-related iron depletion and nutritional factors may contribute to this sex difference. Anaemia prevalence was highest among participants aged **40–59 years (56.7%)**, followed by those aged ≥60 years (51.5%) and <40 years (45.6%); however, age category was not significantly associated with anaemia. **AlDallal et al.** reported a greater occurrence of anaemia among older individuals with diabetes, suggesting that advancing age may increase susceptibility through accumulation of chronic disease and nutritional deficiencies [15]. Similarly, **Gausi et al.** found that anaemia in individuals with diabetes was associated with multiple clinical factors, including renal dysfunction and comorbid disease rather than age alone [16]. The absence of a significant age-group association in the present study may therefore reflect the heterogeneous nature of anaemia. HbA1c showed a more nuanced relationship with anaemia in the updated analysis. Although the proportion of anaemia was higher among participants with HbA1c <7% than among those with HbA1c ≥7%, the categorical association did not reach statistical significance (57.3% vs 40.7%; p=0.076). In contrast, mean HbA1c was significantly lower among anaemic participants (6.54 ± 1.88% vs 7.37 ± 2.73%; p=0.031), & HbA1c remained independently associated with anaemia after adjustment, with each 1% increase associated with lower odds of anaemia (adjusted OR 0.83, 95% CI 0.72–0.97; p=0.020). **Ahmad et al.** emphasized that HbA1c can be influenced by changes in erythrocyte turnover and iron status independent of actual glycaemia [17]. Likewise, **AlQarni et al.** demonstrated that correction of iron deficiency may alter HbA1c values, with considerable heterogeneity between studies [10]. These findings support cautious interpretation of HbA1c in patients with haematological abnormalities and do not establish a causal protective effect of higher HbA1c.

MCV showed no significant association with anaemia. Although anaemia was numerically more frequent among participants with macrocytic indices, the differences between microcytic, normocytic and macrocytic groups were not statistically significant. Since MCV provides a morphological rather than etiological classification of anaemia, further evaluation with iron studies, vitamin B12, folate, renal function and inflammatory markers would be required to establish the underlying causes. The study has certain limitations, including its relatively modest sample size and the absence of detailed nutritional, renal and inflammatory markers, which limited assessment of the specific causes of anaemia. In addition, the observational design does not permit inference of causality. Overall, female sex was associated with greater odds of anaemia, while higher HbA1c was independently associated with lower odds; age and MCV were not independent predictors.

CONCLUSION

The present study demonstrated a high prevalence of anaemia (51.3%), with a significantly greater burden among females. Higher HbA1c levels were independently associated with lower odds of anaemia, highlighting the potential influence of haemato-logical status on HbA1c interpretation. However, age and MCV showed no significant independent association. These findings emphasize the importance of routine anaemia screening and comprehensive haematological evaluation in individuals with diabetes to ensure accurate interpretation of HbA1c and appropriate clinical management.

CLINICAL SIGNIFICANCE

The clinical significance of this study lies in its potential to bridge the gap between research findings and practical healthcare applications. It emphasizes the importance of translating scientific observations into meaningful improvements in patient care, diagnosis, and treatment outcomes. By highlighting real world relevance, the study contributes to evidence based medical practice and supports informed clinical decision making. Ultimately, the findings aim to enhance patient quality of life, optimize therapeutic strategies, and promote better disease management in clinical settings.

ABBREVIATIONS

HbA1c: Glycated Haemoglobin
MCV: Mean Corpuscular Volume
HbA1c: Glycated Haemoglobin
CI: Confidence Interval
MCV: Mean Corpuscular Volume

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AUTHOR CONTRIBUTIONS

All authors significantly contributed to the study conception and design, data acquisition, or data analysis and interpretation. They participated in drafting the manuscript or critically revising it for important intellectual content, consented to its submission to the current journal, provided final approval for the version to be published, and accepted responsibility for all aspects of the work. Additionally, all authors meet the authorship criteria outlined by the International Committee of Medical Journal Editors (ICMJE) guidelines.

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CONFLICT OF INTEREST

Authors declared that there is no conflict of interest.

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None

ETHICAL APPROVAL & CONSENT TO PARTICIPATE

All necessary consent & approval was obtained by authors.

CONSENT FOR PUBLICATION

All necessary consent for publication was obtained by authors.

DATA AVAILABILITY

All data generated and analyzed are included within this research article. The datasets utilized and/or analyzed in this study can be obtained from the corresponding author upon a reasonable request.

USE OF ARTIFICIAL INTELLIGENCE (AI) & LARGE LANGUAGE MODEL (LLM)

The authors confirm that no AI & LLM tools were used in the writing or editing of the manuscript, and no images were altered or manipulated using AI & LLM.

AUTHOR'S NOTE

This article serves as an important educational tool for the scientific community, offering insights that may inspire future research directions. However, they should not be relied upon independently when making treatment decisions or developing public health policies.

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