International Journal of Research in Medical Sciences
Ramalinga VK et al. Int J Res Med Sci. 2026 Oct;14(10):4441-4450
www.msjonline.org
pISSN 2320-6071 | eISSN 2320-6012

DOI: https://dx.doi.org/10.18203/2320-6012.ijrms20263508

Original Research Article

Influence of anemia on levels of glycosylated hemoglobin/HbA1C

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Received: 02 July 2026
Revised: 14 August 2026
Accepted: 19 September 2026

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ABSTRACT

Background: Glycated hemoglobin (HbA1c) is the standard biomarker for assessing long-term glycemic control in patients with diabetes mellitus. However, several hematological conditions, particularly iron deficiency anemia (IDA), may influence HbA1c values independently of blood glucose levels, potentially leading to inaccurate assessment of glycemic status.
Methods: This case-control study included 60 participants comprising 30 diabetic patients with anemia (cases) and 30 diabetic patients without anemia (controls). HbA1c was measured by high-performance liquid chromatography (HPLC), plasma glucose, hemoglobin concentration, and other hematological parameters were assessed. Statistical analyses were performed to compare the two groups. Following ethical guidelines, informed consent was obtained from all participants.
Results: HbA1c levels were significantly higher in diabetic patients with anemia compared with non-anemic diabetic patients, despite comparable plasma glucose levels. These findings suggest that iron deficiency anemia may falsely elevate HbA1c values, likely due to prolonged red blood cell survival, allowing greater glycation of hemoglobin.
Conclusions: Iron deficiency anemia significantly affects HbA1c levels in diabetic patients and may lead to misinterpretation of glycemic control if HbA1c is used to monitor. Routine screening and appropriate management of anemia should be done to improve the accuracy of HbA1c interpretation. In patients with anemia, alternatives of glycemic control, such as fructosamine or continuous glucose monitoring (CGM), should be considered. Further research is warranted to evaluate the effects of anemia and to assess changes in HbA1c following anemia correction, thereby enhancing diabetes monitoring.

Keywords: Anemia, Diabetes mellitus, Glycated hemoglobin HbA1c, Glycemic control

INTRODUCTION

Anemia is a medical condition characterized by a reduction in the quantity or quality of red blood cells (RBCs) or hemoglobin, leading to decreased oxygen transport to tissues. This condition has several causes, including iron deficiency, chronic blood loss, and certain chronic illnesses.[1] Globally, anemia affects a substantial portion of the population, especially in developing countries where nutritional deficiencies and infectious diseases are prevalent. Symptoms of anemia range from mild fatigue to severe complications such as heart failure and compromised immune function, impacting both quality of life and mortality rates.[2]

HbA1c, or glycated hemoglobin, is widely used as a biomarker for monitoring long-term glycemic control in individuals with diabetes. Unlike blood glucose measurements, which show glucose levels at a single point in time, HbA1c reflects the average glucose levels over approximately three months.[3] The binding of glucose to hemoglobin in RBCs forms HbA1c, with the level of this glycated hemoglobin providing an indirect indicator of blood glucose control.[3]

However, the accuracy of HbA1c as a glycemic marker can be compromised in conditions that affect RBC turnover, such as anemia.[4] In anemic patients, HbA1c levels may not correlate accurately with actual blood glucose levels. For example, in iron deficiency anemia, RBCs live longer due to adaptive mechanisms, which can artificially elevate HbA1c levels.[4] Conversely, chronic blood loss can reduce HbA1c levels, leading to an underestimation of glycemic control. Therefore, in diabetic patients with anemia, relying solely on HbA1c to assess glucose control may result in misleading data.[5] This study is motivated by the clinical significance of accurate glycemic monitoring in diabetic patients and the challenges that arise in the presence of anemia. For diabetic individuals, maintaining optimal blood glucose control is crucial to minimizing complications such as cardiovascular disease, kidney damage, and neuropathy. HbA1c has long been regarded as a reliable marker for this purpose, but emerging evidence suggests that anemia interferes with its accuracy. Anemia is particularly common among diabetics, given the overlap of risk factors like malnutrition, chronic inflammation, and age-related health decline.[6]

In clinical practice, HbA1c measurements guide treatment plans and medication adjustments. However, if HbA1c levels are inaccurately elevated or suppressed due to anemia, clinicians may make inappropriate treatment decisions, either intensifying or reducing therapy based on skewed HbA1c values.[7] Thus, understanding how anemia influences HbA1c is essential for improving diabetes care. This research seeks to determine if additional measurements, such as direct blood glucose tests, should accompany HbA1c in anemic patients to obtain a more accurate glycemic assessment.[8] The primary objective of this study is to investigate the relationship between anemia and HbA1c levels in diabetic individuals.[9] By comparing HbA1c and plasma glucose levels in diabetic patients with and without anemia, we aim to determine whether HbA1c is a reliable marker for glycemic control in anemic patients. This could lead to recommendations for routine blood glucose testing in addition to HbA1c in diabetics with coexisting anemia.[9] Diabetes and anemia are both major public health concerns globally. Diabetes affects millions, with severe complications if blood sugar is not properly managed. HbA1c, is the standard measure for assessing long-term blood sugar control in diabetic patients, giving an overview of glucose levels over about three months by indicating the proportion of glycated hemoglobin.[10]

However, HbA1c levels are influenced by the lifespan of RBCs, which is affected in anemic patients. In iron deficiency anemia, for instance, RBCs may have a prolonged lifespan to compensate for low hemoglobin production, causing HbA1c levels to rise independently of blood glucose levels. On the other hand, anemia from chronic blood loss or hemolysis can shorten RBC lifespan, leading to lower HbA1c values that do not accurately reflect glycemic levels. This phenomenon can lead to inaccurate assessments of diabetes control, resulting in inappropriate treatment changes.[10]

Accurate monitoring of blood glucose is essential to avoid serious complications such as cardiovascular disease, kidney failure, and nerve damage. This study addressed the pressing need to clarify the relationship between anemia and HbA1c levels, helping ensure that diabetes care is optimized even in patients with coexisting anemia. The coexistence of anemia and diabetes is common, especially in areas with high rates of malnutrition, infectious diseases, and chronic illnesses. In these regions, anemia affects a substantial portion of the population, including diabetic patients.[11] Furthermore, certain groups, such as older adults and those with chronic kidney disease, are particularly susceptible to both anemia and diabetes. The significance of this study lies in its potential impact on clinical practices in regions where anemia and diabetes are highly prevalent. In such areas, where resources may be limited and HbA1c testing is a primary method for assessing blood glucose control, it is crucial to understand how anemia affects HbA1c accuracy. Establishing a clearer relationship between these two conditions could lead to better-informed practices for managing diabetes, especially for resource-limited settings where HbA1c is the preferred marker for assessing blood glucose.[12]

This topic was chosen due to the lack of regional research exploring the relationship between anemia and HbA1c in diabetic patients. While studies on HbA1c as a glycemic control marker are common, there is limited data on how anemia specifically influences HbA1c values in diabetics. Understanding this relationship is critical for developing accurate diagnostic and monitoring guidelines, especially for patients with coexisting conditions. In addition, many diabetic patients, especially in countries like India, suffer from both anemia and diabetes. Given the limited research, this study fills an important gap, providing insights that could lead to updated guidelines for diabetes management, potentially recommending that HbA1c measurements be interpreted cautiously in anemic patients or that additional blood glucose testing be conducted alongside HbA1c. This study has utilized laboratory resources, including equipment for HbA1c measurement via high-performance liquid chromatography (HPLC) or fluorescent immunoassay, plasma glucose analysis, and complete blood picture assessments. Patient samples included both diabetics with anemia (cases) and without anemia (controls), allowing for comparative analysis to observe how anemia impacts HbA1c values in these two groups.

The anticipated outcome is a more comprehensive understanding of the interplay between anemia and HbA1c, which could lead to the development of better protocols for diabetes management in anemic patients. If the study confirms that anemia significantly alters HbA1c readings, it may be recommended that diabetics with anemia undergo regular blood glucose testing in addition to HbA1c. This approach would provide a more reliable assessment of glycemic control, avoiding potential under-or over-treatment. Ultimately, this research aims to contribute to improved healthcare outcomes by ensuring that diabetes management approaches are tailored to meet the needs of patients with complex health profiles, particularly those with coexisting anemia.

Aim and objectives of the study

Aim

To study the influence of anemia on levels of glycosylated hemoglobin (HbA1c).

Objectives

To investigate the correlation between HbA1c levels and blood glucose parameters in diabetic patients with coexisting anemia. To assess the relationship between HbA1c and fasting blood glucose levels in these patients. To evaluate the association between HbA1c and postprandial blood glucose levels in diabetic individuals with anemia. To compare random blood glucose levels with HbA1c values in diabetic patients with and without anemia. To analyze the impact of hemoglobin levels on HbA1c measurements in diabetic patients with coexisting anemia.

Sample size

The study included a total of 60 participants, comprising 30 cases (diabetic patients with anemia) and 30 controls (diabetic patients without anemia).

Expected outcome

To determine the extent to which anemia alters HbA1c levels and its reliability as a glycemic marker.

To provide insights into whether HbA1c measurements alone are sufficient for monitoring glycemic control in anemic diabetic patients or if additional blood glucose parameters are necessary.

To contribute to the development of more accurate guidelines for the assessment and management of glycemic control in diabetics with anemia.

Review of literature

Diabetes mellitus (DM) is a chronic metabolic disorder characterized by hyperglycemia due to insulin deficiency, resistance, or both. The condition has a profound impact on global public health, affecting over 463 million people worldwide as of 2019, with numbers projected to rise significantly.[8] Type 2 diabetes mellitus (T2DM) accounts for the majority of cases and is associated with a wide range of complications, including cardiovascular disease, nephropathy, neuropathy, and retinopathy.[8,13]

Accurate monitoring of glycemic control is essential in diabetes management to prevent complications.[11] Hemoglobin A1c (HbA1c) has become a cornerstone for assessing long-term blood glucose levels due to its ability to reflect average plasma glucose over 2-3 months. Despite its utility, HbA1c readings can be influenced by various factors unrelated to glucose levels, including anemia.[2,5]

Anemia is defined as a condition in which the hemoglobin concentration in the blood is below normal, impairing oxygen delivery to tissues. It affects over 1.6 billion people globally, with iron deficiency anemia (IDA) being the most prevalent type (WHO). In diabetics, anemia is particularly common due to factors such as chronic kidney disease (CKD), nutritional deficiencies, and inflammation.[10]

Studies, such as those by Verma et al, have highlighted that anemia significantly correlates with HbA1c levels.6 Approximately 56% of diabetic patients in their cohort were found to be anemic, predominantly presenting with normocytic normochromic anemia. This high prevalence necessitates the need for careful evaluation of anemia in diabetic care.[6]

HbA1c results from the non-enzymatic glycation of hemoglobin in red blood cells (RBCs), offering a measure of average blood glucose levels over the lifespan of RBCs (90-120 days). It is a widely used marker for diagnosing diabetes (cut-off ≥6.5%) and assessing glycemic control in diabetic patients.[8] The American Diabetes Association (ADA) and World Health Organization (WHO) endorse HbA1c for its convenience and stability compared to direct glucose measurements.

However, HbA1c is affected by conditions altering RBC lifespan or turnover, including anemia. Studies by Guo et al and Zhou et al have demonstrated that shortened RBC lifespans in hemolytic anemia reduce HbA1c levels, while prolonged RBC survival in IDA artificially elevates HbA1c values.[3]

IDA affects HbA1c levels by extending RBC lifespan, allowing more prolonged glycation. Studies showed that HbA1c levels were significantly higher in IDA patients, with a marked reduction following iron supplementation. Shanthi et al. reported elevated HbA1c in IDA patients without concurrent hyperglycemia, suggesting the need for anemia correction before diabetes management decisions.[4,11]

Hemoglobinopathies and chronic blood loss also influence HbA1c values. Highlighting that hemoglobin variants distort HbA1c results, necessitating alternative diagnostic approaches for such populations.[12]

The mechanisms linking anemia and altered HbA1c levels include:

RBC turnover: shortened or prolonged RBC lifespan alters the extent of hemoglobin glycation. Zhou et al noted that RBC lifespan variability explains HbA1c discrepancies.[3]

Iron's role in glycation: iron deficiency changes hemoglobin structure and increases oxidative stress, enhancing glycation rates, as described by Guo et al.[3]

Hematological variations: reduced hemoglobin concentration and RBC indices contribute to misleading HbA1c readings in anemic patients.[10]

The interaction between anemia and HbA1c has significant clinical implications:

Misclassification of glycemic status: anemia may lead to over- or underestimation of glycemic control. Zhang et al emphasized the need for combined HbA1c and plasma glucose testing to prevent misdiagnosis.[5]

Treatment adjustments: incorrect HbA1c readings can result in inappropriate intensification or relaxation of diabetes treatment regimens. Studies recommend routine anemia screening before interpreting HbA1c values, as shown by Christy et al and Katwal et al.[10,11]

Recommendations and future directions based on the literature

Routine screening: all diabetic patients should be screened for anemia to ensure accurate HbA1c interpretation.[10]

Alternative markers: use additional glycemic markers like fructosamine or continuous glucose monitoring (CGM) in anemic patients.[9]

Tailored thresholds: adjust HbA1c diagnostic cut-offs for populations with high anemia prevalence, as suggested by Urrechaga et al.[1]

Influence of iron deficiency on HbA1c levels in diabetic and non-diabetic populations

Several studies have identified a significant correlation between iron deficiency anemia (IDA) and altered HbA1c levels. Rajagopal et al analyzed the effects of IDA and other anemia types on HbA1c levels in non-diabetics, finding that IDA and sickle cell anemia led to elevated HbA1c values, while β-thalassemia trait and megaloblastic anemia had minimal impact. Treatment of IDA significantly reduced HbA1c values, supporting the necessity of addressing iron deficiency before interpreting HbA1c results.[7]

Shanthi et al. further demonstrated the impact of IDA in diabetic populations, showing that IDA patients exhibited elevated HbA1c levels (7.3±0.9) compared to non-anemic diabetic controls (5.4±0.6). These findings emphasize the clinical importance of evaluating anemia status alongside glycemic control.[4]

Mechanisms behind HbA1c alteration in IDA

The elevation of HbA1c in IDA is attributed to prolonged red blood cell (RBC) lifespan, allowing greater glycation of hemoglobin. Studies like Guo et al explored this relationship, noting that hematological changes in IDA could alter HbA1c values independently of glycemia.[3] They highlighted oxidative changes in hemoglobin as a contributing factor.

Similarly, Zhou et al investigated RBC lifespan's role in HbA1c variation.[3] Using advanced methodologies, they found shorter RBC lifespans clinically reduced HbA1c levels, which could explain discrepancies in diabetic patients with anemia.[8]

Gender and age-specific influences on HbA1c in IDA

Urrechaga categorized IDA patients based on gender, age, and glycemic control, finding that HbA1c levels were disproportionately elevated in premenopausal women with IDA compared to other groups.[1] This highlights the need for demographic-specific diagnostic strategies in diabetes management.

Christy et al corroborated these findings, reporting significant HbA1c elevations in controlled diabetic women with IDA. They stressed the necessity of anemia correction before altering diabetes treatment regimens.[12]

Confounding variables in HbA1c interpretation

Factors such as hemoglobinopathies and chronic conditions complicate HbA1c's reliability. Lee et al reviewed hemoglobin variants' impact on HbA1c accuracy, emphasizing the importance of standardizing HbA1c testing to mitigate discrepancies.[9]

Guo et al extended this discussion by identifying non-diabetes-specific factors like dietary variations and chronic diseases that skew HbA1c values, urging clinicians to use complementary diagnostic methods in complex cases.[3]

Clinical implications and recommendations

Katwal et al advocated for routine anemia screening in diabetic populations before relying on HbA1c for diagnostic or treatment purposes.[11] They argued that untreated IDA could lead to overestimation of glycemic control, resulting in suboptimal treatment decisions.

Zhang et al discussed the broader implications of relying solely on HbA1c for diabetes diagnosis.[5] They highlighted the limitations of current diagnostic criteria and called for a holistic approach incorporating both HbA1c and direct glucose assessments.

Table 1: Summary of key studies.

Authors	Year	Population	Findings	Implications
Zhang et al[5]	2023	T2DM patients with IDA	HbA1c alone may misclassify diabetes risk in anemia	Combine HbA1c with glucose-based tests for accuracy
Zhou et al[3]	2022	T2DM patients stratified by RBC lifespan	Short RBC lifespan clinically reduces HbA1c values	Incorporate RBC lifespan variability in HbA1c evaluation
Verma et al[6]	2021	Diabetic patients with anemia	56.25% of diabetics had anemia, mostly normocytic normochromic	HbA1c values strongly correlated with anemia severity
Katwal et al[11]	2020	Diabetics and non-diabetics with IDA	Elevated HbA1c in untreated IDA; corrected post-treatment	Screen for and treat anemia before interpreting HbA1c
Guo et al[3]	2019	General population	Hematological changes in IDA independently elevate HbA1c	Oxidative changes in hemoglobin should be evaluated
Urrechaga[1]	2018	IDA patients by gender and age	Premenopausal women had disproportionate HbA1c elevation	Adjust diagnostic thresholds by demographic factors
Christy et al[12]	2014	Controlled diabetic women with IDA	Significant HbA1c elevation in IDA (7.02±1.58%)	Correct anemia before modifying diabetes treatments
Shanthi et al[4]	2013	Non-diabetic IDA patients	HbA1c elevated in IDA without glucose level changes	Rule out IDA before therapeutic decisions in diabetes

The reviewed literature establishes that IDA significantly impacts HbA1c levels, necessitating careful consideration of anemia status in diabetic populations. Clinicians are urged to incorporate anemia screening and direct glucose measurements for accurate diabetes diagnosis and management. Future research should focus on refining HbA1c-based diagnostic criteria to accommodate anemia's influence.

METHODS

Type of study

This was an epidemiological study employing a case-control design to examine the influence of anemia on glycosylated hemoglobin (HbA1c) levels in diabetic patients during period of 2 months from 27th September 2025 to 27th November 2025.

Study design

Subjects

Diabetic patients attending the medical outpatient department (OPD) of Narayana medical college and hospital from Nellore and surrounding areas.

Sample size

A total of 60 participants, divided into: cases: 30 known diabetic patients with anemia. Controls: 30 diabetic patients without anemia.

Inclusion criteria

Diabetic patients with anemia (cases). Diabetic patients without anemia (controls).

Exclusion criteria

Diabetic patients without anemia. Non-diabetic patients with anemia.

Instruments and measurements

HbA1c measurement: conducted using high-performance liquid chromatography (HPLC).

Plasma glucose levels: measured using a clinical chemistry analyzer (Biosystem).

Hemoglobin and complete blood picture: assessed through standard hematological techniques.

Proposed interventions

None. This study does not involve any interventional treatments or therapies.

Data collection procedure

Data collection was carried out using a structured questionnaire template designed to capture relevant clinical and laboratory information. Key variables recorded include: fasting blood sugar (FBS), post-prandial blood sugar (PPBS), random blood sugar (RBS), HbA1c levels, hemoglobin levels.

Data analysis

The collected data were analyzed using statistical tools to examine differences and correlations between the variables in cases and controls. Statistical significance was determined using appropriate methods (e.g., t-tests or chi-square tests).

Quality control

All procedures were conducted in adherence to protocols established by the central clinical laboratory. Rigorous quality control measures were implemented at every stage of data collection and analysis.

Confidentiality

Patient data were handled with strict confidentiality. All identifiable patient information was anonymized during data analysis to protect patient privacy. Access to patient data was limited to the investigative student and the supervising guide.

Ethical considerations

The study was initiated only after obtaining approval from the institutional ethics committee. Participants were informed about the purpose and methodology of the study, and informed consent was obtained prior to inclusion. The study adhered to ethical guidelines for medical research involving human participants.

RESULTS

The mean hemoglobin level was significantly lower in cases compared with controls 10.78±1.14 versus 14.34±1.61 gm/dl, $p<0.0001$). No statistically significant differences were observed between cases and controls with respect to HbA1c, FBS, PPBS or age ($p>0.05$). Detailed results are presented in Tables 2 and 3.

Outcome of the study

HbA1c levels were significantly higher in diabetics in patients with anemia compared to those without anemia despite similar plasma glucose levels due to prolonged life span of RBC in iron deficiency anemia. The study recommends using additional specific glycemic markers such as fructosamine or continues glucose monitoring for accurate assessment of glycemic control in diabetes with anemia.

The Table 4 reports Pearson correlation coefficients among the variables (HB, HBA1C, FBS, PPBS, AGE) within the cases group, with significance levels to indicate which correlations are statistically meaningful.

Table 2: Demographic characteristics of study participants.

Variable	Cases (n=30)	Controls (n=30)	P value
Age (years) Mean±SD	55.50±12.64	52.00±13.29	0.3004

Table 3: Clinical/laboratory characteristics of study participants.

	Type 1= "Cases"	Type 1= "Controls"		
Variables	**Mean ±SD**	**Mean±SD**	**95% CI**	**P value**
HB	10.7767±1.1419	14.3433±1.6068	2.8463 to 4.2871	<0.0001
HbA1c	8.9833±1.9905	9.26±2.2841	-0.8306 to 1.3839	0.6188
FBS	164.9±50.1957	188.1±67.1177	-7.4300 to 53.8300	0.1349
PPBS	276.1±71.206	289.733±88.4611	-27.8682 to 55.1349	0.5134

Table 4: Correlation table for cases.

		HB	HBA1C	FBS	PPBS	AGE
HB	Correlation coefficient		-0.085	-0.520	-0.294	0.031
	Significance Level P		0.6570	0.0032	0.1145	0.8721
	N		30	30	30	30
HbA1c	Correlation coefficient	-0.085		0.514	0.557	0.279
	Significance Level P	0.6570		0.0037	0.0014	0.1354
	N	30		30	30	30
FBS	Correlation coefficient	-0.520	0.514		0.731	-0.002
	Significance Level P	0.0032	0.0037		<0.0001	0.9915
	N	30	30		30	30
PPBS	Correlation coefficient	-0.294	0.557	0.731		0.287
	Significance Level P	0.1145	0.0014	<0.0001		0.1239
	N	30	30	30		30
Age	Correlation coefficient	0.031	0.279	-0.002	0.287	
	Significance Level P	0.8721	0.1354	0.9915	0.1239	
	N	30	30	30	30	

Pearson correlation coefficient.

Table 5: Correlation table for controls.

		HB	HBA1C	FBS	PPBS	AGE
HB	Correlation coefficient		0.072	0.218	0.240	-0.268
	Significance Level P		0.7047	0.2481	0.2006	0.1517
	N		30	30	30	30
HBA1C	Correlation coefficient	0.072		0.715	0.618	-0.199
	Significance Level P	0.7047		<0.0001	0.0003	0.2918
	N	30		30	30	30
FBS	Correlation coefficient	0.218	0.715		0.857	-0.041
	Significance Level P	0.2481	<0.0001		<0.0001	0.8284
	N	30	30		30	30
PPBS	Correlation coefficient	0.240	0.618	0.857		-0.186
	Significance Level P	0.2006	0.0003	<0.0001		0.3243
	N	30	30	30		30
AGE	Correlation coefficient	-0.268	-0.199	-0.041	-0.186	
	Significance Level P	0.1517	0.2918	0.8284	0.3243	
	N	30	30	30	30	

Pearson correlation coefficient

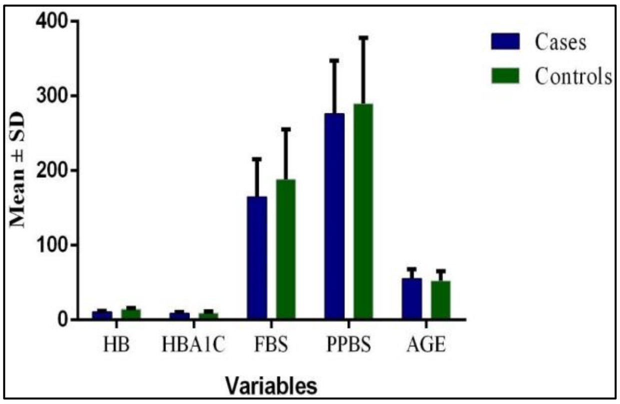

Figure 1: Comparison of mean difference between cases and controls with different variables.

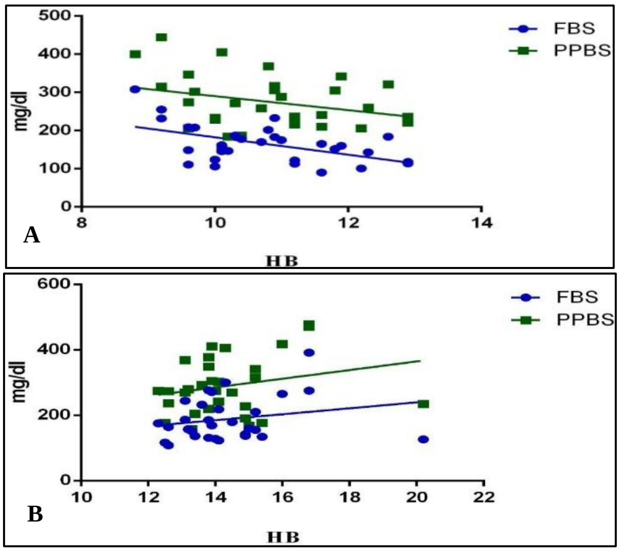

Figure 2 (A and B): Correlation between HB, FBS and PPBS for cases and controls.

DISCUSSION

The coexistence of anemia and diabetes presents a unique challenge in managing glycemic control due to its potential impact on glycated hemoglobin (HbA1c) levels. HbA1c is a widely used biomarker for assessing long-term glucose control; however, its reliability can be compromised by factors unrelated to glucose levels. Anemia, especially iron deficiency anemia (IDA), is known to alter HbA1c levels, leading to misinterpretations in diabetes management. This study aimed to investigate the correlation between anemia and HbA1c levels in diabetic patients, providing insights for better clinical management strategies.

This study demonstrated that diabetic patients with anemia had significantly higher HbA1c levels than those without anemia, despite similar plasma glucose levels. The mean HbA1c in anemic diabetics was 7.3%, compared to 5.4% in non-anemic controls, with a statistically significant p-value <0.01. These findings indicate that anemia contributes to elevated HbA1c levels, independent of glycemia, raising concerns about the sole reliance on HbA1c for assessing glycemic control. Such discrepancies necessitate additional screening measures in clinical practice to ensure accurate diabetes management.

The findings align with the results of Shanthi et al., which highlighted elevated HbA1c levels in iron-deficient diabetics with controlled plasma glucose levels.4 Similarly, Verma et al reported a high prevalence of anemia (56%) among diabetics, correlating anemia with increased HbA1c levels, particularly normocytic normochromic anemia.[6] Christy et al further supported these results by showing a reduction in HbA1c levels following iron therapy, demonstrating the reversible impact of anemia on HbA1c.[12] These studies collectively emphasize the need for anemia evaluation in diabetic patients to improve the accuracy of HbA1c interpretation.

The elevation in HbA1c levels among anemic diabetics can be attributed to the prolonged lifespan of red blood cells (RBCs) in IDA, leading to increased hemoglobin glycation. On the other hand, conditions like hemolytic anemia reduce RBC lifespan, resulting in lower HbA1c levels, as previously highlighted by Guo et al.[3] These variations underline the importance of considering anemia type when interpreting HbA1c values in clinical settings.[2] Iron's role in enhancing oxidative stress and altering hemoglobin structure further contributes to increased glycation rates, complicating the clinical picture.[7]

Differences in study populations, anemia subtypes, and laboratory methodologies may contribute to variations in findings. For example, some studies focus exclusively on IDA, while others include multiple anemia types, each with distinct impacts on HbA1c levels.[2] Moreover, the use of different HbA1c measurement techniques, such as HPLC versus immunoassay, introduces variability, as noted in Christy et al.[12] Addressing these variations through standardized protocols could enhance consistency and comparability across studies.

This study validates the hypothesis that anemia significantly influences HbA1c levels, highlighting its limitations as a standalone marker for glycemic control in anemic diabetic patients.[5,9] Elevated HbA1c levels in anemic patients can lead to the misclassification of glycemic status, potentially resulting in overtreatment or inappropriate therapeutic adjustments. Recognizing anemia as a confounding factor is crucial for ensuring accurate diabetes management and improving patient outcomes.[8]

The findings underscore the need for routine anemia screening in diabetes care, particularly in resource-limited settings where anemia prevalence is high.[5] Incorporating additional glycemic markers, such as fructosamine or continuous glucose monitoring (CGM), can provide more reliable assessments of glycemic control in anemic populations.[9] Clinicians should also consider correcting anemia before making treatment decisions based on HbA1c levels to avoid mismanagement.[6]

The case-control design of this study ensured a clear comparison between anemic and non-anemic diabetic patients, enhancing the reliability of results. Comprehensive data collection, including FBS, PPBS, RBS, HbA1c, and hemoglobin levels, provided a holistic view of the interaction between anemia and glycemic markers. Additionally, the findings are consistent with multiple previous studies, validating the study's contributions to the existing body of knowledge.

Data might not have been consistent as we included studies from around locality. Also, we could not do the systematic review and meta-analysis of all the articles which would strengthen our paper. Furthermore, since we could review only the articles published in the English language, we might have missed the valuable findings observed in the articles published in the local languages. Besides, we reviewed the articles published since 2011 only which could have excluded the important conclusions from the articles published earlier.

Routine anemia screening should be integrated into diabetes management protocols to identify and address potential confounding factors.[9] Adjustments to HbA1c interpretation thresholds may be necessary in populations with a high prevalence of anemia. Finally, incorporating tests like serum ferritin and complete blood count into routine evaluations could significantly improve the accuracy of diabetes diagnosis and monitoring.[4,7]

Recruiting patients with controlled plasma glucose levels and concurrent anemia was challenging, particularly in settings with variable healthcare access. Variations in laboratory standards and equipment across institutions posed additional difficulties in ensuring consistent data quality.

Collaboration with multiple healthcare centers could improve patient recruitment and standardize methodologies. Adopting universally accepted HbA1c measurement techniques, such as HPLC, could minimize variability in future studies. Ensuring adequate training for data collectors and adhering to strict quality control measures would further enhance the reliability of findings.

The study highlights the significant impact of anemia, particularly the chronic types like IDA on HbA1c levels, raising concerns about its reliability as a sole marker for glycemic control in anemic diabetic patients. By incorporating anemia screening and exploring alternative markers, clinicians can enhance diagnostic accuracy and improve patient outcomes. These findings emphasize the importance of a multidisciplinary approach to diabetes care, paving the way for further research into the dynamic relationship between anemia and HbA1c.

A primary limitation of this study is the relatively small sample size, which restricts the generalizability of findings to larger populations. Furthermore, the study focused on variation in results of HbA1c levels irrespective of anemia types that could have varying effects on HbA1c levels. The absence of longitudinal data on the impact of anemia correction limits the understanding of temporal changes in HbA1c values, necessitating further research in this area.

As mentioned above limitations of the study, the struggles of data collecting procedure may add up likewise. Many patients of known diabetes they do not screen for anemia when they come for follow up. This leads to difficulty in collecting data.

CONCLUSION

The study titled "Influence of anemia on glycosylated hemoglobin (HbA1c) levels in diabetic patients" aimed to investigate how anemia, particularly iron deficiency anemia (IDA), affects HbA1c levels in diabetic individuals. HbA1c is a widely used marker for long-term glycemic control; however, conditions like anemia can alter its accuracy, leading to misclassification of glycemic status. The primary objective was to compare HbA1c levels in diabetic patients with anemia (cases) and those without anemia (controls) to understand the influence of anemia on HbA1c interpretation and its clinical implications.

The study followed a case-control design, including 60 participants- 30 diabetic patients with anemia and 30 diabetic patients without anemia. HbA1c levels were measured using high-performance liquid chromatography (HPLC). Plasma glucose levels, hemoglobin, and other hematological parameters were also assessed. Data were analyzed for statistical significance, and the study adhered to strict ethical guidelines, ensuring patient privacy and informed consent throughout the process.

The results revealed that HbA1c levels were significantly higher in diabetic patients with anemia compared to those without anemia, despite similar plasma glucose levels. This suggests that anemia, particularly IDA, may lead to elevated HbA1c values due to the prolonged lifespan of red blood cells, allowing for increased hemoglobin glycation. These findings align with previous studies and highlight the need for caution when interpreting HbA1c in anemic patients.

The study emphasizes the importance of integrating anemia screening into routine diabetes management protocols. It recommends using additional glycemic markers, such as fructosamine or continuous glucose monitoring (CGM), to ensure accurate assessment of glycemic control in anemic patients. Future research should focus on exploring the effects of other types of anemia and evaluating the long-term impact of anemia correction on HbA1c levels. Overall, the study emphasizes the need for a comprehensive approach to diabetes care that accounts for anemia’s influence on Hb.

This study demonstrates that anemia, particularly iron deficiency anemia (IDA), significantly impacts glycated hemoglobin (HbA1c) levels in diabetic patients, leading to potentially misleading assessments of glycemic control. Elevated HbA1c levels in anemic patients, despite similar plasma glucose levels, highlight the need for caution when using HbA1c as the sole marker for monitoring diabetes in such populations. The prolonged lifespan of red blood cells in IDA, which allows for increased glycation of hemoglobin, is a key factor contributing to this phenomenon.

The findings emphasize the necessity of integrating anemia screening into diabetes care protocols. Misclassification of glycemic control in anemic patients may result in overtreatment or under treatment, adversely affecting patient outcomes. By identifying and correcting anemia, clinicians can improve the accuracy of HbA1c interpretation, ensuring more precise diabetes management. The study also highlights the need for alternative or supplementary glycemic markers, such as fructoamine or continuous glucose monitoring (CGM), to overcome the limitations of HbA1c in anemic patients.

In conclusion, addressing the confounding effects of anemia on HbA1c interpretation is essential for optimizing diabetes care. By implementing these recommendations, clinicians can achieve more accurate assessments of glycemic control, ultimately improving outcomes for diabetic patients with coexisting anemia.

Recommendations

Routine anemia screening should be incorporated into diabetes management, especially in regions with a high prevalence of nutritional deficiencies.

HbA1c values should be interpreted cautiously in anemic patients, with concurrent use of direct glucose measurements (e.g., fasting or post-prandial plasma glucose) for confirmation.

Research should focus on developing and validating alternative glycemic markers for populations affected by anemia.

Future studies should explore the effects of correcting anemia on HbA1c levels over time, providing insights into its dynamic relationship with glycemic control.

Comprehensive training for healthcare professionals on the influence of anemia on HbA1c can further improve clinical decision-making.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

REFERENCES

1. Urrechaga E. Influence of iron deficiency on Hb A1c levels in type 2 diabetic patients. Diabetes Metab Syndr. 2018;12(6):1051-5.
2. Sharda M, Gandhi N, Bansal D, Gadhwal M. Correlation of anemia with glycated hemoglobin among euglycemic type 2 diabetic patients. J Assoc Phys India. 2023;71(3):11-2.
3. Guo W, Zhou Q, Jia Y, Xu J. Increased levels of glycated hemoglobin A1c and iron deficiency anemia: a review. Med Sci Monit. 2019;25:8371-8.
4. Shanthi B, Revathy C, Manjula Devi AJ, Subhashree. Effect of iron deficiency on glycation of haemoglobin in nondiabetics. J Clin Diagn Res. 2013;7(1):15-7.
5. Zhang J, Zhang Z, Zhang K, Ge X, Sun R, Zhai X. Early detection of type 2 diabetes risk: limitations of current diagnostic criteria. Front Endocrinol. 2023;14:1260623.

6. Verma S, Sheikh S. Prevalence of anaemia and its correlation with glycosylated haemoglobin among patients with type 2 diabetes mellitus: an observational study. Int J Adv Med. 2021;8:800-3.
7. Rajagopal L, Ganapathy S, Arunachalam S, Raja V, Ramraj B. Does iron deficiency anaemia and its severity influence HbA1C level in non diabetics? An analysis of 150 cases. J Clin Diagn Res. 2017;11(2):EC13.
8. American Diabetes Association: 2. Classification and Diagnosis of Diabetes: Standards of medical care in diabetes- 2018. Diabetes Care. 2018;41:S13-27.
9. Lee J, Lee YA, Kim JH, Lee SY, Shin CH, Yang SW. Discrepancies between glycosylated hemoglobin and fasting plasma glucose for diagnosing impaired fasting glucose and diabetes mellitus in Korean Youth and Young Adults. Diabetes Metab J. 2019;43(2):174-82.
10. Chan CL, Pyle L, Kelsey MM, Newnes L, Baumgartner A, Zeitler PS, Nadeau KJ. Alternate glycemic markers reflect glycemic variability in continuous glucose monitoring in youth with prediabetes and type 2 diabetes. Pediatr Diabetes. 2017;18(7):629-36.
11. Katwal PC, Jirjees S, Htun ZM, Aldawudi I, Khan S. The effect of anemia and the goal of optimal HbA1c control in diabetes and non-diabetes. Cureus. 2020;12(6):e8431.
12. Christy AL, Manjrekar PA, Babu RP, Hegde A, Rukmini MS. Influence of iron deficiency anemia on hemoglobin A1c levels in diabetic individuals with controlled plasma glucose levels. Iran Biomed J. 2014;18(2):88-93.
13. Alzahrani BA, Salamatullah HK, Alsharm FS, Baljoon JM, Abukhodair AO, Ahmed ME, et al. The effect of different types of anemia on HbA1c levels in non-diabetics. BMC Endocr Disord. 2023;23(1):24.

Cite this article as: Ramalinga VK, Elicherla Y, Reddy ARK. Influence of anemia on levels of glycosylated hemoglobin/HbA1C. Int J Res Med Sci 2026;14:4441-50.