

Original Research Article

Prevalence of anemia among type 2 diabetic patients and its correlation with dietary habits in diabetic center in Taif City-Saudi Arabia

Hamzah M. Alzahrani*, Khaled M. Alshehri, Raghad A. Algorshi, Rhaghda M. Alofi, Abdulaziz J. Al-zahrani, Mohammed Q. Althubaiti, Khalid Mohammed Ali Alshehri

Department of Diabetes, Prince Mansour Military Hospital, Taif City, Makkah, Saudi Arabia

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*Correspondence:

Dr. Hamzah M. Alzahrani,

E-mail: hamzah89yy@gmail.com

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ABSTRACT

Background: People who have diabetes express nutrient deficiencies that can cause anemia. Nutrient deficiencies can be caused by either not eating enough nutrients or by the body's inability to absorb the nutrients that are eaten. This study aims to assess the prevalence and predictors of anemia among type 2 diabetic (T2DM) patients in Saudi Arabia.

Methods: An interview validated questionnaire was used for data collection. It included socio-demographic data; inquiry about exercise, smoking status, past medical history of chronic problems, anemia, anemia symptoms, family history of anemia and consanguinity. In addition, assessment of the dietary habits using 12 questions, anthropometric measurements and hemoglobin (Hb) concentration were done.

Results: A total of 288 patients were included. Males accounted 55.6% of them and 47.5% aged over 60 years. The prevalence of anemia was 21.9%. Multivariate logistic regression analysis revealed that T2DM patients with income of $\geq 10,000$ Saudi Riyals/month were at lower significant risk compared to those with no formal income to have anemia (aOR=0.028; 95% CI: 0.10-0.80), $p=0.017$. Patients with previous history of anemia were at almost 4-folds risk than those without such history, to have anemia (aOR=4.49; 95% CI: 2.17-9.26), $p<0.001$. Patients with symptoms suggestive of anemia were at almost 5-folds risk than those without such symptoms, to have anemia (aOR=4.80; 95% CI: 2.44-9.46), $p<0.001$.

Conclusions: Anemia is moderately prevailing among T2DM patients in Taif, Saudi Arabia. Determinants of anemia were low income, previous history of anemia and having symptoms suggestive of anemia.

Keywords: Type 2 diabetes, Anemia, Prevalence, Dietary habits

INTRODUCTION

Developing countries are experiencing an upsurge in the prevalence of diabetes, which is associated with a high risk of micro vascular complications.^{1,2}

It is expected that the prevalence of long-term complications of diabetes will increase accordingly due to low awareness of the disease and suboptimal management of those with diagnosed diabetes.^{1,3} A recent meta-analysis revealed an overall pooled prevalence of anemia among

type 2 diabetic (T2DM) adult patients as 27%.⁴ It is more prevalent in under developed countries.⁵

People who have diabetes express nutrient deficiencies that can cause anemia. Nutrient deficiencies can be caused by either not eating enough nutrients (because a person restricts his food choices, for example) or by the body's inability to absorb the nutrients that are eaten. Deficiencies in iron, vitamin B12, vitamin B6, and folate, all of them can cause anemia.⁶

Chronic complications of diabetes are macro vascular like coronary heart diseases and micro vascular like

nephropathy and neuropathy, all of them can contribute to anemia in diabetic patients.⁷

A study conducted in Brazil (2015) revealed that patients with T2DM and anemia were those with high body mass, hypertension, increased waist circumference, and longer time of the disease. This set of changes characterizes the anemia as chronic disease, which has a significant adverse effect on quality of life of diabetic patients.⁸ Another study was done in 2022 that comprised a retrospective study of 622 patients (408 with DM and 214 with pre-DM) and results revealed that 19% with DM and 11% with pre-DM had anemia.⁹ Also, patients with diabetes are unlikely to be concerned about anemia, or to seek information about anemia unless their doctor raises the issue.⁸

In Saudi Arabia, few studies are available regarding the prevalence of anemia among diabetic patients and current guidelines on the management of diabetes do not recommend routine screening for anemia. It's thought that early and appropriate intervention in diabetic patients could decrease the incidence of anemia. So, this study aimed to assess the prevalence and predictors of anemia and its correlation with dietary habits among T2DM patients in Saudi Arabia.

METHODS

A cross-sectional survey was carried out on patients of T2DM of all ages and both genders, who attended diabetic center in Prince Mansour Hospital in Taif city, Western Saudi Arabia throughout the period March-June, 2024. Severely ill and patients with cognitive impairment were excluded

The sample size was calculated by using G power program version 3.1.9.2. After identify average numbers of study population attending diabetic center per month by reviewing the patient's registry of last 3 months. We found that the number of type 2 diabetic patients attending diabetic center in one month was about 1000 patients (population size), with the confidence level at 95% and margin of errors at 5%, so the minimum required sample size was 278 patients. A systematic random sample was carried out to recruit the participants of the study as one patient from every 4 patients from each clinic was randomly select to be inviting to participate and in case of absence or refusal of the patient, the next patient was chosen.

An interview questionnaire was developed by the researchers and validated by three consultants in the field of Diabetes and Family Medicine. It included socio-demographic data (sex, age, residence, marital status, education, occupation and monthly income in Saudi Riyal); inquiry about exercise as each participant was asked about performance of exercises, and if yes, how many times per week and accordingly, participant were classified as physically active if they exercised three or more times per week, and as physically inactive if they did

not exercise, and as intermediately active in those who exercises with frequencies less than three times per week, smoking status (smokers or non-smokers); past medical history of chronic problems, anemia, and anemia symptoms; and family history of anemia and consanguinity.^{10,11} Also, the questionnaire included assessment of the dietary habits as every participants was asked 12 questions regarding their dietary habits, these questions include, information about taking daily breakfast, taking at least three meals every day, taking snacks between meals, eating white bread, drinking whole milk, taking refined sugar products, using margarine, butter, or increasing the intake of fat, preference of eating chicken over lean meat, preference of boiled meals over fried meals, preference of fatty meat over lean meat. The response to each question was either yes or no, and each participant was given a score between zero and twelve according to their response to the twelve questions. They were classified into healthy and non-healthy diet groups as those scored of ≥ 9 were considered as healthy diet group, while those scored less than 9 were considered as non-healthy diet group.¹²

In addition, anthropometric measurements were measured as each studied participant was subjected to height measurement to the nearest 0.5 cm without shoes and weight measurement to the nearest 0.1 kg without shoes and with light clothes and body mass index was calculated as weight in kilogram divided by the square of the height (m^2). Body mass index was classified into four categories: underweight ($\text{BMI} < 18.5 \text{ kg m}^2$), normal ($\text{BMI} = 18.5\text{--}24.9 \text{ kg m}^2$), overweight ($\text{BMI} = 25\text{--}29.9 \text{ kg m}^2$), and obese ($\text{BMI} = 30 \text{ kg m}^2$) or more.

All participants were subjected to be screened for the presence or absence of anemia by doing hemoglobin (Hb) concentration (conc.). Anemia was defined according to hemoglobin distribution after applying the current WHO hemoglobin threshold values adjusted for sex and altitude.¹³

One milliliter (1 ml) of whole venous blood were drawn from every participant and will be put in an ethylene-diamine-tetra-acetic acid (EDTA) tube containing one milligram of EDTA anticoagulant which will be mixed gently by inversion (for Hb concentration). All analyses were done at the same day of collection without preservation of the samples or delay in analysis.

Approval of the research proposal has been obtained from the regional Research and Ethics Committee at Al-Hada Armed Forces Hospital, Taif, Saudi Arabia.

Variables were described using frequency and percentage. Pearson's Chi-square test was adopted in univariate analysis to test for the difference between two categorical variables. Multivariate logistic analysis was performed to control for the effect confounding and its results were expressed as adjusted odds ratio (aOR) and 95% confidence interval (CI). Data analysis was performed

using the statistical package for social sciences (SPSS), version 28 ((SPSS Inc., Chicago, Ill., version 28).

RESULTS

A total of 288 patients were included in the study. Their sociodemographic and habitual characteristics are summarized in Table 1. Males accounted 55.6% of them and 47.5% aged over 60 years. Majority of the participants (88.9%) live inside Taif city and 90.3% were married. Most of them were secondary school/below graduated (75.3%) and not employed (76%). The income of 27.8% of them was 10000 Saudi Riyals/month and over while 35.1% had no formal income. Most of them (59%) never practiced physical exercise and 11.1% were smokers.

Table 1: Sociodemographic and habitual characteristics of the participants (n=288).

Characteristics	Frequency	Percentage
Gender		
Male	160	55.6
Female	128	44.4
Age in years		
20-40	25	8.7
41-60	126	43.8
>60	137	47.5
Place of residence		
Inside Taif city	256	88.9
Outside Taif city	32	11.1
Marital status		
Single	28	9.7
Married	260	90.3
Educational level		
Secondary school/below	217	75.3
University	63	21.9
Postgraduate	8	2.8
Employment status		
Not employed	219	76.0
Employed	69	24.0
Income (Saudi Riyals/month)		
No formal income	101	35.1
<10000	107	37.1
≥10000	80	27.8
Exercise		
Never	170	59.0
1-3 times/week	101	35.1
>3 times/week	17	5.9
Smoking		
No	256	88.9
Yes	32	11.1

Medical profile

As displayed from Table 2, duration of diabetes exceeded 10 years in 55.2% of patients. Almost half of them (50.6%) were treated with oral hypoglycemics whereas 42.1% were

treated with a combination of oral hypoglycemics and insulin. Use of metformin was reported among majority (89.9%) of patients.

Diabetic complications, family history of type 2 diabetes and previous history of anemia were observed among 44.4%, 79.5% and 29.5% of patients, respectively.

Having symptoms suggestive of anemia, history of other chronic diseases and family history of anemia were reported among 31.6%, 65.3% and 32.6% of patients, respectively.

Table 2: Medical characteristics of the participants (n=288).

Characteristics	Frequency	Percentage
Duration of diabetes (years)		
<5	50	17.4
6-10	79	27.4
>10	159	55.2
Diabetic therapy		
Oral hypoglycemics	146	50.6
Insulin	18	6.3
Both	124	42.1
Use of metformin		
No	29	10.1
Yes	259	89.9
Diabetic complications		
No	160	55.6
Yes	128	44.4
Family history of type 2 diabetes		
No	59	20.5
Yes	229	79.5
Previous history of anemia		
No	202	70.1
Yes	85	29.5
Having symptoms suggestive of anemia		
No	197	68.4
Yes	91	31.6
History of other chronic diseases		
No	100	34.7
Yes	188	65.3
Family history of anemia		
No	194	67.4
Yes	94	32.6

Dietary habits

Healthy dietary habit was observed among only 22.6% of the patients as illustrated in Figure 1.

Prevalence of anemia

Based on the WHO hemoglobin threshold values adjusted for sex and altitude, the prevalence of anemia was 21.9% as illustrated in Figure 2.

Factors associated with anemia**Univariate analysis**

Female T2DM patients were more likely than males to have anemia (31.3% versus 14.4%), $p=0.001$. Single patients were more likely than married patients to develop anemia (39.3% versus 20%), $p=0.019$. Not employed patients were more likely than employed patients to have anemia (25.1% versus 11.6%), $p=0.018$. Patients with

monthly income ≥ 10000 Riyals were less likely than those with no formal income to have anemia (7.5% versus 34.7%), $p<0.001$. T2DM patients with previous history of anemia were more likely than their peers to suffer from anemia (49.4% versus 10.4%), $p<0.001$. Also patients who reported symptoms suggestive of anemia had higher probability to develop anemia (47.3% versus 10.2%), $p<0.001$. Patients with positive family history of anemia were more likely than their counterparts to have anemia (31.9% versus 17%), $p=0.004$ (Table 3).

Table 3: Factors associated with anemia among type 2 diabetic patients: univariate analysis (n=288).

Characteristics	Anemia		P value*
	No (n=225), N (%)	Yes (n=63), N (%)	
Gender			
Male (n=160)	137 (85.6)	23 (14.4)	0.001
Female (n=128)	88 (68.8)	40 (31.3)	
Age in years			
20-40 (n=25)	18 (72.0)	7 (28.0)	0.093
41-60 (n=126)	106 (84.1)	20 (15.9)	
>60 (n=137)	101 (73.7)	36 (26.3)	
Place of residence			
Inside Taif city (n=256)	201 (78.5)	55 (21.5)	0.650
Outside Taif city (n=32)	24 (75.0)	8 (25.0)	
Marital status			
Single (n=28)	17 (60.7)	11 (39.3)	0.019
Married (n=260)	208 (80.0)	52 (20.0)	
Educational level			
Secondary school/ below (n=217)	168 (77.4)	49 (22.6)	0.817
University (n=63)	51 (81.0)	12 (19.0)	
Postgraduate (n=8)	6 (75.0)	2 (25.0)	
Employment status			
Not employed (n=219)	164 (74.9)	55 (25.1)	0.018
Employed (n=69)	61 (88.4)	8 (11.6)	
Income (Saudi Riyals/month)			
No formal income (n=101)	66 (65.3)	35 (34.7)	<0.001
<10000 (n=107)	85 (79.4)	22 (20.6)	
≥10000 (n=80)	74 (92.5)	6 (7.5)	
Exercise			
Never (n=170)	127 (74.7)	43 (25.3)	0.207
1-3 times/week (n=101)	83 (82.2)	18 (17.8)	
>3 times/week (n=17)	15 (88.2)	2 (11.8)	
Smoking			
No (n=256)	199 (77.7)	57 (22.3)	0.650
Yes (n=32)	26 (81.2)	6 (18.8)	
Body mass index			
Underweight (n=2)	1 (50.0)	1 (50.0)	0.110
Normal (n=37)	33 (89.2)	4 (10.8)	
Overweight (n=108)	88 (81.5)	20 (18.5)	
Obese (n=140)	103 (73.6)	37 (26.4)	
Duration of diabetes (years)			
<5 (n=50)	38 (76.0)	12 (24.0)	0.392
6-10 (n=79)	66 (83.5)	13 (16.5)	
>10 (n=159)	121 (76.1)	38 (23.9)	

Continued.

Characteristics	Anemia		P value*
	No (n=225), N (%)	Yes (n=63), N (%)	
Diabetic therapy			
Oral hypoglycemics (n=146)	120 (82.2)	26 (17.8)	0.218
Insulin (n=18)	14 (77.8)	4 (22.2)	
Both (n=128)	91 (73.4)	33 (26.6)	
Use of metformin			
No (n=28)	19 (67.9)	9 (32.1)	0.218
Yes (n=259)	205 (79.2)	54 (20.8)	
Diabetic complications			
No (n=160)	131 (81.9)	29 (18.1)	0.085
Yes (n=128)	94 (73.2)	34 (26.6)	
Family history of type 2 diabetes			
No (n=59)	45 (76.3)	14 (23.7)	0.699
Yes (n=229)	180 (78.6)	49 (21.4)	
Previous history of anemia			
No (n=202)	181 (89.6)	21 (10.4)	<0.001
Yes (n=85)	43 (50.6)	42 (49.4)	
Having symptoms suggestive of anemia			
No (n=197)	177 (89.8)	20 (10.2)	<0.001
Yes (n=91)	48 (52.7)	13 (47.3)	
History of other chronic diseases			
No (n=99)	81 (81.8)	18 (18.2)	0.263
Yes (n=188)	143 (76.1)	45 (23.9)	
Family history of anemia			
No (n=194)	161 (83.0)	33 (17.0)	0.004
Yes (n=94)	64 (68.1)	30 (31.9)	
Level of glycosylated hemoglobin (%)			
<7 (n=85)	73 (85.9)	12 (14.1)	0.120
7-10 (n=167)	125 (74.9)	42 (25.1)	
>10 (n=36)	27 (75.0)	9 (25.0)	
Dietary habits			
Non healthy (n=223)	170 (76.2)	53 (23.8)	0.150
Healthy (n=65)	55 (84.6)	10 (15.8)	

*Pearson's Chi-square test

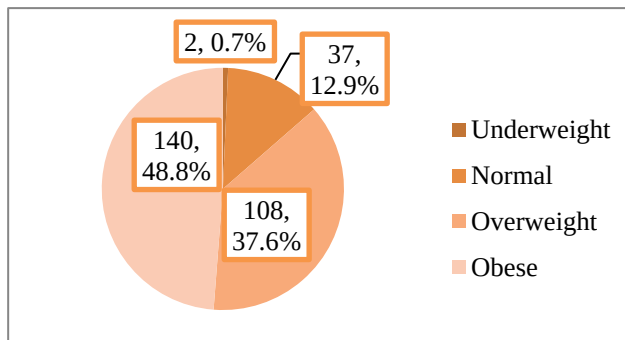


Figure 1: Body mass index of the participants.

Multivariate analysis

Multivariate logistic regression analysis revealed that T2DM patients with income of $\geq 10,000$ Saudi Riyals/month were at lower significant risk compared to those with no formal income to have anemia (aOR=0.028; 95% CI: 0.10-0.80), $p=0.017$. Patients with previous history of anemia were at almost 4-folds risk than those without such history, to have anemia (aOR=4.49; 95% CI:

2.17-9.26), $p<0.001$. Patients with symptoms suggestive of anemia were at almost 5-folds risk than those without such symptoms, to have anemia (aOR=4.80; 95% CI: 2.44-9.46), $p<0.001$. Patients' gender, marital status, employment status, and family history of anemia were not significantly associated with development of anemia, after controlling for the effect of confounding (Table 4).

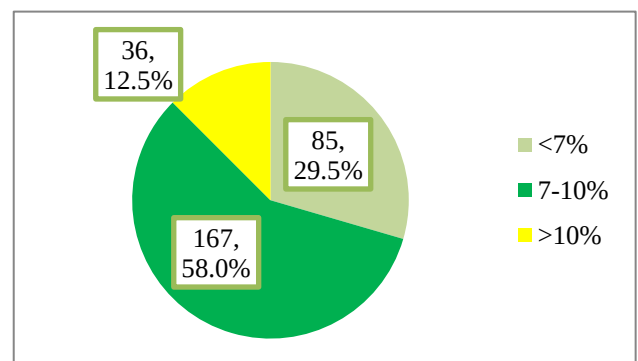
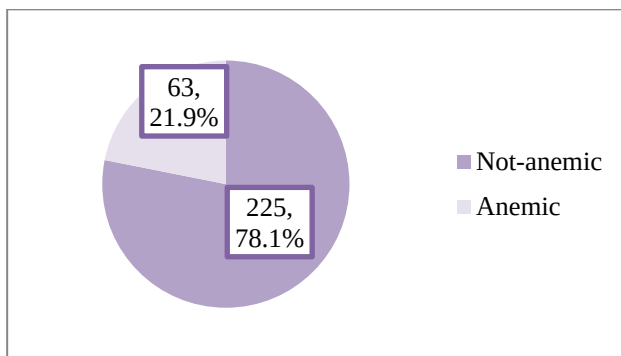
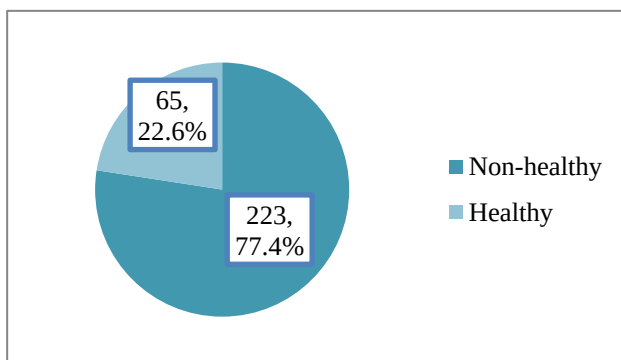


Figure 2: Distribution of the level of glycosylated hemoglobin among the participants.

Table 4: Predictors of anemia among type 2 diabetic patients: results of multivariate logistic regression analysis.

Variables	aOR	95% CI	P value
Income (Saudi Riyals/month)			
No formal income ^a	1.0	---	
<10000	0.84	0.39-1.82	0.666
≥10000	0.28	0.10-0.80	0.017
Previous history of anemia			
No ^a	1.0	---	
Yes	4.49	2.17-9.26	<0.001
Having symptoms suggestive of anemia			
No ^a	1.0	---	
Yes	4.80	2.44-9.46	<0.001

^aReference category, aOR: adjusted odds ratio, CI: confidence interval. Variables of gender, marital status, employment status, and family history of anemia were not significant and thus removed from the results of the final model

**Figure 3: Prevalence of anemia among type 2 diabetic patients.****Figure 4: Distribution of the participants according to their dietary habits.**

DISCUSSION

Although anemia is a relatively common problem among adults with type 2 diabetes and it further carries great risk for them in the form of progression of vascular diabetic complications and increase in the mortality rate, the study of its actual prevalence as well as determinants is lacking in many parts of the world, including Saudi Arabia.¹⁴⁻¹⁶

Thus, this study was conducted to estimate the magnitude and define the determinants of anemia among adults with T2DM in Taif city, Western Saudi Arabia.

Prevalence of anemia, based on the WHO hemoglobin threshold values adjusted for sex and altitude was 21.9% in the current study, which indicated that anemia is a moderate public health problem among those patients.¹³ Various figures were reported in other similar studies. In a recent published systematic review and meta-analysis study included 24 studies with almost 19 thousand patients, the overall pooled prevalence of anemia among T2DM adult patients was 27% (95% CI: 24-31%).⁴ In another recent systematic review and meta-analysis including 51 articles and approximately 26 thousand patients, the overall prevalence of anemia was 35.45% (95% CI: 30.3–40.8).¹⁷

Compared to our figure, other similar studies conducted in Africa reported figures ranged between 22.1% and 35%; indicated that anemia is a moderate public health problem in adults with diabetes.¹⁸⁻²⁰ In Sri Lanka (2024), a rate of 31.3% has been reported.²¹ Regarding our region, a prevalence of 29.7% has been reported in Kuwait (2018).²² However, lower figure has been reported in Ethiopia (8.1%), while higher figures have been reported in India (60%).^{23,24}

Generally speaking, the higher prevalence of anaemia in T2DM patients compared to those without this disease could be due to the inflammatory effect and anti-erythropoietic impacts of diabetes.²⁵

In agreement with results of other similar studies, the present study showed an association between the monthly income and anemia.^{17,26-28}

The results of the present study revealed that previous history of anemia and having symptoms suggestive of anemia were associated with higher prevalence of anemia among T2DM patients. These findings are quite expected. However, we did not find similar findings in cited studies conducted elsewhere.

The univariate analysis of the present study showed predominance of anemia in female than in male patients; although this disappeared in multivariate analysis after controlling for confounders. Some other studies reported that female T2DM patients were more likely to develop anemia than males.^{21,22,24} This could be attributed to factors such as insufficient nutrition, menstrual blood loss, and lack of self-care among female.

The bone marrow's erythrocyte precursors in uncontrolled diabetes are exposed to prolonged glucose toxicity, leading to dysfunction of erythrocytes, which may lead to development of anemia.^{29,30} This may contribute to the development of anaemia.²³ Some studies reported more prevalence of anemia in poorly controlled patients than those with controlled glycemic status.^{21,22,24} However, the

present study didn't find an association between glycemic control and anemia.

In contrast to many other studies, the present study failed to find an association between diabetic micro-vascular complications and anemia.^{4,23,31,32}

Although the effect of dietary habits was investigated extensively in the present study, we didn't confirm its association with the development of anemia. Thus, in-depth study of the dietary habits of T2DM patients should be investigated in further studies by a multi-disciplinary team including nutritionists.

Limitations

Important limitations of the present study should be acknowledged. First, being a single center study could limit the generalizability of its results over other centers. Second, some important factors were not included in the present study such as medication adherence. Moreover, using a cross-sectional study design in this study doesn't allow investigation of the cause and effect relationship of risk factors and anaemia.

CONCLUSION

Anemia is moderately prevailing among T2DM patients in Taif, Saudi Arabia. Determinants of anemia among those patients were low income, previous history of anemia and having symptoms suggestive of anemia. Therefore, it is essential to include screening for anemia into the routine assessment of diabetes-related complications. Design of preventive strategies to reduce the burden of anemia among T2DM patients is needed. Further multi-centric study investigating in-depth the factors associated with anemia is warranted.

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Conflict of interest: None declared

Ethical approval: The study was approved by the Institutional Ethics Committee

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