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PREDIABETES AMONG MEDICAL PERSONAL AGE 25-40 YEARS IN IMAM AL-HASSAN AL-MUJTABA TEACHING HOSPITAL IN KARBALA/IRAQ

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ABSTRACT
Prediabetes is a transitional condition of glucose regulation in which plasma glucose levels are elevated, yet remains below the diagnostic criteria for diabetes. This study aimed to identify the prevalence of prediabetes risk within the sample and to evaluate the risk factors associated with prediabetes among medical professionals aged 25 to 40 years at AL Imam Al Hassan Al-Mujtaba Teaching Hospital. A cross-sectional study was adopted among participants not known to have diabetes, doctors, and pharmacists in the hospital. The study consisted of three parts: the first elicited sociodemographic characteristics; the second included questions about weight, height for body mass index (BMI) assessment, smoking status, adherence to a weight loss plan, medication usage, dietary compliance, and personal and familial medical history; and the third covered opinions on lifestyle and physical activity. A total of 116 medical workers or personnel were included, of whom 71 (61.2%) were female and 21 (18.1%) were prediabetic. High Body Mass Index, a positive family history of diabetes mellitus, increasing age, being a smoker, and male sex were statistically associated with high HbA1c levels. In conclusion, prediabetes is associated with high Body Mass Index, increasing age, a positive family history of diabetes mellitus, male sex, and smoking. Obesity was prevalent among the sample, and there was a positive correlation between HbA1c level and BMI as well as increasing age.

KEYWORDS: Glycated Hemoglobin; Metabolic Risk; Healthcare Professionals; Obesity; Lifestyle Factors.

INTRODUCTION
Diabetes mellitus is a major global public health problem with a steadily increasing prevalence and is often described as an iceberg phenomenon, whereby diagnosed cases represent only a small proportion of the total disease burden, while a much larger number of individuals remain undiagnosed with diabetes or prediabetes. Delayed diagnosis contributes to the development of serious microvascular and macrovascular complications, including retinopathy, nephropathy, neuropathy, and cardiovascular disease, highlighting the importance of early identification through screening and surveillance of high-risk populations.[1]

Prediabetes is an intermediate state of glucose dysregulation characterized by blood glucose levels above normal but below the diagnostic threshold for diabetes. It can be identified using fasting plasma glucose (FPG), the 2-hour plasma glucose value during an oral glucose tolerance test (OGTT), or glycated hemoglobin (HbA1c), although diagnostic criteria differ slightly between the American Diabetes Association (ADA) and the World Health Organization (WHO).[2]

Prediabetes shares the same major risk factors as type 2 diabetes mellitus, including obesity, physical inactivity, hypertension, dyslipidemia, increasing age, family history, genetic predisposition, and certain ethnic backgrounds, including populations from the Middle East.[3]

Although prediabetes is associated with an increased risk of progression to type 2 diabetes, this progression is not inevitable. Strong evidence from large prevention trials has demonstrated that lifestyle interventions, including weight reduction, healthy dietary patterns, and regular physical activity, can significantly delay or prevent the onset of diabetes.[4] Pharmacological therapy, particularly metformin, has also shown benefit in selected high-risk individuals, especially those with obesity and elevated fasting plasma glucose.[5] Furthermore, bariatric surgery has demonstrated favorable effects on glucose metabolism and diabetes remission among obese patients.[6]

Current international guidelines recommend screening adults aged 35 years and older, as well as younger individuals with overweight or obesity who possess additional risk factors. Individuals diagnosed with prediabetes require regular follow-up to facilitate early intervention and reduce the risk of disease progression and long-term complications.[7] However, despite the increasing burden of diabetes and prediabetes worldwide, there is a paucity of epidemiological data from Iraq regarding the prevalence of prediabetes, associated risk factors, and the effectiveness of current screening practices. Most available evidence originates from high-income countries, limiting its applicability to the Iraqi population, where demographic characteristics, lifestyle factors, and healthcare resources differ substantially.[8]

This lack of locally generated evidence represents an important knowledge gap that hinders the development of targeted prevention strategies and evidence-based public health policies. Therefore, the present study was undertaken to investigate prediabetes and its associated risk factors in the Iraqi population, thereby providing local evidence to support early detection, preventive interventions, and healthcare planning.[9]

The A1C indicates the percentage of glycosylation of the HbA1c chain and predicts average blood glucose levels during the preceding two to three months due to the gradual turnover of red blood cells in the body.[10] The HbA1c test was incorporated into the American diabetic association (ADA) recommendations as a diagnostic criterion for diabetes in 2010. Although attempts to standardize laboratory procedures, HbA1c testing has inherent limitations and exhibits an insufficient association between HbA1c levels and average glucose levels in specific individuals. Hemolytic anemias and rapid blood loss can inaccurately reduce HbA1c values, while previous splenectomy and aplastic anemias, which prolong erythrocyte lifespan, can wrongly increase HbA1c levels. Hemoglobinopathies or hemoglobin variations can lead to fluctuations in HbA1c levels and may be more common in specific racial and ethnic populations.[11]

Current evidence demonstrates that prediabetes is a reversible condition and that early detection through appropriate screening, combined with lifestyle modification and, when indicated, pharmacological intervention can substantially reduce the progression to type 2 diabetes and its associated complications.[12] Consequently, international organizations recommend risk-based screening and regular follow-up for individuals with prediabetes to improve long-term health outcomes.[7] However, despite the growing burden of diabetes in Iraq, there is a marked lack of comprehensive epidemiological studies evaluating the prevalence of prediabetes, its associated risk factors, and the implementation of screening strategies within the Iraqi population.[8] This scarcity of local evidence limits the ability of healthcare providers and policymakers to develop evidence-based screening programs, prioritize high-risk groups, and implement effective preventive interventions tailored to the Iraqi healthcare setting. Therefore, this study was conducted to determine the prevalence of prediabetes and identify its associated risk factors among the Iraqi population, with the aim of generating local evidence to support early detection, guide preventive strategies, and inform future public health policies for diabetes prevention.[9]

This study aims to investigate the burden of glycemic dysregulation among healthcare personnel by identifying the prevalence of prediabetes risk within the target population. Furthermore, it seeks to evaluate the underlying metabolic, clinical, and lifestyle risk factors associated with prediabetes among young medical professionals aged 25 to 40 years practicing at Al-Imam Al-Hassan Al-Mujtaba Teaching Hospital, thereby providing a foundational framework for targeted institutional wellness strategies.

PATIENTS AND METHODS

Study Design and Setting

A hospital-based, cross-sectional study was conducted to evaluate prediabetes screening parameters and health-related behaviors among healthcare professionals. The study was carried out at Al-Imam Al-Hassan Al-Mujtaba Teaching Hospital in Karbala, Iraq. Data collection spanned a five-month period from March 1, 2025, to August 1, 2025.

Participant Selection and Eligibility Criteria

The target population comprised active medical doctors and pharmacists working within the facility. A convenient sampling technique was utilized for recruitment. Out of 121 healthcare workers invited to participate, 5 declined initial enrollment, resulting in a final sample size of 116 participants (95.9% response rate).

To ensure data integrity regarding glycemic profiles, strict eligibility criteria were applied.

- **Inclusion Criteria:** Apparently healthy medical professionals (doctors and pharmacists) aged 25 to 40 years who provided informed consent.
- **Exclusion Criteria:** Individuals with a prior diagnosis or medical history of Type 1 or Type 2 Diabetes Mellitus; pregnant individuals; and any participant presenting with clinical conditions or medical records indicative of disorders known to interfere with Hemoglobin A1c (HbA1c) measurements. Healthcare workers who were unable to complete the survey due to administrative duties, time constraints, or refusal of the phlebotomy component were also excluded.

Study Instrument and Language Validation

Data collection was facilitated via a modified version of the Finnish Diabetes Association survey, adapted to evaluate prediabetes screening. Content and face validity were verified through an expert review by a senior clinical consultant.

For linguistic validation, the instrument underwent a forward-translation process from English to Arabic, followed by an independent back-translation to English via automated linguistic tools to ensure semantic equivalence. The final tool was distributed manually by hand. Each questionnaire featured a standardized cover letter detailing the research objectives, institutional affiliations, and an explicit clause requesting permission for subsequent venous blood sampling.

The self-administered questionnaire comprised three distinct thematic sections.

- **Part One (Socio-demographics):** Documented age, biological sex, educational attainment, professional role, and marital status.
- **Part Two (Anthropometrics and Clinical History):** Gathered measured height and weight data, smoking status, active engagement in weight reduction programs, current medications, and dietary adherence. It also screened for personal and familial histories of cardiovascular disease, essential hypertension, and diabetes mellitus.
- **Part Three (Behavioral and Lifestyle Habits):** Assessed physical activity, daily walking habits, and consumption patterns of fruits, vegetables, fast foods, and sugar-sweetened beverages.
  Study design and methodology summarized in below figure.

Anthropometric and Biochemical Assessments

Body Mass Index (BMI)

Anthropometric measurements were taken using calibrated mechanical scales and stadiometers. Participants were weighed in light clothing without shoes. Height was recorded to the nearest centimeter. BMI was calculated using the standard formula.

$$\text{BMI} = \frac{\text{Weight (kg)}}{\text{Height (m)}^2}$$

Nutritional status categories were defined according to the World Health Organization (WHO) diagnostic thresholds.

- **Underweight:** (< 18.5 Kg/m^2)
- **Healthy Range:** (18.5 to 24.9 Kg/m^2)
- **Overweight:** (25.0 to 29.9 Kg/m^2)
- **Obesity:** (30.0 to 39.9 Kg/m^2)
- **Morbid Obesity:** (≥ 40.0 Kg/m^2)

Glycated Hemoglobin (HbA1c) Testing

Following survey completion, a (2 cc) venous blood sample was drawn from the antecubital fossa of consenting participants using standardized disposable syringes and collection tubes. To preserve sample stability, specimens were immediately stored in cold-chain transport containers (ice flasks) and transferred to an external certified laboratory facility in Karbala.

Biochemical analysis of HbA1c levels was performed via Electrochemiluminescence (ECL) immunoassay technology using a calibrated Roche e411 analyzer. In accordance with established clinical guidelines, an HbA1c threshold between (≥ 5.7% -< 6.5%) in individuals not receiving antihyperglycemic therapies was considered diagnostic for prediabetes.

Scoring Matrix for Behavioral Variables

To quantify health-related behaviors from Part Three of the survey, a 4-point Likert scale was instituted. Categorical responses were coded as: *Never* = 1, *Rarely* = 2, *Sometimes* = 3, and *Always* = 4.

For each individual behavioral metric, a mean score was computed. To standardize reporting, these mean scores were converted into percentage scores using the following linear transformation.

$$\text{Standardized Score } (\%) = \left(\frac{\text{Item Mean Score}}{4}\right) \times 100$$

Pilot Evaluation: A pilot study involving 10 healthcare workers was executed in March 2025 to verify logistical feasibility, establish cognitive clarity of the modified items, and determine survey completion time. The average administration time was determined to be approximately 5 minutes. Minor syntax adjustments were integrated into the final questionnaire based on pilot feedback; pilot data were excluded from the definitive statistical analysis.

Ethical and Administrative Considerations: Administrative clearance and ethical approvals were granted by the Arab Board for Health Specializations (Family Medicine curriculum), the Training and Human Development Center at the Karbala Health Directorate, and the institutional review board of Al-Imam Al-Hassan Teaching Hospital. Informative verbal consent was secured from each participant prior to enrollment. To protect participant privacy and maintain data confidentiality, questionnaires were completed in isolation, data anonymity was maintained throughout parsing, and all datasets were secured using alphanumeric codes.

Statistical Analysis
Statistical processing was conducted using SPSS software (Version 21.0 for Windows; IBM Corp., Armonk, NY, USA). Data normality was evaluated using the Kolmogorov-Smirnov test. Nominal and categorical metrics are reported as absolute frequencies and percentages. Continuous numerical data are expressed as means standard deviations.

Bivariate associations between categorical variables were analyzed using the Pearson Chi-square test. Group differences for continuous variables across binary outcomes were assessed using Student's independent t-test. To characterize non-linear continuous relationships between age, BMI, and HbA1c values, non-parametric curve-fitting via quadratic regression correlation models was implemented. Statistical significance for all tests was set a priori at a (p)-value (<0.05).

RESULTS

Table 1 presents the baseline demographic and anthropometric characteristics of the 116 healthcare professionals included in the study. All participants were aged between 25 and 40 years, with a mean age of **31.19 ± 4.42 years**. Females constituted the majority of the study population (**71, 61.2%**), while males accounted for **45 (38.8%)** participants. Regarding professional background, **63 (54.3%)** were physicians and **53 (45.7%)** were pharmacists. Among physicians, the largest proportion were **postgraduate students (31, 49.2%)**, followed by those holding a **senior diploma (23, 36.5%)**, whereas **junior residents/general practitioners** represented **9 (14.3%)**. Among pharmacists, **33 (62.3%)** were general practitioners and **20 (37.7%)** were junior residents.

With respect to marital status, the majority of participants were **married (81, 69.8%)**, followed by **single individuals (33, 28.4%)**, while only **2 (1.8%)** were separated or divorced. The mean body mass index (BMI) was **27.38 ± 4.85 kg/m²** (95% CI: **26.58–28.29 kg/m²**), indicating that, on average, participants were within the overweight range. BMI classification further demonstrated that **75 (64.7%)** participants were **overweight or obese**, **40 (34.5%)** had **normal weight**, and only **1 (0.9%)** participant was **underweighted**. Overall, the study cohort was predominantly composed of female healthcare professionals, with a high proportion of postgraduate physicians and a substantial prevalence of overweight and obesity.

Table 1: Sociodemographic and Clinical Characteristics of Participants.

Characteristics	Categories	Frequency	Percentage (%)
Age (years)	25–40	116	100.0
	Mean ± SD	31.19 ± 4.42	
Sex	Female	71	61.2
	Male	45	38.8
Education	Physicians	63	54.3
	Pharmacists	53	45.7
Level of Doctors' Education	Junior Resident / General Practitioner	9	14.3
	Senior / Diploma	23	36.5
	Postgraduate Student	31	49.2
Level of Pharmacists' Education	Junior Resident	20	37.7
	General Practitioner	33	62.3
Marital Status	Married	81	69.8
	Single	33	28.4
	Separated / Divorced	2	1.8
BMI (kg/m^2)	Mean ± SD	27.38 ± 4.85	
	95% Confidence Interval (CI)	26.58 – 28.29	
BMI Classification	Underweight	1	0.9
	Normal Weight	40	34.5
	Overweight / Obese	75	64.7

Regarding physical activity, 35.3% of participants reported rarely exercising regularly, 30.2% exercised **sometimes**, **26.7%** exercised **always**, while only **7.8%**reported **never** exercising. Similarly, daily walking was relatively uncommon, with nearly half of the participants (**48.3%**) reporting that they **rarely** walked daily to stay active, whereas **21.5%** did so **sometimes**, **13.8% always**, and **16.4% never**.

Dietary habits indicated suboptimal consumption of healthy foods. More than half of the participants (**51.7%**) **rarely** consumed fruits and vegetables daily, while **40.5%** reported **never** consuming them on a daily basis. Only **6.9%** consumed fruits and vegetables **sometimes**, and **0.9%** reported doing so **always**. Regarding the consumption of rich or fatty traditional foods, the majority (**53.4%**) reported **rarely** consuming such foods, followed by **27.6%** who consumed them **sometimes**, **14.7%** who **never** consumed them, and **4.3%** who consumed them **always**. Consumption of sugar-sweetened beverages was also common among participants. Approximately **38.8%** reported **rarely** drinking sweetened juices or soft drinks daily, while **37.9%** consumed them **sometimes**. In contrast, **12.1%** reported **never** consuming these beverages, whereas **11.2%** reported consuming them **always**. Overall, the findings suggest relatively low levels of regular physical activity and daily fruit and vegetable intake among the participants, alongside moderate consumption of high-fat traditional foods and sugar-sweetened beverages as presented in Figure 1.

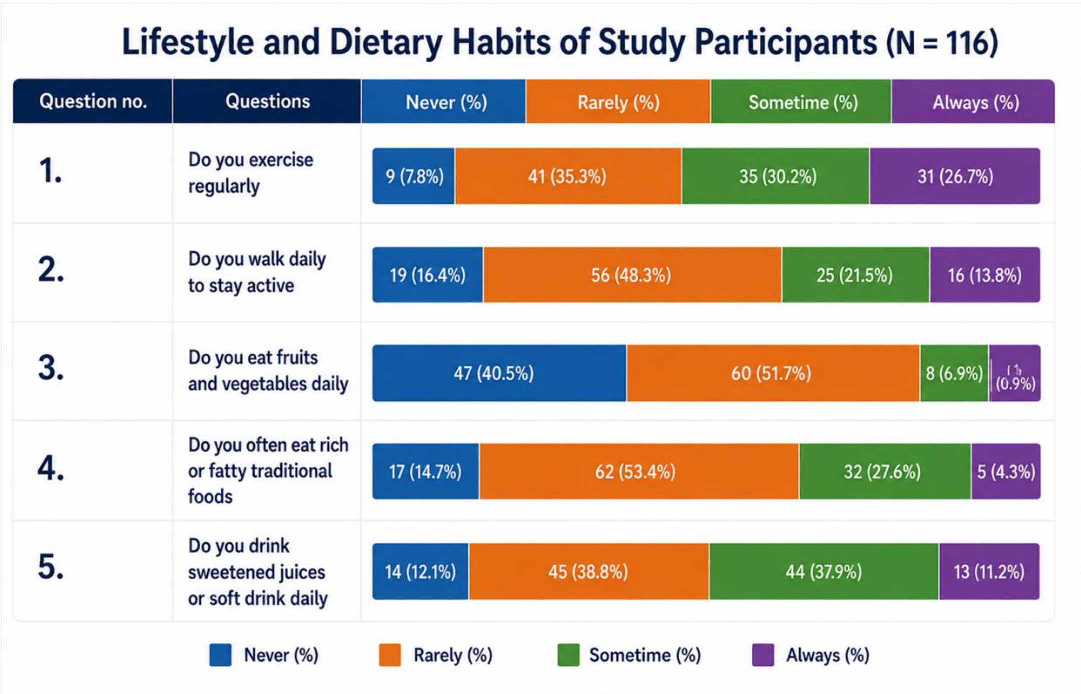

Figure 1: Participant Responses to Lifestyle and Dietary Habits, data presented by No.(%).

Overall, the findings demonstrate that although most participants had normal glycemic status, nearly one-fifth exhibited elevated HbA1c values suggestive of prediabetes despite having no previous diagnosis of diabetes. This proportion highlights the presence of undetected dysglycemia among healthcare professionals and supports the importance of routine HbA1c screening for early identification of individuals at increased risk of developing type 2 diabetes mellitus as presented in Figure 2.

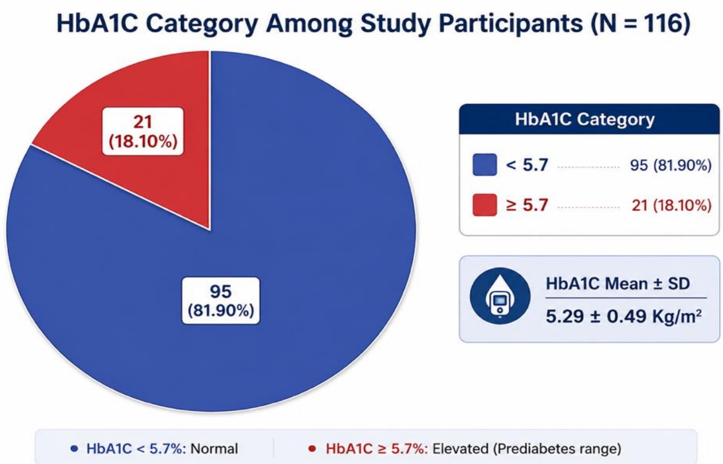

Figure 2: Distribution of Research Participants by HbA1c Category (<5.7 vs. ≥5.7).

Table 2 presents the association between selected demographic characteristics, family history, and HbA1c categories among the study participants. A statistically significant association was observed between **sex** and HbA1c status (**p = 0.004**). Among male participants, **31.1%** had HbA1c levels ≥5.7%, compared with only **9.9%** of females, indicating a higher prevalence of elevated HbA1c among males. In contrast, no significant association was found between **professional category** (physicians vs. pharmacists) and HbA1c levels (**p = 0.845**), as the distribution of normal and elevated HbA1c was comparable between the two professional groups.

Similarly, **marital status** was not significantly associated with HbA1c category (**p = 0.204**). Elevated HbA1c was observed in **22.2%** of married participants compared with **9.1%** of single participants, while none of the separated/divorced participants had HbA1c ≥5.7%; however, this difference did not reach statistical significance. Likewise, **family history of hypertension** showed no significant relationship with HbA1c status (**p = 0.421**), although elevated HbA1c was slightly more common among participants with a positive family history of hypertension (**20.3%**) than among those without (**14.3%**).

A significant association was also identified between **family history of diabetes mellitus** and HbA1c category (**p = 0.005**). Participants with a positive family history of diabetes had a markedly higher prevalence of elevated HbA1c (**28.6%**) compared with those without a family history (**8.3%**). Overall, the findings indicate that **male sex** and a **positive family history of diabetes mellitus** were significantly associated with elevated HbA1c levels, whereas education, marital status, and family history of hypertension were not significantly associated with HbA1c category in this study.

Table 2: Association between Participant Characteristics and HbA1c Levels.

Characteristics	Categories	HbA1c < 5.7%	HbA1c ≥ 5.7%	*P* Value[1]
Sex*	Male	31 (68.9)	14 (31.1)	**0.004**
	Female	64 (90.1)	7 (9.9)	
Education	Doctors	52 (82.5)	11 (17.5)	0.845
	Pharmacists	43 (81.1)	10 (18.9)	
Marital Status	Married	63 (77.8)	18 (22.2)	0.204
	Single	30 (90.9)	3 (9.1)	
	Divorced / Separated	2 (100.0)	0 (0.0)	
Family History of Hypertension	Positive	59 (79.7)	15 (20.3)	0.421
	Negative	36 (85.7)	6 (14.3)	
Family History of DM*	Positive	40 (71.4)	16 (28.6)	**0.005**
	Negative	55 (91.7)	5 (8.3)	

Table 3 presents the association between weight management practices, dietary habits, smoking status, and HbA1c categories among the study participants. No statistically significant association was observed between **following a weight loss plan** and HbA1c category (**p = 0.901**). Elevated HbA1c (≥5.7%) was identified in **19.0%** of participants who followed a weight loss plan compared with **17.9%** of those who did not. Likewise, adherence to a **specific diet** was not significantly associated with HbA1c levels (**p = 0.985**). The prevalence of elevated HbA1c was similar among participants following a high-protein diet (**16.7%**), those using calorie calculation (**16.7%**), and those not following any specific diet (**18.4%**).

In contrast, **smoking status** demonstrated a statistically significant association with HbA1c category (**p = 0.031**). Elevated HbA1c was detected in **35.0%** of smokers compared with **15.1%** of non-smokers, indicating that smokers were more likely to have HbA1c levels in the prediabetes range. However, when smoking was further categorized by **type of smoking**, no statistically significant association with HbA1c category was observed (**p = 0.126**). Elevated HbA1c was present in **36.4%** of cigarette smokers and **50.0%** of shisha smokers, whereas none of the vape users had HbA1c levels ≥5.7%. Among non-smokers, **16.8%** exhibited elevated HbA1c levels. Overall, the findings indicate that **smoking status** was the only lifestyle factor in this analysis that showed a significant association with elevated HbA1c levels, whereas following a weight loss plan, adherence to a specific diet, and the type of smoking were not significantly associated with glycemic status.

Table 3: Association Between Lifestyle Factors and HbA1c Levels.

Characteristics	Categories	HbA1c < 5.7%	HbA1c ≥ 5.7%	*P* Value
Following Weight Loss Plan?	Yes	17 (81.0)	4 (19.0)	0.901
	No	78 (82.1)	17 (17.9)	
Specific Diet	High Protein Diet	10 (83.3)	2 (16.7)	0.985
	No Diet	80 (81.6)	18 (18.4)	

	Calorie Calculation	5 (83.3)	1 (16.7)	
Smoker*	Yes	13 (65.0)	7 (35.0)	**0.031**
	No	82 (85.4)	14 (14.6)	
Type of Smoking	Cigarette	7 (63.6)	4 (36.4)	0.126
	Shisha	1 (50.0)	1 (50.0)	
	Vape	8 (100.0)	0 (0.0)	
	Non-smoker[3]	79 (83.2)	16 (16.8)	

Table 4 presents the association between lifestyle behaviors and HbA1c categories among the study participants. No statistically significant association was observed between the **frequency of regular exercise** and HbA1c category (**p = 0.296**). The proportion of participants with HbA1c ≥ 5.7% was **19.4%** among those who never exercised, **25.7%** among those who exercised rarely, **12.2%** among those who exercised sometimes, and **11.1%** among those who exercised regularly. Although participants who exercised more frequently tended to have a lower prevalence of elevated HbA1c, these differences were not statistically significant.

Similarly, **walking daily to stay active** was not significantly associated with HbA1c status (**p = 0.619**). Elevated HbA1c was identified in **12.5%** of participants who never walked daily, **24.0%** of those who walked rarely, **14.3%** of those who walked sometimes, and **26.3%** of participants who reported always walking daily. These findings indicate no significant relationship between daily walking habits and glycemic status.

No statistically significant association was found between **daily fruit and vegetable consumption** and HbA1c category (**p = 0.910**). All participants who reported never or rarely consuming fruits and vegetables had HbA1c levels below 5.7%; however, these categories included very small numbers of participants. Among those who consumed fruits and vegetables sometimes and always, elevated HbA1c was observed in **23.3%** and **14.9%**, respectively. Likewise, the **frequency of consuming rich or fatty traditional foods** was not significantly associated with HbA1c category (**p = 0.878**). The prevalence of elevated HbA1c ranged from **15.6%** among those who rarely consumed such foods to **40.0%** among those who never consumed them, although the latter group contained only five participants.

Similarly, **daily consumption of sweetened juices or soft drinks** showed no significant association with HbA1c category (**p = 0.544**). Elevated HbA1c was present in **15.4%** of participants who never consumed these beverages, **18.2%** among those who rarely consumed them, **15.6%** among those who consumed them sometimes, and **28.6%** among those who consumed them always. Overall, none of the evaluated lifestyle behaviors, including physical activity, walking habits, fruit and vegetable intake, consumption of fatty traditional foods, or intake of sugar-sweetened beverages, demonstrated a statistically significant association with HbA1c category in this study.

Table 4: Association Between Lifestyle and Dietary Habits and HbA1c Levels.

Characteristics	**Categories**	**HbA1c < 5.7%**	**HbA1c ≥ 5.7%**	***P* Value**
Exercise Regularly	Never	25 (80.6)	6 (19.4)	0.296
	Rarely	26 (74.3)	9 (25.7)	
	Sometimes	36 (87.8)	5 (12.2)	
	Always	8 (88.9)	1 (11.1)	
Walk Daily to Stay Active	Never	14 (87.5)	2 (12.5)	0.619
	Rarely	19 (76.0)	6 (24.0)	
	Sometimes	48 (85.7)	8 (14.3)	
	Always	14 (73.7)	5 (26.3)	
Eat Fruits and Vegetables Daily[2]	Never	1 (100.0)	0 (0.0)	0.910
	Rarely	8 (100.0)	0 (0.0)	
	Sometimes	46 (76.7)	14 (23.3)	
	Always	40 (85.1)	7 (14.9)	
Eat Rich or Fatty Traditional Foods[3]	Never	3 (60.0)	2 (40.0)	0.878
	Rarely	27 (84.4)	5 (15.6)	
	Sometimes	52 (83.9)	10 (16.1)	
	Always	13 (76.5)	4 (23.5)	
Drink Sweetened Juices or Soft Drinks Daily[4]	Never	11 (84.6)	2 (15.4)	0.544
	Rarely	36 (81.8)	8 (18.2)	
	Sometimes	38 (84.4)	7 (15.6)	
	Always	10 (71.4)	4 (28.6)	

Table 5 compares the mean age and body mass index (BMI) between participants with normal HbA1c levels (<5.7%) and those with elevated HbA1c levels (≥5.7%). Participants with HbA1c ≥5.7% were significantly older than those with HbA1c <5.7%, with mean ages of **33.95 ± 4.63 years** and **30.58 ± 4.15 years**, respectively (**p = 0.001**). This finding indicates that increasing age was significantly associated with higher HbA1c levels among the study participants. Similarly, participants with elevated HbA1c had a significantly higher mean BMI than those with normal HbA1c (**29.33 ± 5.08 kg/m² vs. 26.94 ± 4.72 kg/m²**, respectively; **p = 0.041**). These results suggest that both older age and higher BMI were significantly associated with elevated HbA1c levels in this cohort of healthcare professionals, supporting the role of advancing age and excess body weight as important risk factors for impaired glycemic status.

Table 5: Comparison of Age and BMI Across HbA1c Categories.

Characteristics	HbA1c Status	N	Mean	SD	*P* Value
Age (years)	< 5.7%	95	30.58	4.15	**0.001**
	≥ 5.7%	21	33.95	4.63	
BMI (kg/m²)	< 5.7%	95	26.94	4.72	**0.041**
	≥ 5.7%	21	29.33	5.08	

Figure 3A illustrates the relationship between body mass index (BMI) and HbA1c levels among the study participants using a scatter plot with a fitted quadratic trend line. The analysis demonstrated a **significant positive association** between BMI and HbA1c levels (**R^2 = 0.100, p = 0.003**). As BMI increased, HbA1c values tended to increase, although the strength of the association was modest. The scatter plot shows that most participants were clustered within a BMI range of approximately **22–32 kg/m²** and HbA1c values between **4.8% and 5.6%**, with a few participants exhibiting higher BMI and HbA1c values. The quadratic trend line indicates a gradual upward trend in HbA1c with increasing BMI, suggesting that individuals with higher body mass index were more likely to have elevated glycemic levels. These findings support the association between excess body weight and impaired glycemic status and reinforce the importance of maintaining a healthy BMI to reduce the risk of prediabetes. **Figure 3B** illustrates the relationship between age and HbA1c levels among the study participants using a scatter plot with a fitted quadratic trend line. The analysis demonstrated a **borderline statistically significant positive association**between age and HbA1c levels (**R^2 = 0.052, p = 0.050**). Although the strength of the association was weak, HbA1c values showed a slight tendency to increase with advancing age.

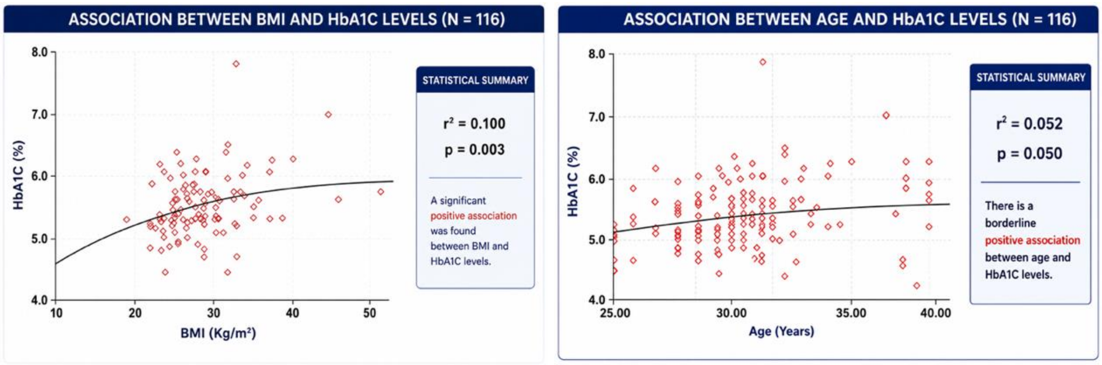

Figure 3: Correlation Model Between (A) Body Mass Index (BMI), (B) Age with HbA1c Levels among medical professionals at AL Imam Al Hassan Al-Mujtaba Teaching Hospital.

The scatter plot indicates that most participants were clustered between **28 and 32 years of age**, with HbA1c values predominantly ranging from **4.8% to 5.6%**. A limited number of participants exhibited higher HbA1c values across the older age groups. The fitted quadratic trend line demonstrates a gradual upward trend, suggesting that increasing age may be associated with higher glycemic levels. These findings are consistent with the comparison of mean age between HbA1c categories, indicating that older participants were more likely to have elevated HbA1c levels and may therefore be at greater risk of prediabetes.

DISCUSSION

The majority of participants in the study were women, which was expected since most medical workers are female. Although medical workers are doctors and pharmacists, more than 90% reported not consuming fruits and vegetables, while 31.9% consumed fatty foods and 50.9% drank sweetened juices and soft drinks. Only 7.8% consumed fruits and vegetables daily, making them the least likely to adopt this healthy dietary habit. In contrast, 56.9% of participants reported sometimes or always engaging in regular exercise.

Nearly two-thirds (64.7%) of overweight or obese medical workers rarely walked daily to maintain their physical activity. A very small percentage had undergone HbA1C screening prior to the current assessment, despite their medical background. This highlights the importance of prediabetes screening, as it enables the early identification of high-risk individuals who might otherwise remain undetected until complications develop.

This study revealed a prediabetes prevalence of 18.1% among healthcare professionals aged 25 to 40 years, with a 95% confidence interval of 11.2–25.0%. The relatively wide interval is likely due to the small sample size. As no previous studies have been conducted on prediabetes screening in Karbala, the present study provides the first evidence on this subject and underscores its public health importance. The prevalence rate in the present study was lower than that reported by Al-Azzawi in Baghdad and Mansour et al. in Basrah.[13] It was also lower than rates found in other countries, such as Liechtenstein.[14] This wide variation may be explained by the fact that all participants in the present study were medical professionals, whereas participants in other studies were members of the general population. The difference may also be influenced by the relatively small sample size of this study.

The findings of Abdalla et al. in Saudi Arabia and Mezban et al. in Baghdad/Rusafa were comparable to those of the present study.[15] This similarity in prevalence may be attributed to the comparable settings and the fact that all studies were conducted within the health sector.

The results are consistent with other studies, showing that prediabetes is strongly correlated with older age. This finding aligns with Abdalla et al. in Saudi Arabia and Mezban et al. in Baghdad/Al-Rusafa[15], while Al-Azzawi et al. at the Baghdad[13] teaching hospital found no significant correlation with age. This disparity may be attributed to the small sample size of the present study, as well as the varied backgrounds of the participants, which included health professionals.

Furthermore, the age distribution of prediabetes in this study is particularly noteworthy. While type 2 diabetes in highly developed countries primarily affects the elderly, in Arab nations it commonly affects people under 60, as documented in several studies in Iraq 13. In the present study, participants with prediabetes were aged between 25 and 40 years, which has significant implications for both economic productivity and health expenditure.

A significant association between male sex with prediabetes, which differs with research conducted in other regions of the world that revealed no difference or a slight male excess.[16] This discrepancy could be caused by the participants' stressful health work or the small sample size of this study.

Several studies have demonstrated a significant correlation between BMI and HbA1c, emphasizing the role of obesity in poor glycemic control and as a risk factor for type 2 diabetes. For instance, Al-Rubeaan et al.[17] in Saudi Arabia found that adults' HbA1c and insulin resistance were significantly correlated with their BMI. Similarly, Bener et al.[17] in Qatar reported that participants who were overweight or obese had significantly higher HbA1c than those of normal weight. Motamed et al. in Iran[19] also showed a strong correlation between BMI and HbA1c, further supporting the link between obesity and impaired glucose metabolism.

According to estimates from the National Center for Health and Nutrition examination survey (NHANES III), 45.7% of individuals with prediabetes were obese, and 78.5% were overweight. In both sexes and across all ethnic groups, obesity is a powerful predictor of type 2 diabetes.[20] These convergent findings underscore the importance of weight management strategies in clinical and public health settings to improve glycemic control and reduce the incidence of prediabetes and type 2 diabetes. Interventions aimed at lowering BMI through dietary and lifestyle modifications are likely to reduce HbA1c and enhance overall metabolic health.

The findings were in line with the Centers for Disease Control and Prevention's (CDC) 2017 (20) diabetes report card, which indicated an inverse relationship between diabetes prevalence and level of education .The inclusion of medical professionals among the study participants may help to explain this observation.

There was no significant difference in the prevalence of hypertension or high cholesterol levels among those with prediabetes. Two established risk factors for type 2 diabetes are hypertension and dyslipidemia.[21] These results were consistent with those of previous research, such as the Canadian Health Measures study and the Caribbean population study of African origin.[22] This resemblance can be explained by our sample's medical setting. According to Ahmed W.et al., the study was conducted in India between 2017 and 2018[23] and Mansour et al.[24] in AL- Basrah, those with a family history of hypertension had a significantly higher frequency of diabetes. The findings, however, are different from other researches that found no significant association between prediabetes and a family history of hypertension. The discrepancy could be explained by the two research' notable different sample sizes.

According to Ahmed W.et al., the study in India (2017–2018).[23] People having a family history of diabetes had a threefold higher prevalence of the disease (27.8% vs. 9.2%) than people without such a history. Mansour et al.

In AL-Basrah[24] also discovered an association between prediabetes and family history of diabetes. The findings are consistent with other research regarding the prevalence of prediabetes in people with a family history of diabetes (28.6% versus 8.3%). These findings could be due to biological predispositions to insulin resistance and beta-cell dysfunction, shared family lifestyle factors, and inherited genes which affect insulin and glucose metabolism.

In the present study, a highly significant association was observed between smoking and prediabetes, which is consistent with other studies that reported a strong relationship, such as those by Mansour et al[24] in Al Basrah, Aeschbacher et al.[14] and Ahmed W. et al. in India[23] These studies likewise demonstrated a highly significant association between smoking and prediabetes. The similarity between the present study and previous research may be explained by the fact that smoking has well-documented effects on insulin resistance, oxidative stress, and systemic inflammation, all of which contribute to impaired glucose metabolism and the development of prediabetes. Therefore, it is reasonable that both this study and the others reported a highly significant association between smoking and prediabetes.

In contrast, a study conducted in India[25] reported no direct impact of smoking on HbA1c levels in patients with type 2 diabetes. This discrepancy could be explained by differences in sample characteristics, lifestyle factors such as diet and physical activity, or variations in the study design and methodology, which may have influenced the outcomes.

In the present study, no significant association was found between physical activity and prediabetes. This contrasts with several studies conducted in Iraq. For instance, Rashad et al. (2025)[26] in Zakho, Kurdistan Region, reported that lower levels of physical activity were associated with undiagnosed diabetes mellitus, suggesting a potential link between reduced physical activity and prediabetes. Similarly, Alogaily et al. (2019)[21] in Baghdad found that prediabetes prevalence was 20.6%, with higher rates observed in individuals with lower physical activity levels. Furthermore, Molan et al. (2025)[27] in Basrah identified barriers to exercise among patients with type 2 diabetes, including lack of energy and motivation, which may also affect prediabetes progression.

The discrepancy between this study finding and these studies may be attributed to the small sample size. Nevertheless, these Iraqi studies support the beneficial role of physical activity in preventing prediabetes, emphasizing the need for further research with larger, more diverse populations and objective activity measurements.

Limitations and Strengths

The relatively small sample size may have reduced the statistical power of the study. Moreover, the participants were recruited from a single hospital, which may restrict the generalizability of the findings to the wider population. In addition, individuals’ willingness to have their HbA1c levels measured may have been influenced by testing accessibility, potentially introducing selection bias. Despite these limitations, the study has several strengths. As no previous studies have been conducted on prediabetes screening in Karbala, the present study provides the first evidence on this subject and underscores its public health importance. lt is one of the few investigations conducted in Iraq on prediabetes and related risk factors, thus providing valuable baseline data for future research. Furthermore, the use of validated instruments and standardized diagnostic criteria enhances the reliability of the results.

CONCLUSION

This study highlight that the prevalence of prediabetes among healthcare professionals aged 25 to 40 years was 18.1%, underscoring the critical clinical importance of targeted screening strategies among young populations. Statistical analysis demonstrated a clear prediabetes association with male sex, obesity, increasing age, smoking status, and a positive family history of diabetes mellitus. This metabolic burden is further mirrored by high rates of poor physical and dietary behaviors within the cohort. Approximately two-thirds (64.7%) of the surveyed medical professionals were classified as either overweight or obese. Furthermore, dietary non-compliance was widespread; more than 90% of the participants did not consume fruits and vegetables daily, while 31.9% reported eating fatty foods, and 50.9% regularly consumed sweetened juice and soft drinks.

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