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ORIGINAL ARTICLE

Prevalence of Prediabetes among Apparently Healthy Iraqi Adults

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Summary

Prediabetes is defined as a metabolic state intermediate between normal glucose homeostasis and diabetes and individuals with prediabetes do not meet the criteria for being diagnosed with diabetes but have glucose level higher than normal. We conduct this study to evaluate the prevalence of prediabetes and associated risk factors among group of Iraqi apparently healthy adults. During the period from April to December, 2024 we conducted this cross-sectional study in Kirkuk city including a total of 200 apparently health Iraqi adults of both genders. Prediabetes status was diagnosed according to the standard guidelines. We sub grouped the study participants according to the results of fasting blood glucose and glucose tolerance tests into four subgroups; demographic and anthropometric measurements were reported. Our findings showed that the overall prevalence of prediabetes was 29%, prevalence of impaired fasting glucose (IFG), impaired glucose tolerance (IGT) and combined (IFG & IGT) was, 8.5%, 11.5% and 9%, respectively. In conclusion, the prevalence of prediabetes was generally high, nonetheless it was within the range reported in previous Iraqi studies. Older age, higher body mass index, larger waist circumference, history of hypertension and family history of diabetes mellitus were significant risk factor for high prevalence of prediabetes. Gender did not affect the prevalence of prediabetes. Further large-scale studies at the national level are strongly recommended for more precise estimation and to develop preventive and control measures

Keywords: ***Prediabetes, Epidemiology, Risk factors, Iraqi Adults***

1. INTRODUCTION

Diabetes Mellitus (DM) is a metabolic disease characterized by chronic hyperglycemia resulting from absolute or relative insulin deficiency. This condition results from changes in the production and secretion and/or mechanism of action of insulin, which also results in disturbances in lipid and protein metabolism [1,2].

A series of complications, dysfunctions and insufficiencies of various organs may also arise, particularly affecting the renal, neurological, cardiovascular and ophthalmological systems, which require early diagnosis and treatment [1,2].

According to the World Health Organization (WHO), DM has two main subclasses, Type 1 Diabetes Mellitus (T1DM) and type 2 DM (T2DM). Type 1 DM is defined by an autoimmune destruction of the beta cells of the pancreas, resulting in an absolute insulin deficiency. Type 1 DM contributed for almost 5-10% of all DM cases. Type 2 Diabetes Mellitus (T2DM) is the most common form of diabetes, accounting for approximately 90-95% of all diabetics [3]

Diabetes Mellitus occurs due to changes in insulin secretion and progressive resistance, which is the primary etiopathogenic factor [4]

Currently, T2DM is widely understood as a combination of metabolic alterations including pre-diabetes and metabolic syndrome. These alteration usually precede the definite diagnosis of DM and contribute to its development [5,6]

Prediabetes is characterized by relatively high glucose levels, but not high enough to be classified as diabetes. However, Prediabetes considered as a stage of dysglycemia between normoglycemia and diabetes. Prediabetes, typically identified by laboratory investigation of fasting blood glucose (FBG), glycosylated hemoglobin (HbA1C), or two hours post-load blood glucose (2hBG). Prediabetes is a term for those who are at risk of getting diabetes. At this stage, insulin is not used by the target organs, leading to an increase in its secretion by beta cells, thus leading to abnormal fasting blood glucose (AGJ) and impaired glucose tolerance (IGT). The increasing number of people with prediabetes around the world represents a major public health problem, and it doesn't bode well for the growing epidemic of diabetes and its consequences. A large data has been accumulated during the last 20 years about the natural

history, detection and the effective treatment. Nonetheless, there still some controversy about the optimal definition of Prediabetes [7,8].

The transition from prediabetes status to diabetes may takes long duration, up to many years, but it may occur more quickly within a potential of 2-3 years. Almost 25% of prediabetic peoples develop DM within 3-5 years and the rate of progression to DM increases over the longer periods. However, there is a wide range of progression from prediabetes to T2DM in the published studies ranged between 2% to 24%. The annual rate of progression from prediabetes to T2DM is about 5%-10% and about 70% of prediabetic population will develop T2DM at their lifetime and the risk of conversion increases significantly among overweight and obese individual [9]. In addition to the progression rates, the center for disease control and prevention (CDC) reported that almost 90% of prediabetes individuals are unaware about their condition [9]

Prediabetes

• Definition

Prediabetes is a condition of the body that precedes the development of type 2 diabetes. It is considered as an intermediate stage between a healthy state and type 2 diabetes. In this case, the glucose concentration has not yet reached the critical level at which DM is diagnosed, but it has already gone beyond the upper limit of the norm. Prediabetes is characterized by metabolic disorders that can develop over several years without any obvious symptoms [7,10].

• Risk factors

Different modifiable and non-modifiable risk factors can contribute to prediabetes status in the general population; the modifiable risk factors include the nutritional status, physical activity, compliance with circadian rhythms and lifestyle habits. The non-modifiable factors are age, gender, heredity and the environmental factors [11–16]. The risk factors of prediabetes are generally include, sedentary lifestyle, regular overeating, unhealthy diet with high amounts of refined sugar, overweight/obesity, pregnancy, pancreatic diseases, disorders of the endocrine system, high levels of cholesterol in the blood, arterial hypertension, polycystic ovary syndrome, diseases of the heart and circulatory system, smoking and alcohol abuse, regular stress and psycho-emotional stress, chronic insomnia, long-term use of glucocorticosteroids or oral contraceptives, hereditary predisposition to diabetes and Ethnic predisposition. However,

the risk of prediabetes and the later conversion to diabetes have shown to be significantly increases with the presence of a combination of these risk factors; for instance, the coexistence of obesity, higher diastolic blood pressure, increased blood levels of triglycerides, high concentrations of lactic acid, bilirubin, lactate, and alanine transaminase (ALT) activity in the circulating blood. Nonetheless, with a healthy lifestyle, normalization of body weight, and adequate therapy for the above conditions and diseases, the predisposition to developing diabetes mellitus remains latent in most people and does not manifest itself [11–16].

• **Clinical features**

Regarding the clinical features and presentations most cases of prediabetes are asymptomatic. However, they can be detected accidentally based on laboratory tests that revealed an elevated blood glucose level, thus prediabetic individual may not receive optimal care and majority of these cases are unaware of their diagnosis [17]. Despite most cases are asymptomatic, some prediabetic cases may develop symptoms but they are less pronounced and irregular; These symptoms include increased thirst, increases appetite, weight loss or gain, sweating, polyuria, fatigue, darkened skin , dry skin, itching and blurred vision, recurrent skin infection, bleeding gums, prolonged healing of wounds and abrasions, menstrual irregularities, amenorrhea, and sexual weakness [18]. From other point of view, prediabetes provokes a failure of normal glucose metabolism and hormonal imbalances in the body. This may be accompanied by problems with thermoregulation, chronic insomnia with regular night awakenings and hot flashes [19–22].

• **Diagnosis**

It is often accidentally; however, the following tests are used for screening and evaluation. The Key tests for diagnosis are 12-hour fasting blood glucose (between 100-125 mg/dL), two-hour glucose tolerance test (blood glucose between 140-199 mg/dL), random blood glucose of 140-199 mg/dL and glycated hemoglobin HbA1c test between 5.7% to 6.7% are diagnostic of prediabetes [18].

• **Treatment**

Preventing conversion to DM and reduce the cardiovascular complications is the main goal of managing patients with prediabetes to prevent development of complications. The Important components of successful management are informing and motivating patients, dispensary

management, monitoring of carbohydrate metabolism indicators, blood lipids and arterial pressure. To date, the effectiveness of both non-pharmaceutical and pharmaceutical strategies has been proven in individuals with prediabetes. It has been widely postulated that prediabetes is considered a reversible condition - with the help of proper management. Non-pharmaceutical management strategies include lifestyle changes, as well as weight loss by 5-7% of the initial weight over 6-12 months. At the same time, very low-calorie diets are not recommended, and fasting is contraindicated. The clinical guidelines of endocrinologists recommend that lifestyle changes should be based on maintaining optimal weight, practicing physical activity of 150 minutes/week in minimum, starting with moderate activity and increasing the duration and intensity as possible. Prediabetic individual should sleep for at least seven hours a day; quitting smoking and restrict alcohol consumption [23,24]. Pharmaceutical therapy is most often prescribed when the non-pharmaceutical management strategies failed to yield positive results. Although many endocrinologists try to avoid using hypoglycemic drugs, these drugs are necessary in some individuals with prediabetes; metformin is the first choice, previous studies have shown that among prediabetic individuals, metformin reduced the risk of conversion to DM by almost 3%. Furthermore, metformin has shown to be the most effective option for treatment and control in women with history of gestational diabetes, individuals with a body mass index of ≥ 35 kg/m², ≤ 60 years old, FBG ≥ 110 mg/dL and in cases with HbA1c of ≥ 6% [23,24].

• **Complications**

Without timely medical care and regular monitoring of glucose levels, prediabetes develops to type 2 diabetes. The average rate of conversion from prediabetes to diabetes is about 11% and this rate depend mainly on the population characteristics and diagnostic criteria. Untimely treatment increases the likelihood of developing severe complications like nephropathy, neuropathy, retinopathy, ketoacidosis, trophic ulcers, myocardial infarction and other serious complications [23].

The aforementioned facts, dignify why we should concern about prediabetes, particularly in our country. In Iraq, few studies addressed the problem of prediabetes, its prevalence and the associated factors among Iraqi population which necessities further studies to fill the gap in the literature about this condition, taking into account the rate of progression to DM, the burden

of prediabetes on the individuals of our community and the health system can be highlighted. Therefore, the objective of this study is to estimate the prevalence of prediabetes among group of Iraqi adults and to investigate the possible contributing factors

2. METHODOLOGY

In this study, a cross-sectional study design with analytic utility was adopted during a period of 10 months in Kirkuk city

Inclusion criteria:

1. Adult Iraqi individuals older than 18 years of both genders
2. Apparently healthy individuals
3. Live in the same study area for at least 6 months prior to participation in the study
4. Consenting to participate as volunteer
5. Agreed to perform the necessary investigations and clinical assessment

Exclusion criteria:

1. Known case with proved diagnosed type I or type II DM
2. Women with history of gestational diabetes
3. Currently take hypoglycemic drugs for any reason
4. Pregnant or breast-feeding ladies
5. Individuals with current acute illnesses or infections that interfere with glucose metabolism
6. Patients with chronic diseases and malignancies
7. Currently use corticosteroids or other medications that affect glucose metabolism
8. Unable to provide the consent due to mental or cognitive disorders

Study population, sample size and sampling technique:

Study population consisted of all the apparently healthy Iraqi individuals who did not have DM and visiting the selected center during the study period. A convenient sample of 200 individuals was selected using sequential convenience sampling technique involving individual who are readily available and agreed to participate in the study. After completing the laboratory testing, the study participants were later divided into four groups according to their FPG and GTT.

Data collection and study tools

Data were collected using a data collection form (Questionnaire) as a study tool. This questionnaire included the demographic data, anthropometric measurements, medical and surgical history, obstetrical history for women, family history of DM. Also, it included the findings laboratory investigations.

Measurements and investigations:

Weight and height of the study participants were measured using a standardized scales and the results approximated to the nearest 0.5 digit. Body mass index then calculated as a measure of weight relative to height. We used the standard equation of the BMI in calculation where:

BMI = Weight in kilogram/ squared height in meter [25].

Clinically, all the study participants were evaluated and instructed to have empty bladder, fast for 8 hours (overnight) and refrain from consuming caffeine-containing beverages or smoking cigarettes for at least 12 hours.

Laboratory tests were performed after collecting blood samples from all participants. A sample of venous blood was collected from all participants under completely sterile and aseptic conditions with assurance of the participant's privacy. The performed blood tests included. Fasting blood glucose, glucose tolerance test (GTT) which is performed after fasting and 120 minutes post-ingestion of 75 g of glucose

The clinical guidelines for the diagnosis of DM and prediabetes were adopted for diagnostic purposes of this study.

Data analysis

Data analysis was performed using the statistical package for social sciences (SPSS, IBM, US) software for windows version 26. Descriptive and inferential statistics were expressed according to type the variables; scale variables like age, anthropometric measurements and biochemical parameters were expressed as mean and standard deviation. Nominal (Categorical) variables expressed as frequency and percentages. Comparison and statistical tests were applied accordingly and the appropriate statistical tests used according to the type of variables and when applicable at a level of significance of ≤ 0.05.

3. RESULTS

The general demographic characteristics of the 200 participants in the study are summarized in (**Table 1**). According to blood testing of these participants, they were categorized in four groups; included 17 participants (8.5%) with elevated glucose tolerance test and normal FBG, namely, (IGT group), the second group included 23 participants (11.5%) with impaired fasting blood glucose (IFG group) and normal glucose tolerance test, combined group included 18 (9%) participants with both, elevated IGT and IFG , the remaining 142 participants (71%), (Normal group) whose both tests were normal. According to this distribution a total of 58 participants were prediabetic producing a prevalence of prediabetes of 29%. (**Figure 1**). Further comparisons were performed regarding the mean FBS and GTT across the four groups, as shown in (**Table 2**), where, the participants in combined group had significantly the higher mean FBS and GTT rather than individuals in other groups, the mean value was (109.9 ± 9.0) and (175 ± 18.1) respectively.

As shown in (**Table 3**), no significant differences were found in the gender distribution across the four participant groups, (P. value >0.05). The age distribution across the four groups, revealed that participants with IGT were significantly older than other participants, the mean age in this group was 52.2 ± 13 years compared to 48.6 ± 14.1 in IFG group, 47.8 ± 12.0 in combined group and 41.9 ± 14.4 in normal group, (P. value <0.05), for the body mass index (BMI), participants in the combined group had the larger BMI with a mean BMI of 32.2 ± 5.0 kg/m² followed by those in the IGT (mean BMI: 30.8 ± 3.7), IFG groups (mean BMI: 28.0 ± 4.0 kg/m²), and the lower BMI reported among participants in the normal group (mean BMI: 25.6 ± 4.0 kg/m²), (P. value <0.05).

Regarding the waist circumference, the comparison in each gender revealed that the lower mean waist circumference was reported among participants with normal GTT and FBS; the mean waist circumference was 89 ± 12.8 cm and 93.9 ± 9.2 cm, respectively, (P. value <0.05). All these findings are summarized in (**Table 4**).

Additionally, we performed a bivariate Pearson's correlation analysis using the age, BMI and waist circumference of the participants as independent variables against FBS and GTT as dependent variables, results of this correlation analysis revealed a strong direct (positive)

correlation between all the three independent variables and each of FBS and GTT, in all variables the R. value >0.70 and P. value <0.001, (**Table 5**).

Further analysis was performed using cross-tabulation to assess the association between prediabetes as dependent variable and each of history of hypertension and family history of DM as independent variables, results of this analysis showed a significant association between these two factors and higher prevalence of prediabetes, (**Table 6**).

Table 1. General characteristics of the study participants (N=200)

Variable	No.	%
Gender		
Male	88	44.0
Female	112	56.0
Age (year)		
20 – 29	35	17.5
30 – 39	51	25.5
40 – 49	35	17.5
50 – 59	40	20.0
> 60	39	19.5
Mean ± SD (range)	44.1 ± 14.3 (20 – 76)	
BMI (kg/m²)		
< 25	81	40.5
25 – 30	76	38.0
> 30	43	21.5
Mean ± SD (range)	26.9 ± 4.7 (17.5 - 45.3)	
Waist circumference/ cm, Mean ± SD (range)		
Male	97.2 ± 10.2 (68 – 130)	
Female	92.16 ± 14 (60 - 130)	
History of Hypertension		
Yes	54	27.0
No	146	73.0
Family history of DM		
Yes	39	19.5
No	161	80.5

SD: standard deviation of the mean, BMI: Body mass index

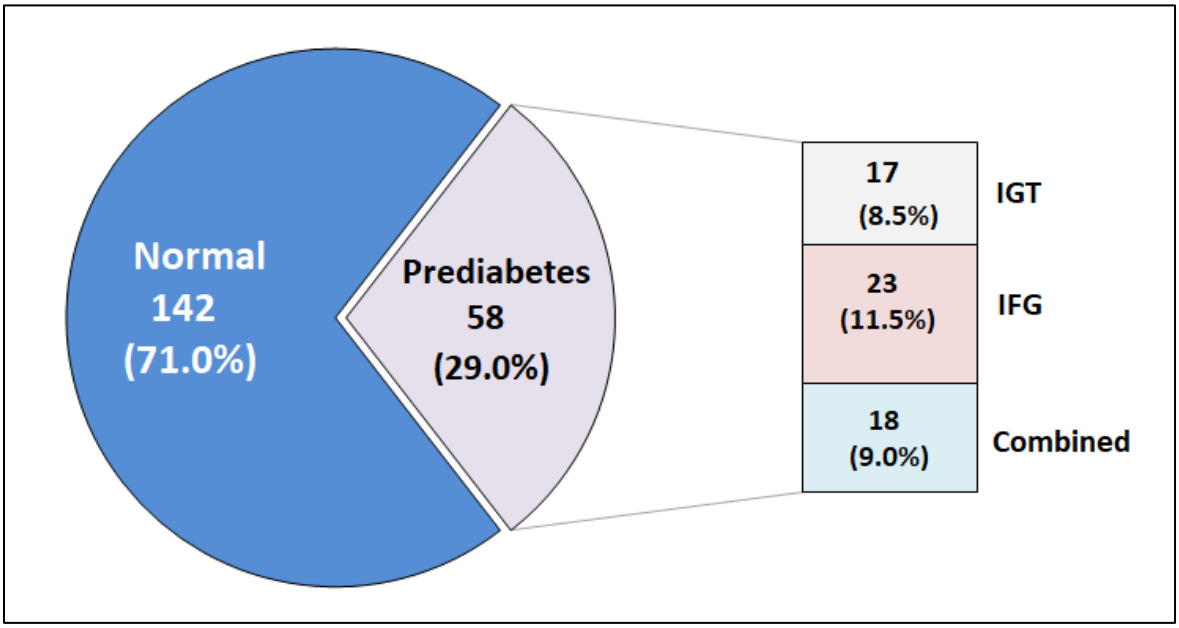

Figure 1. Overall Prevalence of Prediabetes, IGT, IFG and combined status among the study participants (N=200)

Table 2. Comparison of mean FBS and GTT among the study groups

Group	Statistic	FBS	GTT
IGT (n=17)	Mean ± SD	91.9 ± 5.6	157± 14.3
	Range	80- 99	140 -191
IFG (n=23)	Mean ± SD	107.8 ± 5.5	117±17.4
	Range	100 - 122	86 - 138
Combined (n=18)	Mean ± SD	109.9 ± 9.0	175±18.1
	Range	100 - 125	141 - 198
Normal (n=142)	Mean ± SD	88.8 ± 6.5	116±17.2
	Range	65 - 99	64 - 147
P. value		**0.001**	**<0.001**

Table 3. Gender distribution among the studied groups

Group	Male		Female		Total	
	No.	%	No.	%	No.	%
IGT	11	12.5	6	5.4	17	8.5
IFG	10	11.4	13	11.6	23	11.5
Combined	4	4.5	14	12.5	18	9.0
Normal	63	71.6	79	70.5	142	71.0
Total	88	100.0	112	100.0	200	100.0

P. value = 0.36, not significant

Table 4. Comparison of mean age, BMI and waist circumference among the study groups

Group	Age (year)	BMI (kg/²)	Waist circumference (cm)	
			Females	Males
IGT	52.2 ± 13.7	30.8 ± 3.7	97.5 ± 11.3	107.2 ± 7.7
IFG	48.6 ± 14.1	28.0 ± 4.0	97.6 ± 16.6	101.2 ± 6.2
Combined	47.8 ± 12.0	32.2 ± 5.0	102.6 ± 12.1	106.5 ± 15.8
Normal	41.9 ± 14.4	25.6 ± 4.0	89.0 ± 12.8	93.9 ± 9.2
P. value	0.006	0.001	0.001	0.003

Values are presented as mean ± standard deviation (SD)

Table 5 Results of bivariate Pearson's correlation analysis between age, BMI and Waist circumference against FBS and GTT among the study participants

Variable		Statistics	FBS	GTT
Age		R	0.732	0.788
		P. value	<0.001	<0.001
BMI		R	0.702	0.800
		P. value	<0.001	<0.001
Waist circumference	Males	R	0.713	0.729
		P. value	<0.001	<0.001
	Females	R	0.831	0.822
		P. value	<0.001	<0.001

BMI: Body mass index, FBS: Fasting blood sugar, GTT: Glucose tolerance test, R: Pearson's correlation coefficient

Table 6. Cross-tabulation for the association between prediabetes and each of hypertension and family history of diabetes mellitus

Variable	Prediabetes		Normal		Total		P. value
	No.	%	No.	%	No.	%	
Hypertension							
Yes	30	55.6	24	44.4	54	27.0	<0.001
No	28	19.2	118	80.8	146	73.0	
Total	58	29.0	142	71.0	200	100	
Family history of DM							
Yes	25	64.1	14	35.9	39	19.5	<0.001
No	33	20.5	128	79.5	161	80.5	
Total	58	29.0	142	71.0	200	100	

DM: diabetes mellitus

4. DISCUSSION

In the current study we found that the overall prevalence of prediabetes was 29%, including those with IFG , IGT and combined. This rate was higher than that reported in previous Iraqi studies; in Baghdad, Alogaily et al. [26] found a prevalence rate of 20.6% among 262 Iraqi individuals in Baghdad during 2019. In other Iraqi study conducted in 2022 by Jassim et al. [27] the prevalence of prediabetes was 17% among 735 Iraqi participants from Baghdad. In 2015, higher prevalence rate of prediabetes was found by Omar Farooq Al Azzawi [28] who concluded that among 300 Iraqi individual, the rate of prediabetes was 33.66%. In other countries in our region the prevalence rates are varied, in Saudi Arabia it was 28.3% [29], other Saudi study documented a prevalence rate of 20% with no significant difference between both genders [30]. In Iran, a prevalence rate of 18.22% reported by Moradpour et al. [31] in 2022. However, there is a wide variation in the prevalence of prediabetes status among the Eastern Mediterranean region countries; recent systematic review [32] showed the prevalence of prediabetes in these countries ranged between 7.8% - 35%. This discrepancy among the studies could be attributed to the definition of prediabetes adopted in different studies and the parameters used in detection for instance Jassim et al. used hemoglobin A1c for diagnosis

of prediabetes [27]. However, the rates of prediabetes reported in our study and that of Alogaily et al. et al. [26] highlight the fact that the prevalence of prediabetes is increasing among Iraqi population.

The mean blood glucose (93.2±10.3 mg/dl) which was slightly lower than the results in the earlier national Iraqi survey conducted by the Iraqi Ministry of health in 2006 [33] which was(95.4 mg/dl) [37]. The combined group (IFG+IGT) had higher mean FBG and GTT than other groups. Regarding the gender, no statistically significant differences had been found, in contrast to Oman where male gender was associated with increased risk of prediabetes [34]. Regarding the age, Individuals with IGT were older (mean; 52.2 ± 13.7 years) than those in the other groups. Direct positive correlation had been found between FPG, GTT with the age, this result similar to the study in Oman and CNCDRSII. [33,34].

Regarding BMI, it was significantly higher among individuals in the combined group had than other groups, and those in IGT group had higher mean BMI than those in IFG and normal groups, these findings in line with that reported in the Omani study [34]. The mean BMI of the study participants was (26.9±4.7) which slightly lower than the results in CNCDRSII (28.1)and the prevalence of participants with BMI>25 was (59.5%) which was lower than that of CNCDRSII (66.9%) [33]. Elevated FPG is more prevalent among obese individuals compared to group IGT or combined groups. It had been significantly found that FPG and GTT had directly correlated to the BMI value. The correlation of prediabetes state was significantly correlated with waist circumference, in both genders. Among females, combined group had the largest waist circumference (102.6) cm compared to other groups. Among males the largest waist circumference was found in IGT group (107.2) cm, little lower in combined group (106.5) cm compared to IFG group or normal. Hypertension and positive family history of DM were significantly associated with higher rates of prediabetes state, these findings agreed that reported in previous studies from Iraq, Saudi Arabia, China and Iran [27,29–32,35]. However, prediabetes shared almost the same risk factors of DM, these risk factors are commonly prevalent among Iraqi population. The main risk factors include obesity, unhealthy diet, sedentary life style and low physical activity, high prevalence of hypertension and other risk factors play an important role in the development of prediabetes and overt DM and its complications [27,29,30].

5. CONCLUSIONS

The overall prevalence of prediabetes among the study participants was 29%, IGT was 8.5%, IFG was 11.5% and the combined (IGT and IFG) prevalence was 9%. Older age, larger BMI, larger waist circumference, presence of hypertension and family history of diabetes mellitus were significantly associated with higher rates of prediabetes. Gender was not significantly associated with the prevalence of prediabetes. However, according to our findings and conclusions we recommend educating the Iraqi population about the risk factors and the risk of conversion of prediabetes to DM. However, to address the high prevalence of prediabetes, it is essential to promote nutritional and dietary habits education and encouraging enrolment in regular physical activities. From other point of view, while a screening program for DM is already implemented in Iraq, it is recommended to achieve multimodal approaches screening and implementation of different screening methods such as hemoglobin A1c. Moreover, using telehealth approach and digital tools to reach out the individuals as remote screening. Establishing a robust follow-up and monitoring system for those at high risk. Finally, we suggest conducting further large-scale studies at a national level for more precise estimation and addressing the magnitude of the problem.

Ethical Approval:

All ethical issues were approved by the authors. Data collection and patient's enrollment were in accordance with Declaration of Helsinki of World Medical Association, 2013 for the ethical principles of researches involving human. Verbal informed consent was obtained from each participant and data were kept confidentially.

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