Saudi Journal of Biological Sciences 30 (2023) 103777

HOSTED BY

Contents lists available at ScienceDirect

Saudi Journal of Biological Sciences

journal homepage: www.sciencedirect.com

Original article

Investigating the relationship between lifestyle factors, family history, and diabetes mellitus in non-diabetic visitors to primary care centers

Fahad Abdulaziz Alrashed [a,*], Tauseef Ahmad [b], Muneera M. Almurdi [c], Abdulfattah S. Alqahtani [c], Dalyah M. Alamam [c], Abdulrahman M. Alsubiheen [c]

[a] Department of Cardiac Sciences, College of Medicine, King Saud University, P.O. Box 7805, Riyadh 11472, Saudi Arabia
[b] Department of Medical Education, College of Medicine, King Saud University, P.O. Box 7805, Riyadh 11472, Saudi Arabia
[c] Department of Health Rehabilitation Sciences, College of Applied Medical Sciences, King Saud University, P.O. Box 10219, Riyadh 11433, Saudi Arabia

ARTICLE INFO

Article history:
Received 19 June 2023
Revised 31 July 2023
Accepted 5 August 2023
Available online 11 August 2023

Keywords:
Diabetes biological factors
Non-diabetic
Family history of diabetes
Primary care centers
Genetics of diabetes

ABSTRACT

We investigated the risk levels associated with diabetes mellitus. They were assessed based on whether anyone in their family had a history of diabetes. The data collected are measurements of blood pressure, weight, height, and smoking habits, as well as physical activity and educational status. Based on the American Diabetes Association's (ADA) recommendations, the questionnaire included a diabetes risk assessment. The risk of diabetes was 76.3% among participants with a family history of diabetes. There is a 41.1% chance of diabetes among those participants whose fathers had diabetes, and a 39.3% chance of diabetes among those participants whose mothers had diabetes. Additionally, those participants who have siblings with diabetes were 24% at high risk for developing diabetes. The prevalence of the risk of having a family history of diabetes is higher in the women in the family (RR = 3.12; P = 0.0001) as compared to the men in the family (RR = 1.9; P = 0.0001). Risk of diabetes more in the male (1.13 times higher) in the current study based on the ADA scale. There is evidence that various factors, including lifestyle choices, physical attributes, and family history, influence the risk of developing diabetes in the current study. The results of the current study indicate that there is a strong association between patients with T2D and those who have a family history of diabetes. Considering Saudi Arabia's high diabetes risk, evidence-based lifestyle modifications are needed.

1. Introduction

Type 2 diabetes mellitus (T2DM) is a chronic disease, characterized by abnormally high blood sugar levels. Diabetes occurs when body becomes resistant to insulin, or when pancreas cannot produce enough insulin to keep blood sugar levels within a healthy range. Approximately over 500 million people die each year from diabetes around the world, making it the leading cause of death (Sun et al., 2022, KAISER et al., 2018). Due to increasing prevalence rate, an estimate has been made that, diabetes mellitus will be ranked as the seventh most common cause of death in the world by 2030 (Mathers and Loncar, 2006), According to the World Health Organization, world-wide, diabetes is one of the leading causes of death. It is estimated that diabetes will cause 1.5 million deaths worldwide in 2019, reported by the World Health Organization (WHO, 2021). The number of people who die from T2DM-related causes is increasing, according to a study (Mayeda et al., 2013).

Diabetic-related comorbidities, such as renal failure (Looker et al., 2014), stroke (Peters et al., 2014), and heart attack (Zannad et al., 2015) contribute to the high death rate associated with diabetes. Based on the International Diabetes Federation (IDF), over 8.8% of the world's population over the age of 20 is estimated to be affected by diabetes (Sun et al., 2022). Middle East and North Africa (MENA) is one of the regions in the world that has a higher

* Corresponding author at: Department of Cardiac Sciences, College of Medicine, King Saud University, Riyadh, Saudi Arabia, BMedSc, King Saud University; MSc and DipIC in Molecular Medicine, Imperial College London; MSc in Medical Education, King Saud University; PhD in Vascular Sciences, Imperial College London.

E-mail addresses: faaalrashed@ksu.edu.sa (F. Abdulaziz Alrashed), tahmad@ksu.edu.sa (T. Ahmad), malmurdi@KSU.EDU.SA (M.M. Almurdi), abalqahtani@ksu.edu.sa (A.S. Alqahtani), dalimam@ksu.edu.sa (D.M. Alamam), aalsubiheen@ksu.edu.sa (A.M. Alsubiheen).

Peer review under responsibility of King Saud University.

Production and hosting by Elsevier

https://doi.org/10.1016/j.sjbs.2023.103777
1319-562X/

prevalence of diabetes than any other region, with an estimated prevalence rate of 9.6% in 2017 and an estimated prevalence of 12.1% by 2045, demonstrating a higher prevalence rate than other parts of the world (IDF, 2017). A author cites data from the World Health Organization reported that prevalence rate of diabetes highest (17.7%) in the Saudi Arabia which was highest among the all developed countries in the MENA region and the world, among other factors (Alramadan et al., 2018). Urbanization, obesity rates, sedentary lifestyles, and aging populations in MENA countries are some of the factors contributing onset of diabetes (Kearns et al., 2014). The prevalence of this disease that has an adverse effect on the public health system, the economy, and the well-being of citizens (Williams et al., 2020). A number of lifestyle factors are also implicated in the development of diabetes. Others studies highlights the importance of health education interventions that are focused on changing people's behavior in order to combat the disease (Abdulghani et al., 2018, Al-Ozairi et al., 2023). It is possible to reduce the chances of getting Type 2 diabetes in people at high risk by more than 80% by attending an education program that teaches them how to prevent the disease from developing (Looker et al., 2014). In addition to having full health-related content, social media platforms have a lot of content that is designed to educate people about a healthy lifestyle and a better quality of life (Giustini et al., 2018, Al-Reshed et al., 2023). Social media platforms have the potential to provide a lot of information about health, health education, and awareness regarding diabetes, but fewer people receive it. There has been a survey conducted in Omani semi-urban communities that indicates that only 46.5% to 57.0% of people in this study population are aware of diabetes concepts, symptoms, and complications(Al Shafaee et al., 2008). Similarly, it was found that about half of the subpopulation in Mongolia had never heard of diabetes, and one-fifth of the population had never heard of it completely(Demaio et al., 2013). About 58% of Malaysia's rural adult population does not know much about diabetes(Minhat and Hamedon, 2014), compared to 57% of Pakistan's rural population poor understanding of diabetes (Ulvi et al., 2009). It is essential to educate the general public about diabetes mellitus, its complications, its risk factors, and treatment to control it as effectively as possible (Robert et al., 2020, Alluhaymid et al., 2020, Vijh et al., 2023). A significant point that needs to be noted is that many diabetics, even those who have been diagnosed with the disease, do not realize they have the disease until the disease has already developed its life-threatening complications. People will be able to manage and prevent many of the health problems associated with diabetes if they have a greater understanding of the disease at a population level. As one of the third largest countries in the Middle East and one of the oldest in the region, Saudi Arabia, there is a lack of awareness among the general population regarding diabetes mellitus, its complications, as well as the risk factors that contribute to this disease. This is despite the fact that Riyadh is the capital city and the largest city in Saudi Arabia. As part of our research, we conducted a comprehensive review of the literature. In our search, we were not able to find any studies that reported on the diabetes risk level and the level of diabetes awareness in the Saudi population that were able to answer these questions.

In this study, we investigated the risk levels associated with diabetes mellitus. They were assessed based on whether anyone in their family had a history of diabetes. Diabetes prevalence was also investigated. Additionally, the researchers investigated whether Saudi citizens were aware of the fact that they had the disease. Using the findings of the report, the authorities will determine whether non-diabetic individuals need to be made more aware of diabetes so that it doesn't spread. As a result, raising awareness about T2DM and its complications is an effective step in reducing the negative impacts of T2DM. This is because prevention is always more effective than treatment, considering that prevention is always a better option.

2. Methods

2.1. Design

Participants in the study were non-diabetic individuals who went to healthcare centers for health checks other than those caused by diabetes problems. A total of five randomly selected primary healthcare centers were randomly selected from the capital city of Saudi Arabia, Riyadh, between the end of November 2021 and the end of July 2022, to collect study data for this study. The target group was defined on the day of the interview as those who had reached 18 years of age or older, and who were free of any chronic health conditions at the time of the interview. The study excluded pregnant women, people who had difficulties communicating effectively, and people suffering from mental illness from participating in this study. As part of this study, it was convenient to use a random sampling method, and participation was entirely voluntary. Participants signed a consent form acknowledging their consent to participate in the study before taking part. Members of the research team conducted individual interviews with all participants in this study in order to collect as much information as possible.

2.2. Data collection

Five well-trained researchers conducted health assessments onsite and conducted questionnaire-based interviews according to a standard data collection protocol. Data collection includes measures of blood pressure, weight, and height, as well as smoking habits, education status, physical activity. A hospital record indicates the participant's age and cholesterol level based on the information provided by the hospital. To calculate a person's Body Mass Index (BMI), multiply their weight in kilograms by their height in meters squared (Cameron, 1978). It was determined that standardized mercury sphygmomanometers were used in order to measure the blood pressure three times on the right arm, in accordance with the guidelines of the WHO and International Society of Hypertension (Chalmers et al., 1999). Researchers were all final-year medical students enrolled in MBBS programs and received uniform training. Further interviews or examinations were conducted if missing details or errors were discovered. It was necessary to standardize all measuring instruments prior to the survey.

2.3. Instrument and setting

The development of the standard bilingual (English and Arabic) questionnaire was based on an extensive literature review that was based on previous studies and guidelines. There were three parts to the questionnaire: the first part about the sociodemographic background of the respondents. In a second aspect of the questionnaire, which was developed by the American Diabetes Association (ADA), there was also a screening tool for diabetes risk based on parameters developed by this organization((ADA), 2022). It is in the third part of this article that we will discuss a number of risk factors that are related to common awareness perceptions and habits that are typical to a community's culture. We collected demographic information about the individuals in the first part of the study. This included gender, family history of diabetes, physical activity, age, education level, and body mass index.

This questionnaire also contained a screening application that could be used by the respondents in order to determine whether they were at risk for diabetes, which was based on parameters that

had been recommended by the American Diabetes Association. In order to assess the actual risk of developing diabetes, we used a validated questionnaire developed by the American Diabetic Association to assess each participant's actual risk. As part of the questionnaire, the following questions are included: if you have had gestational diabetes in the past or do you have a family history of the disease, your age, gender, and your weight, and height, as well as any history of hypertension. Based on the information collected through the American Diabetes Association's diabetes risk questionnaire, diabetes risk factors can be determined based on self-reported information. Those under ages of 40 year were given no points, those between 40 and 49 years were given one point, those between 50 and 59 years were given two points, and those over 60 years were given three points. Males had one point and females zero, but women with gestational diabetes had one. Patients with a history of hypertension had 1 point, otherwise 0 points. Patients who were physically active had 0 points and those who were not had 1. Patients with a family history of diabetes had 1 point, and those without 0 points. In relation to height and weight, it is determined whether the individual is normal weight 0 points, or overweight 1 point. A maximum score of eleven (11) can be achieved by adding up the scores of each of the risk factors. A score of<5 indicates that there is a low risk of diabetes; however, if the score is equal to or greater than 5, then there is a high risk of undiagnosed prediabetes or type 2 diabetes. Even so, fasting blood glucose levels (ADA) are the only method that can be used to determine the diabetes risk ratio with any reliability.

The fourth part of this study examines the relationship between lifestyle-related knowledge and behaviors, diabetes awareness levels, and diabetes risk factors with respect to diabetes. In order to achieve the study's objectives pertaining to diabetes common awareness and regular habits, an extensive literature review was conducted in order to design a questionnaire that participants could conduct on themselves in order to achieve the study's objectives. A panel of four members of the medical diabetes clinical consulting team with substantial experience dealing with diabetic patients reviewed the prepared version of the document and discussed it extensively during the review process. Following two meetings and extensive discussion, nine items were agreed upon by the panel members. The consulting team and the ethical committee are recommended to conduct a pilot study before undertaking the final study. In order to increase diabetes awareness, team members plan to conduct a pilot study involving 25 to 40 participants. This pilot study was conducted by a family medicine clinic in Riyadh, Saudi Arabia, which included 31 participants, during the period of 26th September to 3rd October 2022. Our results were shared with the Ethics Committee following the completion of the pilot study. A reliability coefficient of 0.826 was found for the awareness questionnaire.

2.4. Statistical analysis

For the purpose of entering and analyzing all the collected data, Microsoft Excel was used. As a statistical analysis, IBM SPSS version 24.0 (Armonk, NY, USA) was used (IBM Corporation, Armonk, NY, USA). In addition to estimating the prevalence, confidence intervals of 95% were calculated. Pearson's chi-square test and multivariate analysis (Risk ratios) were used to determine and quantify the associations between risk factors and awareness and the variables considered. This study has been set at the significance level of $p < 0.05$for the entire dataset.

3. Results

We analyzed the data of 713 participants, 474 (66.5%) of whom were males and 239 (33.5%) of whom were females. We found significant differences in the gender of participants as well as their family history of DM. A majority (52.6%) of the participants were between the ages of 18 and 39 in this study. Most participants were graduates, followed by secondary school 30.5%, postgraduate 9.7%, primary school 6.4%, and illiterate 2.8%. In the current study 23.3% participants smokers, 97.1% of whom knew about diabetes mellitus, and 69% of participants had a family history of the diabetes. The prevalence of diabetes in the family of the participants was 34.1% for fathers, 28.8% for mothers, and 16.5% for siblings. Physically active: 16% of participants were physically active, 43.9% of participants did some exercise or were physically active sometimes, and 40.1% of participants did not participate in any physical activity at all in the current study. Of the participants, 30.2% had high blood pressure, 64% had increase level of cholesterol, and 36.7% were overweight and obese. A majority of 84.2% of participants knew diabetes affected the organs. Furthermore, 46.7% of the participants in this study had high diabetes risk according to the ADA scale (Table1).

The risk of diabetes was 76.3% higher among participants with a family history of diabetes. There is a 41.1% chance of diabetes among those participants whose fathers had diabetes, and a 39.3% chance of diabetes among those participants whose mothers had diabetes. Additionally, those participants who have siblings with diabetes are at high risk for developing diabetes at 24% (Table 2).

3.1. Diabetes family history and risk level among non-diabetics

The prevalence of the risk of having a family history of diabetes is higher in the women in the family (RR = 3.12; $P = 0.0001$) as compared to the men in the family (RR = 1.9; $P = 0.0001$), but risk of diabetes more in the male (1.13 times higher). The majority of participants (n = 682, 95.7%) knew diabetes is a common health problem, among whom those with diabetic family members were much more aware (RR = 2.38; P=<0.0001) about it, diabetes as a common health problem among the study participants, with a particularly heightened awareness observed in individuals with diabetic family members. And out of 682 participants most (n = 329, 98.8%) of the participants were also in the diabetic risk subject in the current study. The study also found that 286 participants did not participate in physical activity despite a family history of diabetes (n = 188, 38.2%), and these individuals were $\sim$ 1.3 times more likely to develop diabetes than those who did participate in physical activity (RR = 1.23; $P = 0.14$). Furthermore, 64% of participants stated that they had high cholesterol, but they did not have severe chances of diabetes, they were at moderate to mild risk levels of developing diabetes (RR = 1.05; $P = 0.64$). A total of 337 (47.3%) participants out of 713 individuals had high blood pressure. Among them, most of the participants (n = 238, 48.4%) had family members who had diabetes mellitus. Participants with high blood pressure had a $\sim$ 1.3 times increased risk of developing diabetes than those without high blood pressure (RR = 1.29; $P = 0.11$). Participants who smoked cigarettes had the only mild risk of developing diabetes (RR = 1.10; $P = 0.06$), since smoking was not included in the ADA's risk calculation. Similarly, a majority (84.2%) of participants were aware that diabetes can affect other organs of the body, but those participants with family members who have been affected by diabetes were more likely to know (RR = 2.38, P= <0.0001) than those without diabetes family members. The majority of the participants were also aware that obesity is also a chronic

Table 1
Demographic information of participants and association with family history of DM.

Item	Categories	N(%) = 713	χ2(P-value)
Gender	Male	474(66.5)	7.55(0.05)
	Female	239(33.5)	
Age	18–39	375(52.6)	6.17(0.10)
	40–49	192(26.9)	
	50–59	104(14.6)	
	60 or older	42(5.9)	
Education level	illiterate	20(2.8)	29.89(0.000)
	Primary schooling	46(6.4)	
	Secondary schooling	217(30.5)	
	Graduate	361(50.6)	
	Post graduate	69(9.7)	
So you smoke	Yes	166(23.3)	17.6(0.000)
	No	547(76.7)	
Heard about DM	Yes	692(97.1)	0.65(0.48)
	No	21(2.9)	
Family history of DM	Yes	492(69.0)	0
	No	221(30.9)	
Father have DM	Yes	243(34.1)	164.3(0.000)
	No	470(65.7)	
Mother have DM	Yes	205(28.8)	128.2(0.000)
	No	508(71.2)	
Sibling have DM	Yes	118(16.5)	53.0(0.000)
	No	595(83.5)	
Are you Physically active	Yes	114(16.0)	7.81(0.02)
	Sometime	313(43.9)	
	No	286(40.1)	
Do you have high blood pressure	Yes	215(30.2)	5.10(0.01))
	No	498(69.8)	
Do you have high cholesterol	Yes	456(64.0)	2.85(0.24)
	Not sure	133(18.7)	
	No	124(17.4)	
Diagnosed with GDM (Women)	Yes	55(7.7)	13.1(0.000)
	No	658(92.3)	
Do you think diabetes affect organs	Yes	600(84.2)	3.05(0.05)
	No	113(15.8)	
BMI	Underweight	199(27.9)	1.26(0.73)
	Normal	252(35.3)	
	Overweight	226(31.7)	
	Obese	36(5.0)	
DM risk test according to ADA scale	No risk/low	380(53.3)	14.7(0.000)
	High risk	333(46.7)	
Awareness level	Poor	82(11.5)	5.29(0.07)
	Moderate	298(41.8)	
	Good	333(46.7)	

disease, and it is associated with a higher risk of developing diabetes as a result of being overweight and obese (Table 3).

3.2. Family history of diabetes and risk level in non-diabetes participants about their lifestyle knowledge and behavior

As a result of this study, we found that there was some lack of knowledge about consuming soft drinks. The majority of participants taking soft drinks among them knew that they had a family history of diabetes, and these individuals had a significant level (RR = 1.3; P = 0.03) of diabetes risk. Participants who consumed a high amount of animal products (meat, milk, eggs, etc.) also had a significantly higher risk of diabetes (RR = 1.4; P = 0.04). Among participants with a family history of diabetes, 3.8 times more vegetables were consumed (RR = 3.8; P = 0.003). In contrast, those who did not consume vegetables had a higher risk of developing diabetes (sometimes vegetables = 2.0 times; really using vegetables = 1.1 times). The majority of those who have a family history of diabetes consume more fruit in their daily lives (RR = 2.4; P=<0.0001) than those who do not have a family history of diabetes. In addition, those who took fruits for a longer period of time had a reduced risk of diabetes than those who took fruits for a shorter period of time (RR = 1.8; P = 0.14). A higher risk of diabetes was also associated with the consumption of candy (89.3%; 1.13 times higher) and junk food (86.1%; 1.2 times higher). In the current study, coffee consumption was associated with an increased risk of diabetes (RR = 1.29; P = 0.25). The majority of participants (n = 334; 46.8%) reported consuming bakery items, and among them, a majority of participants (n = 261; 53%) had a family history of diabetes. A severe (1.6 times higher) risk of diabetes is associated with the consumption of more bakery items (RR = 1.62; P=<0.0001). There was a mild association between eating more dry fruits and diabetes risk (Table 4).

4. Discussion

There are very few studies in Saudi Arabia that have examined diabetes awareness knowledge based on their family history of diabetes and risk levels among non-diabetic individuals. There is a mild to moderate association between family history and T2D. In the current study, 76% of participants had families with a history of diabetes. Of these participants, 41.1% were at high risk of diabetes if their father had diabetes, 39.3% were at high risk of diabetes if their mother had diabetes, and 24% had diabetes risk if they were siblings. All of this information is based on a diabetes risk test conducted by the ADA. It is only possible to calculate the diabetes risk ratio accurately by measuring the fasting blood glucose level (ADA). As far as family history and T2D incidence

Table 2
Multivariate analysis for diabetes risk levels in different categories of participants.

Item	Categories	N(%)	Family history of DM				Diabetes Risk test			
			Yes	95%CI	P-value	No*	Higher risk	95%CI	P-value	Low/ no risk **
Gender	Male	474 (66.5)	311 (63.2)	1.90(1.5–2.3)	< 0.0001	163 (73.8)	252(75.7)	1.13(0.91–1.4)	0.26	222(58.4)
	Female	239 (33.5)	181 (36.8)	3.12(2.2–4.4)	< 0.0001	58(26.2)	81(24.3)	0.51(0.37–0.70)	< 0.0001	158(41.6)
Diabetes is a common health problem	Yes	682 (95.7)	479 (97.4)	2.38(1.9–2.8)	< 0.0001	201 (91.8)	329(98.8)	0.93(0.78–1.1)	0.45	353(92.9)
	No	31(4.3)	13(2.6)	0.70(0.30–1.7)	0.46	18(8.2)	4(1.2)	0.14(0.04–0.47)	0.001	27(7.1)
Could diabetes be prevented	Yes	594 (83.3)	425 (86.4)	2.54(2.0–3.14)	< 0.0001	167 (76.3)	282(84.7)	0.90(0.74–1.1)	0.31	312(82.1)
	No	119 (16.7)	67(13.6)	1.28(0.82–2.0)	0.26	52(23.7)	51(15.3)	0.75(0.48–1.16)	0.2	68(17.9)
Are you Physical active	Yes	114(16)	72(14.6)	1.71(1.08–2.7)	0.02	42(19.0)	50(15.0)	0.78(0.49–1.2)	0.28	64(16.8)
	Not regularly	313 (43.9)	232 (47.2)	2.86(2.12–3.8)	< 0.0001	81(36.7)	125(37.5)	0.67(0.5–0.87)	0.003	188(49.5)
	No	286 (40.1)	188 (38.2)	1.91(1.42–2.5)	< 0.0001	98(44.3)	158(47.4)	1.23(0.92–1.6)	0.14	128(33.7)
High cholesterol	Yes	456 (64.0)	324 (65.9)	2.45(1.9–3.12)	< 0.0001	132 (59.7)	234(70.3)	1.05(0.84–1.3)	0.64	222(58.4)
	Not sure	133 (18.7)	83(16.9)	1.67(1.08–2.5)	0.01	50(22.6)	34(10.2)	0.34(0.21–0.54)	< 0.0001	99(26.1)
	No	124 (17.4)	85(17.3)	2.17(1.38–3.4)	0.0008	39(17.6)	65(19.5)	1.1(0.71–1.6)	0.66	59(15.5)
High blood pressure	Yes	337 (47.3)	238 (48.4)	2.4(1.8–3.1)	< 0.0001	99(44.8)	186(55.9)	1.23(0.94–1.6)	0.11	151(39.7)
	Not sure	183 (25.7)	121 (24.6)	1.95(1.35–2.8)	0.0004	62(28.1)	56(16.8)	0.44(0.30–0.64)	< 0.0001	127(33.4)
	No	193 (27.1)	133 (27.0)	2.2(1.53–3.19)	< 0.0001	60(27.1)	91(27.3)	0.89(0.63–1.26)	0.51	102(26.8)
Smoking cigarettes	Yes	320 (44.9)	223 (45.3)	2.29(1.7–3.05)	< 0.0001	97(43.9)	180(54.1)	1.28(0.98–1.6)	0.06	140(36.8)
	Sometime	139 (19.5)	90(18.3)	1.83(1.20–2.7)	0.004	49(22.2)	57(17.1)	0.69(0.46––1.0)	0.08	82(21.6)
	No	254 (35.6)	179 (36.4)	2.38(1.7–3.2)	< 0.0001	75(33.9)	96(28.8)	0.60(0.44–0.82)	0.001	158(41.6)
Diabetes affect other body organs	Yes	600 (84.2)	423 (86.0)	2.38(1.9–2.9)	< 0.0001	177 (80.1)	302(90.7)	1.01(0.83–1.2)	0.89	298(78.4)
	No	113 (15.8)	69(14.0)	1.56(0.99–2.4)	0.05	44(19.9)	31(9.3)	0.37(0.23–0.61)	0.0001	82(21.6)
Being overweight or obese	Yes	651 (91.3)	449 (91.3)	2.2(1.8–2.7)	< 0.0001	202 (91.4)	309(92.8)	0.90(0.74–1.0)	0.29	342(90)
	Not sure	10(1.4)	5(1.0)	1.0(0.21–4.5)	1	5(2.3)	3(0.9)	0.42(0.08–2.1)	0.3	7(1.8)
	No	52(7.3)	38(7.7)	2.71(1.31–5.5)	0.006	14(6.3)	21(6.3)	0.67(0.34–1.32)	0.25	31(8.2)

*No– Participants without a family history of DM were used as a reference;
** Low/No risk – participants with low or no risk of DM were used as a reference.

are concerned, the European countries did not show any evidence of heterogeneity. The risk was even higher for individuals with two or more relatives with diabetes or with a younger mother's diagnosis (Scott et al., 2013). Having a diabetic spouse increases your risk of developing diabetes, confirming there are shared environmental factors involved (Khan et al., 2003). Even so, only a minority of women's risks could be explained by lifestyle and anthropometric factors in an analysis of the only large prospective study that examined the interaction between family history and risk in an attractive prospective setting (van 't Riet et al., 2010, Abdulghani et al., 2023). Biological parents who had diabetes posed a sustained increase in the risk of T2D (Hemminki et al., 2010). In another Swedish, study reported that A family risk greater than 30% can be considered clinically relevant when two siblings have diabetes (Hemminki et al., 2010). Diabetes awareness was higher or moderate among participants with secondary or higher education, as 90.0% had such education. There is a correlation between education and diabetes awareness scores in other parts of the world, consistent with the finding and evidence that education plays a significant role in the knowledge of diabetes. Approximately 90% of the participants had secondary or higher education, which may account for higher or moderate levels of diabetes awareness. In other parts of the world, there have been many studies that have found a positive correlation between educational attainment and diabetes awareness score, which is consistent with the fact that education is a predictor of diabetes awareness in other parts of the world (Al Shafaee et al., 2008, Kassahun and Mekonen, 2017). The current study found that many participants believed diabetes was a common problem among them, especially those with a family history of diabetes. An identical finding was reported by many studies: If one family member had a diabetes problem, more or less everyone in the family knew about diabetes(Kassahun and Mekonen, 2017, Scott et al., 2013, Sargeant et al., 2000, H. M. Abdulghani; M. M Ahmed; A. M. Al-Rezqi; S. A. Althunayan, 2021). In the current study, diabetes awareness scores were not equally distributed among physically active and non-active indi-

Table 3
Multivariate analysis of association of knowledge and behaviors factors with their diabetes risk levels.

Item	Categories	N(%)	Family history of DM				Diabetes Risk test			
			Yes	95%CI	P-value	No *	Higher risk	95%CI	p-value	Low/ no risk **
Drinking good amount of soft drinks	Yes	617 (86.7)	420 (85.4)	2.1(1.7–2.6)	< 0.0001	197 (90.0)	308(92.5)	1.3(0.8–1.5)	0.03	311(81.8)
	Sometime	54(7.6)	46(9.3)	5.7(2.4–13.3)	< 0.0001	8(3.7)	18(5.4)	0.50(0.2–0.9)	0.04	36(9.5)
	No	40(5.6)	26(5.3)	1.8(0.84–4.0)	0.12	14(6.4)	7(2.1)	0.2(0.08–0.5)	0.001	33(8.7)
Consuming lots of animal products	Yes	222 (31.1)	148 (30.1)	2.0(1.43–2.7)	0.0001	74(33.8)	129(38.7)	1.4(1.0–1.9)	0.04	93(24.5)
	Sometime	132 (18.5)	90(18.3)	2.1(1.38–3.3)	0.0007	42(19.2)	66(19.8)	1(0.6–1.5)	1	66(17.4)
	No	359 (50.4)	254 (51.6)	2.4(1.8–3.2)	< 0.0001	103 (47.0)	138(41.4)	0.62(0.4–0.8)	0.003	221(58.2)
Eating more vegetables	Yes	39(5.5)	31(6.3)	3.8(1.5–9.4)	0.003	8(3.7)	10(3.0)	0.34(0.14–0.8)	0.01	29(7.6)
	Sometime	24(3.4)	14(2.8)	1.4(0.52–3.7)	0.5	10(4.6)	16(4.8)	2.0(0.7–5.5)	0.18	8(2.1)
	No	650 (91.2)	447 (90.9)	2.2(1.8–2.7)	< 0.0001	201 (91.8)	307(92.2)	1.1(0.7–1.3)	0.24	343(90.3)
Eating lots of fruits	Yes	157 (22.0)	112 (22.8)	2.4(1.6–3.7)	< 0.0001	45(20.5)	70(21.0)	0.8(0.54–1.1)	0.26	87(22.9)
	Sometime	37(5.2)	23(4.7)	1.6(0.73–3.6)	0.22	14(6.4)	24(7.2)	1.8(0.81–4.1)	0.14	13(3.4)
	No	519 (72.8)	357 (72.6)	2.2(1.7–2.7)	< 0.0001	160 (73.1)	239(71.8)	0.85(0.6–1.0)	0.14	280(73.7)
Eating candy in daily life	Yes	637 (89.3)	446 (90.7)	2.3(1.9–2.8)	< 0.0001	189 (86.3)	307(92.2)	1.13(0.9–1.3)	0.18	330(86.8)
	Sometime	25(3.5)	16(3.3)	1.7(0.66–4.7)	0.25	9(4.1)	12(3.6)	0.92(0.3–2.4)	0.87	13(3.4)
	No	51(7.2)	30(6.1)	1.4(0.72–2.8)	0.3	21(9.6)	14(4.2)	0.37(0.18–0.7)	0.008	37(9.7)
Eating junk food or market food	Yes	614 (86.1)	428 (87.0)	2.3(1.8–2.8)	< 0.0001	184 (84.0)	301(90.4)	1.2(1.0–1.4)	0.02	313(82.4)
	Sometime	55(6.2)	35(7.1)	1.7(0.90–3.4)	0.09	20(9.1)	22(6.6)	0.67(0.34–1.2)	0.22	33(8.7)
	No	44(6.2)	29(5.9)	1.9(0.9–4.09)	0.08	15(6.8)	10(3.0)	0.29(0.12–0.6)	0.003	34(8.9)
Drinking Coffee (Everyday)	Yes	117 (16.4)	89(18.1)	3.1(1.9–5.2)	< 0.0001	28(12.8)	66(19.8)	1.29(0.82–2.0)	0.25	51(13.4)
	Sometime	132 (18.5)	85(17.3)	1.8(1.1–2.7)	0.007	47(21.5)	59(17.7)	0.80(0.53–1.2)	0.31	73(19.2)
	No	464 (65.1)	318 (64.6)	2.2(1.7–2.7)	< 0.0001	144 (65.8)	208(62.5)	0.81(0.64–1.0)	0.06	256(67.4)
Consuming more bakery items	Yes	334 (46.8)	261 (53.0)	3.5(2.6–4.8)	< 0.0001	73(33.4)	207(62.1)	1.62(1.2–2.1)	0.0004	127(33.4)
	Sometime	254 (35.6)	147 (29.8)	1.3(1.01–1.8)	0.04	107 (48.8)	73(21.9)	0.40(0.29–0.5)	< 0.0001	181(47.6)
	No	123 (17.3)	84(17.0)	2.1(1.3–3.3)	0.0009	39(17.8)	53(15.9)	0.75(0.48–1.1)	0.21	70(18.4)
Eating dry fruits	Yes	201 (28.2)	57(25.8)	0.3(0.27–0.5)	0.0001	144 (29.3)	109(32.7)	1.18(0.84–1.6)	0.32	92(24.2)
	Sometime	182 (25.5)	62(28.1)	0.51(0.3–0.7)	0.0005	120 (24.4)	85(25.5)	0.87(0.61–1.2)	0.46	97(25.5)
	No	330 (46.3)	102 (46.2)	0.44(0.3–0.5)	< 0.0001	228 (46.3)	139(41.7)	0.72(0.5–0.95)	0.01	191(50.3)

*No– Participants without a family history of DM were used as a reference;
** Low/No risk – participants with low or no risk of DM were used as a reference.

Table 4
Link of Family History with ADA risk scale.

Diabetes history	Categories	N(%)	ADA Risk scale	
			High risk	No risk/ Low
Family history	Yes	333(46.7)	254 (76.3)	79(23.7)
Father	Yes	333(46.7)	137(41.1)	196(58.9)
Moher	Yes	333(46.7)	131(39.3)	202(60.7)
Siblings	Yes	333(46.7)	80(24.0)	253(76.0)

viduals, but physically inactive people had high diabetes risk scores. Hot weather during most of the year may prevent physical activity in the Saudi population(Al-Drees et al., 2016, Kanaley et al., 2022, Teich et al., 2019). There was a mild level of diabetes risk due

to high cholesterol in 64% of the current study participants. People with diabetes are at an increased risk of hypertension, heart disease, retinopathy and foot problems due to the uncontrolled hemoglobin A1c levels, as well as high serum cholesterol levels (Hsu et al., 2000, Ravid et al., 1998, Abdulghani et al., 2018). Our finding similar with, Hypertensive participants also had a significantly high diabetes risk score(Vesa et al., 2020, Abdulghani et al., 2021). When you do not engage in physical activity, you may gain weight as a result of a sedentary lifestyle. Obesity is a risk factor for metabolic diseases, particularly diabetes. Almost ~ 92% of participants who were aware of being overweight or obese had chronic health conditions, including diabetes. Participants from other countries were also at a higher risk of diabetes if they were obese or overweight(Al-Thani et al., 2019, Fatema et al., 2017). Microvascular diabetes complications are affected differently by smoking in different reports. Smoking has been shown to adversely affect diabetic nephropathy in several studies, but its effect on retinopathy and neuropathy is unclear(Targher et al., 1997). The current study found that smokers had ~ 1.3 times higher chance of diabetes than those who didn't smoke. Animal protein, saturated fat, and refined carbohydrates are typically found in a diet that is low in these foods and high in animal protein. There is an increase in diabetes due to the consumption of more animal products and protein (Trapp and Barnard, 2010).

Many evidence base study reported that the healthy or low carbohydrate containing diet reduced the glycemic index and BMI of the people with diabetes (Baqer et al., 2022 & Al-Ozairi et al., 2022).

The risk of diabetes was higher (1.4 times) in participants who consumed more animal products than in those who consumed the least in the current study. Similar study found that, in cross-sectional and prospective studies, eating meat regularly may increase diabetes risk by as much as twice compared to avoiding meat altogether(Vang et al., 2008, Tonstad et al., 2013). Other dietary components influence insulin sensitivity in food trials or protect against diabetes in observational studies (Jenkins et al., 2003). Vegetarian diets are high in vegetables and fruit, which reduce oxidative stress, chronic inflammation, and free radical damage. There is evidence that vegans consume an average of one-third more vegetables and fruits each day than non-vegetarians do on a daily basis (Tonstad et al., 2009). These dietary components have been shown to reduce type 2 diabetes by 40% based on observational studies(Jenkins et al., 2003). Additionally, we found that individuals who consume fruits and vegetables are much less likely to develop diabetes. Bakery products are widely consumed in the KSA. A local and international study found that participants who consumed more bakery products had significantly higher risk scores for diabetes (Abdulghani et al., 2021, Midhet et al., 2010, Hodge et al., 2007). Several studies have shown that dietary changes are effective in delaying or preventing type 2 diabetes(Wang et al., 2016). Many evidence base study reported that the healthy or low carbohydrate containing diet reduced the glycemic index and BMI of the people with diabetes (Baqer et al., 2022, Al-Ozairi et al., 2023). Study participants' awareness of diabetes affects their other body organs, as we found in the current study. Diabetes can damage the blood vessels anywhere in the body over time, from the legs to the kidneys to the eyes, which is called diabetic vascular disease. There is a close correlation between excessive visceral obesity and cardiovascular diseases, as well as the cardiovascular risk factors associated with excess visceral obesity and type 2 diabetes mellitus (Ford, 2005, Yusuf et al., 2005). There are a few limitations to be addressed. Using the convenience sampling method, the participants were selected from one of Saudi Arabia's biggest cities, Riyadh. Therefore, it was not possible to generalize the findings of the study. A study could be conducted on this matter in more depth about the same disciplines. A participant without a medical record is also excluded from the current study.

5. Conclusion

Proactive public health awareness campaigns can reduce diabetes prevalence risks in the general population, particularly among the elderly, those with less education, and those who are physically inactive and obese. The data underscores the significance of family history as a key factor in diabetes risk assessment. This highlights the strength and independence of family history as a risk factor for T2D. T2D etiology can be better understood by understanding the factors explaining the relationship between family history and risk. Adopting a healthier lifestyle by limiting soft drink consumption and moderating the intake of animal products may play a significant role in reducing the risk of diabetes among susceptible individuals. Saudi Arabia was at high risk of diabetes, which necessitated evidence-based lifestyle modifications.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgement

The authors extend their appreciation to the Deputyship for Research and Innovation, "Ministry of Education" in Saudi Arabia for funding this research (IFKSUOR3-063-2).

Participant consent and Ethics approval

Institutional review board approval was obtained from the college of medicine at KSU for the study protocol. Participants were required to consent to participate in the study before completing the questionnaires.

References

Abdulghani, H., Ahmed, M., Al-Rezqi, A., Althunayan, S., Mran, A., Alshaya, A., Alharbi, F., Abdulghani, A., Ahmad, T., 2021. Knowledge and awareness levels of diabetes mellitus risk factors among nondiabetic visitors of primary health care centers: a multicenter study. Eur. Rev. Med. Pharmacol. Sci. 25, 7066–7077.

Abdulghani, H.M., Alrajeh, A.S., Alsalman, B.H., Alturki, L.S., Alnajashi, N.S., Irshad, M., Alharbi, K.H., Albalawi, Y.E., Alsuliman, Y.A., Ahmad, T., 2018. Prevalence of diabetic comorbidities and knowledge and practices of foot care among diabetic patients: a cross-sectional study. Diabetes Metab. Syndr. Obes. 11, 417–425.

H. M. ABDULGHANI; M. M AHMED; A. M. AL-REZQI; S. A. ALTHUNAYAN, A. L. M., ; A. K. ALSHAYA,; F. K. ALHARBI,; A. H. ABDULGHANI,; T. AHMAD. 2021. Knowledge and awareness levels of diabetes mellitus risk factors among nondiabetic visitors of primary health care centers: a multicenter study. *Eur Rev Med Pharmacol Sci,* 25**,** 7066-7077.

ABDULGHANI, H. M., ALANAZI, K., ALOTAIBI, R., ALSUBEEH, N. A., AHMAD, T. & HAQUE, S. 2023. Prevalence of Potential Dropout Thoughts and Their Influential Factors Among Saudi Medical Students. 13**,** 21582440221146966.

(ADA), A. D. A. 2022. Risk Test. https://diabetes.org/diabetes/risk-test.

AL SHAFAEE, M. A., AL-SHUKAILI, S., RIZVI, S. G., AL FARSI, Y., KHAN, M. A., GANGULY, S. S., AFIFI, M. & AL ADAWI, S. 2008. Knowledge and perceptions of diabetes in a semi-urban Omani population. *BMC Public Health,* **8,** 249.

Al-Drees, A., Abdulghani, H., Irshad, M., Baqays, A.A., Al-Zhrani, A.A., Alshammari, S. A., Alturki, N.I., 2016. Physical activity and academic achievement among the medical students: A cross-sectional study. Med. Teach. 38 (Suppl 1), S66–S72.

Alluhaymid, Y.M., Alotaibi, F.Y., Alotaibi, A.B., Albasha, A.M., Alnaim, A.S., Sabi, E.M., Mujamammi, A.H., 2020. Awareness of diabetic retinopathy among Saudis with diabetes type 2 in Riyadh city. J. Family Med. Prim. Care 9, 4229–4233.

Al-Ozairi, A., Taghadom, E., Irshad, M., Al-Ozairi, E., 2023. Association between depression, diabetes self-care activity and glycemic control in an Arab population with type 2 diabetes. Diabetes Metab. Syndr. Obes. 16, 321–329.

Alramadan, M.J., Magliano, D.J., Almigbal, T.H., Batais, M.A., Afroz, A., Alramadhan, H.J., Mahfoud, W.F., Alragas, A.M., Billah, B., 2018. Glycaemic control for people

with type 2 diabetes in Saudi Arabia - an urgent need for a review of management plan. BMC Endocr. Disord. 18, 62.
AL-RESHED, F., SINDHU, S., AL MADHOUN, A., BAHMAN, F., ALSAEED, H., AKHTER, N., MALIK, M. Z., ALZAID, F., AL-MULLA, F. & AHMAD, R. 2023. Low carbohydrate intake correlates with trends of insulin resistance and metabolic acidosis in healthy lean individuals. 11.
Al-Thani, A.-A., Farghaly, A., Akram, H., Khalifa, S., Vinodson, B., Loares, A., Abou-Samra, A.-B., 2019. Knowledge and perception of diabetes and available services among diabetic patients in the state of Qatar. Central Asian J. Glob. Health 8.
BAQER, A., IRSHAD, M., AZIZIEH, M., MURAD, S., TAGHADOM, E., ALKANDARI, J. & AL OZAIRI, E. 2022. The Effect of Low-Carbohydrate Diet on Glycemic Control and Body Weight in People with Type 1 Diabetes. *Endocrine Practice,* 28**,** S32.
CAMERON, N. 1978. The Methods of Auxological Anthropometry. *In:* FALKNER, F. & TANNER, J. M. (eds.) *Human Growth: 2 Postnatal Growth.* Boston, MA: Springer US.
CHALMERS, J., MACMAHON, S., MANCIA, G., WHITWORTH, J., BEILIN, L., HANSSON, L., NEAL, B., RODGERS, A., NI MHURCHU, C. & CLARK, T. 1999. 1999 World Health Organization-International Society of Hypertension Guidelines for the management of hypertension. Guidelines sub-committee of the World Health Organization. *Clin Exp Hypertens,* 21**,** 1009-60.
Demaio, A.R., Otgontuya, D., de Courten, M., Bygbjerg, I.C., Enkhtuya, P., Oyunbileg, J., Meyrowitsch, D.W., 2013. Exploring knowledge, attitudes and practices related to diabetes in Mongolia: a national population-based survey. BMC Public Health 13, 236.
Fatema, K., Hossain, S., Natasha, K., Chowdhury, H.A., Akter, J., Khan, T., Ali, L., 2017. Knowledge attitude and practice regarding diabetes mellitus among Nondiabetic and diabetic study participants in Bangladesh. BMC Public Health 17, 1–10.
FORD, E. S. 2005. Prevalence of the metabolic syndrome defined by the International Diabetes Federation among adults in the U.S. *Diabetes Care,* 28**,** 2745-9.
GIUSTINI, D., ALI, S. M., FRASER, M. & KAMEL BOULOS, M. N. 2018. Effective uses of social media in public health and medicine: a systematic review of systematic reviews. *Online J Public Health Inform,* 10**,** e215.
Hemminki, K., Li, X., Sundquist, K., Sundquist, J., 2010. Familial risks for type 2 diabetes in Sweden. Diabetes Care 33, 293–297.
Hodge, A.M., English, D.R., O'Dea, K., Giles, G.G., 2007. Dietary patterns and diabetes incidence in the Melbourne Collaborative Cohort Study. Am. J. Epidemiol. 165, 603–610.
Hsu, C.-Y., Bates, D.W., Kuperman, G.J., Curhan, G.C., 2000. Diabetes, hemoglobin A1c, cholesterol, and the risk of moderate chronic renal insufficiency in an ambulatory population. Am. J. Kidney Dis. 36, 272–281.
IDF 2017. International Diabetes Federation. *IDF Diabetes Atlas,* 6th ed. Brussels: IDF; 2017.
Jenkins, D.J., Kendall, C.W., Marchie, A., Jenkins, A.L., Augustin, L.S., Ludwig, D.S., Barnard, N.D., Anderson, J.W., 2003. Type 2 diabetes and the vegetarian diet. Am. J. Clin. Nutr. 78, 610s–616s.
Kaiser, A.B., Zhang, N., der Pluijm, W.V., 2018. Global prevalence of type 2 diabetes over the next ten years (2018–2028). Diabetes 67.
Kanaley, J.A., Colberg, S.R., Corcoran, M.H., Malin, S.K., Rodriguez, N.R., Crespo, C.J., Kirwan, J.P., Zierath, J.R., 2022. Exercise/physical activity in individuals with type 2 diabetes: A consensus statement from the American College of Sports Medicine. Med. Sci. Sports Exerc. 54, 353–368.
Kassahun, C.W., Mekonen, A.G., 2017. Knowledge, attitude, practices and their associated factors towards diabetes mellitus among non diabetes community members of Bale Zone administrative towns, South East Ethiopia. A cross-sectional study. PLoS One 12, e0170040.
Kearns, K., Dee, A., Fitzgerald, A.P., Doherty, E., Perry, I.J., 2014. Chronic disease burden associated with overweight and obesity in Ireland: the effects of a small BMI reduction at population level. BMC Public Health 14, 143.
Khan, A., Lasker, S.S., Chowdhury, T.A., 2003. Are spouses of patients with type 2 diabetes at increased risk of developing diabetes? Diabetes Care 26, 710–712.
Looker, H.C., Nyangoma, S.O., Cromie, D.T., Olson, J.A., Leese, G.P., Black, M.W., Doig, J., Lee, N., Lindsay, R.S., McKnight, J.A., Morris, A.D., Pearson, D.W., Philip, S., Wild, S.H., Colhoun, H.M., 2014. Rates of referable eye disease in the Scottish National Diabetic Retinopathy Screening Programme. Br. J. Ophthalmol. 98, 790–795.
Mathers, C.D., Loncar, D., 2006. Projections of global mortality and burden of disease from 2002 to 2030. PLoS Med. 3, e442.
Mayeda, E.R., Haan, M.N., Kanaya, A.M., Yaffe, K., Neuhaus, J., 2013. Type 2 diabetes and 10-year risk of dementia and cognitive impairment among older Mexican Americans. Diabetes Care 36, 2600–2606.
Midhet, F.M., Al-Mohaimeed, A.A., Sharaf, F.K., 2010. Lifestyle related risk factors of type 2 diabetes mellitus in Saudi Arabia. Saudi Med. J. 31, 768–774.
Minhat, H.S., Hamedon, T.R., 2014. Understanding towards diabetes mellitus among rural adult community in Malaysia. World J. Med. Sci. 11, 217–221.
Peters, S.A., Huxley, R.R., Woodward, M., 2014. Diabetes as a risk factor for stroke in women compared with men: a systematic review and meta-analysis of 64 cohorts, including 775,385 individuals and 12,539 strokes. Lancet 383, 1973–1980.
RAVID, M., BROSH, D., RAVID-SAFRAN, D., LEVY, Z. & RACHMANI, R. J. A. O. I. M. 1998. Main risk factors for nephropathy in type 2 diabetes mellitus are plasma cholesterol levels, mean blood pressure, and hyperglycemia. 158**,** 998-1004.
ROBERT, A. A., AL AWAD, A. D. & AL DAWISH, M. A. 2020. Current Status of Knowledge and Awareness of Diabetes Mellitus in Saudi Arabia. *Curr Diabetes Rev*.
Sargeant, L.A., Wareham, N.J., Khaw, K.T., 2000. Family history of diabetes identifies a group at increased risk for the metabolic consequences of obesity and physical inactivity in EPIC-Norfolk: a population-based study. The European Prospective Investigation into Cancer. Int. J. Obes. Relat. Metab. Disord. 24, 1333–1339.
Scott, R.A., Langenberg, C., Sharp, S.J., Franks, P.W., Rolandsson, O., Drogan, D., van der Schouw, Y.T., Ekelund, U., Kerrison, N.D., Ardanaz, E., Arriola, L., Balkau, B., Barricarte, A., Barroso, I., Bendinelli, B., Beulens, J.W., Boeing, H., De Lauzon-Guillain, B., Deloukas, P., Fagherazzi, G., Gonzalez, C., Griffin, S.J., Groop, L.C., Halkjaer, J., Huerta, J.M., Kaaks, R., Khaw, K.T., Krogh, V., Nilsson, P.M., Norat, T., Overvad, K., Panico, S., Rodriguez-Suarez, L., Romaguera, D., Romieu, I., Sacerdote, C., Sánchez, M.J., Spijkerman, A.M., Teucher, B., Tjonneland, A., Tumino, R., van Der, A.D., Wark, P.A., McCarthy, M.I., Riboli, E., Wareham, N.J., 2013. The link between family history and risk of type 2 diabetes is not explained by anthropometric, lifestyle or genetic risk factors: the EPIC-InterAct study. Diabetologia 56, 60–69.
Sun, H., Saeedi, P., Karuranga, S., Pinkepank, M., Ogurtsova, K., Duncan, B.B., Stein, C., Basit, A., Chan, J.C.N., Mbanya, J.C., Pavkov, M.E., Ramachandaran, A., Wild, S.H., James, S., Herman, W.H., Zhang, P., Bommer, C., Kuo, S., Boyko, E.J., Magliano, D. J., 2022. IDF Diabetes Atlas: Global, regional and country-level diabetes prevalence estimates for 2021 and projections for 2045. Diabetes Res. Clin. Pract. 183, 109119.
Targher, G., Alberiche, M., Zenere, M.B., Bonadonna, R.C., Muggeo, M., Bonora, E., 1997. Cigarette smoking and insulin resistance in patients with noninsulin-dependent diabetes mellitus. J. Clin. Endocrinol. Metab. 82, 3619–3624.
Teich, T., Zaharieva, D.P., Riddell, M.C., 2019. Advances in exercise, physical activity, and diabetes mellitus. Diabetes Technol. Ther. 21, S112–S122.
Tonstad, S., Butler, T., Yan, R., Fraser, G.E., 2009. Type of vegetarian diet, body weight, and prevalence of type 2 diabetes. Diabetes Care 32, 791–796.
Tonstad, S., Stewart, K., Oda, K., Batech, M., Herring, R.P., Fraser, G.E., 2013. Vegetarian diets and incidence of diabetes in the Adventist Health Study-2. Nutr. Metab. Cardiovasc. Dis. 23, 292–299.
Trapp, C.B., Barnard, N.D., 2010. Usefulness of vegetarian and vegan diets for treating type 2 diabetes. Curr. Diab. Rep. 10, 152–158.
Ulvi, O.S., Chaudhary, R.Y., Ali, T., Alvi, R.A., Khan, M.F., Khan, M., Malik, F.A., Mushtaq, M., Sarwar, A., Shahid, T., Tahir, N., Tahir, Z., Shafiq, S., Yar, A., Alam, A. Y., 2009. Investigating the awareness level about diabetes mellitus and associated factors in Tarlai (rural Islamabad). J. Pak. Med. Assoc. 59, 798–801.
VAN 'T RIET, E., DEKKER, J. M., SUN, Q., NIJPELS, G., HU, F. B. & VAN DAM, R. M. 2010. Role of adiposity and lifestyle in the relationship between family history of diabetes and 20-year incidence of type 2 diabetes in U.S. women. *Diabetes Care,* 33**,** 763-7.
VANG, A., SINGH, P. N., LEE, J. W., HADDAD, E. H. & BRINEGAR, C. H. 2008. Meats, processed meats, obesity, weight gain and occurrence of diabetes among adults: findings from Adventist Health Studies. *Ann Nutr Metab,* 52**,** 96-104.
VESA, C. M., POPA, L., POPA, A. R., RUS, M., ZAHA, A. A., BUNGAU, S., TIT, D. M., CORB ARON, R. A. & ZAHA, D. C. J. D. 2020. Current data regarding the relationship between type 2 diabetes mellitus and cardiovascular risk factors. 10**,** 314.
Vijh, D., Imam, M.A., Haque, M.M.U., Das, S., Islam, A., Malik, M.Z., 2023. Network pharmacology and bioinformatics approach reveals the therapeutic mechanism of action of curcumin in Alzheimer disease. Metab. Brain Dis. 38, 1205–1220.
Wang, P.Y., Fang, J.C., Gao, Z.H., Zhang, C., Xie, S.Y., 2016. Higher intake of fruits, vegetables or their fiber reduces the risk of type 2 diabetes: A meta-analysis. J. Diabetes Investig. 7, 56–69.
WHO 2021. Global Report on Diabetes https://www.who.int/news-room/fact-sheets/detail/diabetes.
Williams, R., Karuranga, S., Malanda, B., Saeedi, P., Basit, A., Besançon, S., Bommer, C., Esteghamati, A., Ogurtsova, K., Zhang, P., Colagiuri, S., 2020. Global and regional estimates and projections of diabetes-related health expenditure: Results from the International Diabetes Federation Diabetes Atlas. Diabetes Res. Clin. Pract. 162, 108072.
YUSUF, S., HAWKEN, S., OUNPUU, S., BAUTISTA, L., FRANZOSI, M. G., COMMERFORD, P., LANG, C. C., RUMBOLDT, Z., ONEN, C. L., LISHENG, L., TANOMSUP, S., WANGAI, P., JR., RAZAK, F., SHARMA, A. M. & ANAND, S. S. 2005. Obesity and the risk of myocardial infarction in 27,000 participants from 52 countries: a case-control study. *Lancet,* 366**,** 1640-9.
Zannad, F., Cannon, C.P., Cushman, W.C., Bakris, G.L., Menon, V., Perez, A.T., Fleck, P. R., Mehta, C.R., Kupfer, S., Wilson, C., Lam, H., White, W.B., 2015. Heart failure and mortality outcomes in patients with type 2 diabetes taking alogliptin versus placebo in EXAMINE: a multicentre, randomised, double-blind trial. Lancet 385, 2067–2076.