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# Knowledge and awareness levels of diabetes mellitus risk factors among nondiabetic visitors of primary health care centers: a multicenter study

H.M. ABDULGHANI[1], M.M. AHMED[2], A.M. AL-REZQI[2], S.A. ALTHUNAYAN[2], A.L. MRAN[2], A.K. ALSHAYA[2], F. K. ALHARBI[2], A.H. ABDULGHANI[3], T. AHMAD[2]

[1]Department of Medical Education, College of Medicine, King Saud University, Riyadh, Saudi Arabia
[2]Collage of Medicine, King Saud University, Riyadh, Saudi Arabia
[3]King Fahad Medical City, Riyadh, Saudi Arabia

**Abstract. – OBJECTIVE: People with a high risk of developing Type 2 Diabetes Mellitus are primarily due to lifestyle factors and can be reduced by implementing awareness programs. Therefore, this study evaluates the diabetic awareness level, risk factors, and lifestyle behaviors among nondiabetic participants.**

**PATIENTS AND METHODS: This is a cross-sectional study conducted among 538 nondiabetic participants based on American Diabetic Association (ADA) parameters via face-to-face interview. The sample was collected from five different primary health care centers from November 2019 to February 2020. The target population was nondiabetic with age ≥18 years and participants with other serious chronic illnesses, pregnant women, or unable to communicate effectively were excluded.**

**RESULTS: A total of 538 participants without diabetes data were analyzed, of which 363 (67.5%) were males. Good, moderate, and insufficient knowledge of Type 2 Diabetes Mellitus awareness was 34.6%, 52.4%, and 13.0%, respectively. The knowledge level in females' participants was significantly less than the males (OR=2.4; $p$=0.0005). About 44% had diabetic risk, and the prevalence of diabetes risk was significantly high in males (OR=1.7), obesity (OR=2.9), overweight (OR=2.3), and high blood pressure (OR= 2.2) (all $p < 0.05$). The risk of diabetes was increased in those participants who consumed more bakery items ($p < 0.05$). The diabetes risk score was negatively associated with diabetes awareness levels (r= -0.29, $p$= 0.063).**

**CONCLUSIONS: The risk of diabetes in the general population can be prevented by proactive public health awareness campaigns, particularly among elderly age group, with lower educational level, physically inactive, and obese.**

*Key Words:*
Awareness of diabetes, Diabetes risk factors, Non-diabetic population, Prevalence, Saudi Arabia.

## Introduction

Type 2 diabetes mellitus (T2DM) is a chronic metabolic condition characterized by hyperglycemia, primarily initiated by insulin resistance or deficiency. Currently, about 500 million people are living with diabetes worldwide[1]. According to the World Health Organization, diabetes mellitus will be the seventh leading cause of death worldwide by 2030[2,3]. In 2019, 1.5 million deaths were directly caused by diabetes[4]. T2DM related deaths are on the rise, according to a previous study[5]. The death rate is rising due to diabetes related chronic comorbidities, including heart attack[6], stroke[7], and renal failure[8]. International Diabetes Federation (IDF) has estimated that approximately 8.8% of the global population over 20 was affected by diabetes. Compared to other regions of the world, the Middle East and North Africa (MENA) countries have a higher prevalence of diabetes rate and estimated prevalence rate of 9.6% in 2017, expected to rise to 12.1% by 2045[9]. The prevalence of diabetes in Saudi Arabia as a developed country is the highest (17.7 %) in the region and worldwide[10].

The high prevalence of diabetes in MENA is due to urbanization, sedentary lifestyle, high obesity rates, and an aging population in these countries[11]. Diabetes' high prevalence has a major impact on the country's economy, public health system, and population well-being[12]. The onset of diabetes is


*Corresponding Author:* Hamza Mohammad Abdulghani, MD; e-mail: hamzaabg@gmail.com

also linked with lifestyle factors, which reinforces the importance of health education interventions targeting people's behavior change. People at high risk of developing Type 2 diabetes can reduce their chances of getting the condition by more than 80% by the education program[13]. Social media platforms have full health-related content and educate people for a healthy lifestyle and better quality of life[14]. However, fewer people receive health education and awareness information about diabetes on social media platforms. A survey conducted in Omani semi-urban communities reported the awareness of diabetes concepts, symptoms, and complications was only 46.5% to 57.0% in this study population[15]. Similarly, in Mongolia, about 50% of the subpopulation and one-fifth of the total population never heard about diabetes[16]. In Malaysia's about 58% of the rural adult population[17], while about 57% of the Pakistani rural population (Islamabad) had poor knowledge of diabetes[18]. The awareness and knowledge of diabetes mellitus, its risk factors, complications, and treatment have an important role in diabetes control[19]. Although, many diabetic patients do not realize that they have the disease until its life-threatening complications strike. Awareness of diabetes at the population level will guide people for better management and prevention of health problems. In Riyadh city, the capital of Saudi Arabia, the biggest country in the Middle East, it is unclear how much the general public knows about diabetes mellitus, its complications, risk factor, and their awareness level. Extensive literature search could not find any study that reported the diabetes risk level and the awareness knowledge level in the Saudi population.

This study has explored the diabetic mellitus risk levels. In addition, the researchers investigated whether Saudis were aware of their disease. After the study has been completed in the relevant areas, shortcomings and myths may be identified. The authorities will determine whether or not it is necessary to raise awareness levels among nondiabetic individuals based on the report's findings. Since the prevention is often preferable to treatment, raising awareness levels will help minimize T2DM and its complications.

## Patients and Methods

### Participants and Design

This cross-sectional study included nondiabetic participants who visited the health care centers for health checkups other than diabetes problems. The study data was collected from five randomly selected primary healthcare centers in Riyadh city, the capital of Saudi Arabia, between November 2019 and February 2020. The target population was aged ≥18 years, and those had no other chronic illnesses on the interview day. This study excluded the participants who were pregnant, unable to communicate effectively, and had mental illness. The sampling method was convenient, and participation was entirely voluntary, and those who agreed to participate in this study signed a consent form. All participants in this study were interviewed individually by research team members.

### Data Collection

Health assessments and questionnaire-based interviews were performed on-site by five well-trained researchers following the standard data collection procedure. The collected data include the measuring of blood pressure, weight, height, smoking habits, educational status, and physical activity. The participants age and cholesterol level were noted from the hospital records. The Body Mass Index (BMI) was calculated as weight in kilograms divided by height in meters squared[20]. The right arm blood pressure was measured three times with standardized mercury sphygmomanometers, as per the World Health Organization/ International Society of Hypertension guidelines[21]. To ensure data validity and reliability, strict protocols were introduced. All researchers were MBBS final-year medical students and uniformly trained. if missing details or any errors were found, further interviews or examinations were performed. Before the survey, all measuring instruments were standardized.

### Questionnaire Preparation

A standard bilingual (Arabic and English) questionnaire was created following a comprehensive literature review based on previous studies and guidelines[22-24]. The questionnaire comprised four parts: the first part consisted of sociodemographic information. The second part of the questionnaire included screening diabetes risk based on American Diabetic Association parameters. The third part of the questionnaire had diabetes awareness knowledge. Finally, the fourth part was about the common awareness perception and regular habits with the risk factor.

### First Part

In the first part, we collected the demographic information of the individual, such as gender,

age, marital status, educational level, family history of diabetes, body mass index, physical activity, etc.

### Second Part

The second part of the questionnaire included screening diabetes risk based on American Diabetic Association parameters. To measure the participant's actual risk of getting diabetes, we used a validated questionnaire by the American Diabetic Association[25] which includes the following questions: age, sex, history of gestational diabetes in females, family history of diabetes, high blood pressure, physical activity, weight, and height. The ADA risk questionnaire collects self-reported information on the seven diabetes risk factors mentioned below, which were organized as follows: age [less than 40 (0 points); 40-49 (1 point); 50-59 (2 points), or 60 years (3 points)], sex [Male (1 point) or Female (0 points)], history of gestational diabetes [Yes (1 point) or No (0 points)), history of hypertension [Yes (1 point) or No (0 points)], family history of diabetes [Yes (1 point) or No (0 points)], physical activity [Yes (0 points) or No (1 point)], and about height and weight, a person's weight status is determined [normal (0 points), overweight (1 point)]. Each level of the risk factors is given a separate score, which is then added together for a maximum score of eleven (11). A score $< 5$ has a low diabetes risk, and a score $\geq 5$ has a high risk of undiagnosed prediabetes or type 2 diabetes. However, a proper diagnosis of diabetes risk ratio can only be made using fasting blood glucose (ADA).

### Third Part

A self-administered questionnaire was designed after an exhaustive literature review to achieve the study's objectives related to diabetes awareness. The prepared version contained ten elements subjected to detailed debate among a panel of three medical diabetes clinical consulting team members with substantial expertise dealing with diabetic patients. Seven items were agreed upon after two meetings and significant discussion among the panel. The consulted team, and the ethical team, recommended that a pilot study has to be conducted before the final study. The team agreed to conduct a pilot study with 20 to 35 participants about diabetes awareness questionnaire. A pilot study was conducted in a general family medicine clinic in Riyadh city from 26$^{th}$ September to 3$^{rd}$ October 2019 with 31 participants. The reliability of the awareness questionnaire was r=0.783 after the pilot study, which we shared with the Ethics Committee. Awareness includes the following questions: do you have knowledge of diabetes [Yes (1 point); No (0 points)], do you believe that diabetes is affecting an increasing number of individuals nowadays [Yes (1 point); No (0 points], did you know that diabetes can be avoided [Yes (2 points); Little bit (1 point); No (0 points)], Daily physical activity reduced DM risk [Yes (2 points); Sometimes (1 point); No (0 points)], diabetes can cause issues in other organs, did you know? [Yes (2 points); Little bit (1 point); No (0 points)], Do you think age is an important factor to develop DM [Yes (2 points); Little bit (1 point); No (0 points)], what factors do you believe have a role in diabetes? [ Obesity (1 point); Family history (1 point); Stress (1 point); Diet habits (1 point); Hypertension (1 point); Others (1 point); no roles (0 points)]. So, awareness questionnaire maximum score point was 16, and the minimum point was 0. After collecting all data from the non-diabetes participants, we calculated the awareness level: if the score is less than eight it means that DM knowledge was poor (< 50% = poor); if awareness score is between 8 to 12 it means that DM knowledge was moderate (50-75% = moderate); if awareness score is more than 13, it means that DM knowledge was good ($\geq$75 =good).

### Fourth Part

Finally, the fourth part of the questionnaire was about lifestyle-related knowledge and behaviors factors with their diabetes awareness level and risk factor.

### Statistical Analysis

All collected data were entered into Microsoft Excel and analyzed using SPSS version 24.0 (IBM, Armonk, NY, USA). The prevalence was estimated along with confidence intervals of 95%. Pearson's chi-square test and odds ratios (ORs) were used to determine and quantify the risk factor and awareness associations between a definite outcome and the variables considered. During the entire study, the statistical significance level has been established as $p<0.05$.

### Ethical Approval

All participants were informed about the study's objectives, and explained the questionnaire items, individually. The Research Ethics Committee of the Faculty of Medicine at King Saud University approved the study.

## Results

A total of 603 participants agreed to participate in the study; of them, 65 participants' data were incomplete and therefore excluded. The remaining 538 participant's data were analyzed: 363 (67.5%) were males, and 175 (32.5%) were females, 352 (65.4%) were married, and 30(24.2%) were smokers. The majority (n= 362, 67.3%) had a family history of diabetes mellitus, and major incidence recorded in father (n=183, 34.0%), followed by mother (n=153, 28.4%), sibling (n=84, 15.6%) and others (n=79, 14.7%). Despite this, a small number of the participants (n= 84, 15.6%) were physically active, 160 (29.7%) were overweight, and 25 (4.6%) were obese. Most of the participants had adequate knowledge (n=282, 52.4%), whereas 186 (33%) had good knowledge, and 70 (13.0%) had a poor knowledge level of diabetes. Of the total participants, more than 44% also had an increase diabetic risk (Table I). Diabetes risk scores decrease with an increase in the awareness score (r= -0.298; $p$=0.063).

### Diabetes Risk Level in Non-Diabetes Participants

The prevalence of diabetes risk among the male participants was significantly higher (OR=1.7;

**Table I.** Demographic information of participants (n=538).

| Item | Categories | N (%) |
|---|---|---|
| Gender | Male | 363 (67.5) |
| | Female | 175 (32.5) |
| Age | 18-39 | 289 (53.7) |
| | 40-49 | 145 (27.0) |
| | 50-59 | 70 (13.0) |
| | 60 or older | 34 (6.3) |
| Marital status | Single | 167 (31.0) |
| | Married | 352 (65.4) |
| | Widowed/Divorced | 19 (3.5) |
| Education level | Illiterate | 16 (3.0) |
| | Primary schooling | 37 (6.9) |
| | Secondary schooling | 173 (31.9) |
| | Graduate | 260 (48.3) |
| | Post graduate | 52 (9.7) |
| Smoker | Yes | 130 (24.2) |
| | No | 408 (75.8) |
| Heard about DM | Yes | 521 (96.8) |
| | No | 17 (3.2) |
| Family history of diabetes | Yes | 362 (67.3) |
| | No | 175 (32.5) |
| If 'yes' than its | Father | 183 (34.0) |
| | Mother | 153 (28.4) |
| | Sibling | 84 (15.6) |
| | Others | 79 (14.7) |
| Are you physically active | Yes | 84 (15.6) |
| | No | 216 (40.1) |
| | Not regular basis | 238 (44.2) |
| Residency | Urban | 526 (97.8) |
| | Rural | 12 (2.2) |
| High blood pressure | Yes | 155 (28.8) |
| | No | 383 (71.2) |
| Previous history of gestation diabetes (Women) | Yes | 40 (7.4) |
| | No | 498 (92.6) |
| BMI | Underweight | 155 (28.8) |
| | Normal | 198 (36.8) |
| | Overweight | 160 (29.7) |
| | Obese | 25 (4.6) |
| Awareness level | Poor | 70 (13.0) |
| | Moderate | 282 (52.4) |
| | Good | 186 (34.6) |
| Diabetes Risk test | Higher risk | 241 (44.8) |
| | Low/ no risk | 297 (55.2) |

$p$=0.003) than the female group. The older patients (age ≥ 60 years) had significantly higher diabetes risk (OR= 4.4) than the younger age group ($p$< 0.0001). Similarly, the age group 50-59 years had a four times higher risk than the younger age group. In addition, a higher education level was negatively associated with diabetes risk factors. Of the family history of diabetes, the diabetes risk was significantly associated with those siblings who had diabetes (OR=2.6; $p$=0.004), followed by mother who had diabetes (OR=2.3; $p$=0.003), and father had diabetes (OR=2.0; $p$=0.01). Moreover, a high risk of diabetes found in the participants who were not physically active and the participants who had high blood pressure (OR=2.2; $p$< 0.0001), participants with obesity (OR=2.9; $p$=0.0007), and overweight (OR=2.3; $p$< 0.0001) (Table II). In the current study, smoking did not challenge the risk of diabetes, as smoking was not a criterion in the ADA risk calculation.

### Awareness Level of Diabetes in Non-Diabetic Participants

The current diabetes awareness level among the female groups was significantly poor (OR=2.4; $p$=0.0005) compared to the male counterpart. The participants between 40-49 years were less aware of diabetes (OR=1.38; $p$=0.25) than other age groups. However, the age group more than 60 years had good diabetes awareness (OR=1.46; $p$=0.24). The education levels also impacted diabetes awareness, and the primary education participants had poor awareness (OR=2.14; $p$=0.025) compared to the higher education participants. On the other hand, those with a family history of diabetes had good awareness (OR=1.15), particularly those siblings had diabetes (OR= 1.19). Moreover, more physically active participants were less aware (OR= 1.74; $p$=0.1) of diabetes. About 155 (28.8%) of non-diabetes participants had high blood pressure; among them, almost 33% had poor awareness (OR=1.2; $p$=0.48). However, most of the overweight and obese participants had good knowledge. The majority of participants (61.7%) cholesterol level was normal, and they had significantly good awareness of diabetes (OR= 5.12; $p$=<0.0001) (Table III).

### Lifestyle Related Knowledge and Behaviors Factors with Their Diabetes Awareness Levels

Most of the participants (95.4%) reported that diabetes is a common condition; those who have a good level of awareness (98.9%) about diabetes have more understanding about diabetes. Most of the participants (82.3%) reported diabetes could be prevented; among them, there was a good level of knowledge participants (93.5%), and poor level of knowledge participants (60%). Most of the participants reported diabetes effect on other body organs. A good level of aware participants (94.1%) has more understanding about organs effect than the poor level of diabetes aware participants (58.6%; Table IV).

### Lifestyle Related Knowledge and Behavior's Factors with Their Diabetic Risk Factors

Most of the participants (95.4%) have acknowledged that diabetes is a common condition. Among participants (n= 467) who consumed lots of soft drinks, 47.5% had a high risk of diabetes. A significantly high risk of diabetes was also in those participants who consumed lots of animal products (meat, milk, eggs, etc.) ($p$= 0.0001). Moreover, eating lots of candy (90.0%), junk food (89.6%), and bakery items was associated with an increased risk of diabetes. Drinking coffee, eating dry fruits and fruits had no association with the risk of diabetes. Very few participants have reported 'eating more vegetables and most of them were at lower risk of diabetes ($p$= 0.002; Table V).

## Discussion

This is one of the first studies in Saudi Arabia that addressed diabetes awareness levels, knowledge and risk factors among nondiabetic participants. One-third of participants had good knowledge, whereas 13% had poor knowledge. The awareness score was higher than the previous local and international studies[26,27]. Male participants had more diabetes knowledge and awareness levels, despite the increased risk of diabetes than female participants and reported the same trends in a local study[28]. Many nondiabetic participants (44.8%) were under the diabetes risk as per the ADA diabetes risk test; however, the risk proportion was consistent with the previous reports[7,29]. The higher or moderate levels of diabetes awareness could be attributed to the participant's level of education, as 90% of participants had secondary or higher education. The positive relationship between educational attainment and diabetes awareness score was consistent with many studies from other parts of

**Table II.** Diabetes risk levels in different categories of participants.

| Item | Categories | N (%) | Diabetes risk analysis | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | ≥ Higher Risk | OR, 95% CI | *p*-value | ≤ Low Risk | OR, 95% CI | *p*-value |
| Gender | Male | 363 (67.5) | 188 (78.0) | 1.7 (1.2-2.4) | 0.003 | 175 (58.9) | 0.69 (0.5-0.92) | 0.01 |
| | Female | 175 (32.5) | 53 (22.0) | \| | | 122 (41.1) | \| | |
| Age | 18-39 | 289 (53.7) | 66 (27.4) | \| | | 223 (75.1) | \| | |
| | 40-49 | 145 (27.0) | 76 (31.5) | 2.3 (1.5-3.4) | < 0.0001 | 69 (23.2) | 0.61 (0.4-0.86) | 0.004 |
| | 50-59 | 70 (13.0) | 65 (27.0) | 4.0 (2.6-6.3) | < 0.0001 | 5 (1.7) | 0.09 (0.03-0.2) | < 0.0001 |
| | 60 or older | 34 (6.3) | 34 (14.1) | 4.4 (2.5-7.5) | < 0.0001 | 0 (0.00) | 0 | |
| Education level | Illiterate | 16 (3.0) | 11 (4.6) | 1.2 (0.47-2.8) | 0.75 | 5 (1.7) | 0.7 (0.3-2.3) | 0.65 |
| | Primary schooling | 37 (6.9) | 22 (9.1) | 0.99 (0.5-1.9) | 0.99 | 15 (5.0) | 1.0 (0.4-2.2) | 0.99 |
| | Secondary schooling | 173 (31.9) | 80 (33.2) | 0.77 (0.46-1.3) | 0.33 | 93 (31.3) | 1.3 (0.75-2.3) | 0.32 |
| | Graduate | 260 (48.3) | 97 (40.2) | 0.62 (0.4-1.0) | 0.06 | 163 (54.9) | 1.6 (0.9-2.6) | 0.11 |
| | Postgraduate | 52 (9.7) | 31 (12.9) | \| | | 21 (7.1) | \| | |
| Smoking habits | Yes | 130 (24.2) | 61 (25.3) | 1.06 (0.7-1.5) | 0.73 | 69 (23.2) | 0.94 (0.7-1.3) | 0.76 |
| | No | 408 (75.8) | 180 (74.7) | \| | | 228 (76.8) | \| | |
| Family history of diabetes | Yes | 362 (67.3) | 179 (74.3) | 1.4 (0.9-1.9) | 0.05 | 184 (61.9) | 0.78 (0.6-1.0) | 0.11 |
| | No | 175 (32.5) | 62 (25.7) | \| | | 113 (38.0) | \| | |
| If 'yes' than its | Father | 183 (34.0) | 98 (40.7) | 2.0 (1.2-3.4) | 0.01 | 85 (28.6) | 0.6 (0.4-0.96) | 0.03 |
| | Mother | 153 (28.4) | 92 (38.2) | 2.3 (1.3-3.9) | 0.003 | 61 (20.5) | 0.5 (0.34-0.85) | 0.007 |
| | Sibling | 84 (15.6) | 58 (24.1) | 2.6 (1.5-4.6) | 0.004 | 26 (8.8) | 0.4 (0.24-0.73) | 0.002 |
| | Others | 79 (14.7) | 21 (8.7) | \| | | 58 (19.5) | \| | |
| Physically active | Yes | 84 (15.6) | 32 (13.3) | 0.9 (0.6-1.5) | 0.84 | 52 (17.5) | 1.0 (0.7-1.5) | 0.88 |
| | No | 216 (40.1) | 114 (47.3) | 1.4 (0.9-1.8) | 0.09 | 102 (34.3) | 0.78 (0.6-1.0) | 0.13 |
| | Not regular basis | 238 (44.2) | 95 (39.4) | \| | | 143 (48.1) | \| | |
| High blood pressure | Yes | 155 (28.8) | 114 (47.3) | 2.2 (1.6-3.0) | < 0.0001 | 41 (13.8) | 0.4 (0.3-0.6) | < 0.0001 |
| | No | 383 (71.2) | 127 (52.7) | \| | | 256 (86.2) | \| | |
| Previous history of gestation diabetes (Women) | Yes | 40 (7.4) | 29 (12.0) | 1.7 (1.0-2.8) | 0.03 | 11 (3.7) | 0.47 (0.3-0.94) | 0.03 |
| | No | 498 (92.6) | 212 (88.0) | \| | | 286 (96.3) | \| | |
| BMI | Underweight | 155 (28.8) | 23 (28.2) | 0.4 (0.2-0.7) | 0.001 | 132 (44.4) | 1.29 (0.9-1.7) | 0.11 |
| | Normal | 198 (36.8) | 68 (28.2) | \| | | 130 (43.8) | \| | |
| | Overweight | 160 (29.7) | 125 (51.9) | 2.3 (1.5-3.2) | < 0.0001 | 35 (11.8) | 0.33 (0.1-0.5) | < 0.0001 |
| | Obese | 25 (4.6) | 25 (10.4) | 2.9 (1.5-5.4) | 0.0007 | 0 (0.00) | 0 | |
| High cholesterol | Yes | 94 (17.5) | 46 (19.1) | 1.7 (0.9-2.8) | 0.05 | 48 (16.2) | 0.72 (0.5-1.1) | 0.16 |
| | No | 332 (61.7) | 162 (67.2) | 1.6 (1.0-2.5) | 0.02 | 170 (57.2) | 0.72 (0.5-1.0) | 0.67 |
| | No test report | 112 (20.8) | 33 (19.1) | \| | | 79 (26.6) | \| | |

**Table III.** Cost of illness results: this table shows the results of the cost-of-illness model stratified for patients (adults and pediatrics) and for diagnosis.

| Item | Categories | N (%) | Awareness | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Poor level (70) | OR, 95% CI | *p*-value | Moderate level (282) | OR, 95% CI | *p*-value | Good level (186) | OR, 95% CI | *p*-value |
| Gender | Male | 363 (67.5) | 32 (45.7) | \| | | 200 (70.9) | 1.17 (0.8-1.6) | 0.31 | 131 (70.4) | 1.14 (0.7-1.6) | 0.45 |
| | Female | 175 (32.5) | 38 (54.3) | 2.4 (1.4-4.07) | 0.0005 | 82 (29.1) | \| | | 55 (29.6) | \| | |
| Age | 18-39 | 289 (53.7) | 33 (47.1) | \| | | 163 (57.8) | \| | | 93 (50.0) | \| | |
| | 40-49 | 145 (27.0) | 23 (32.9) | 1.38 (0.78-2.45) | 0.25 | 76 (27.0) | 0.92 (0.7-1.3) | 0.67 | 46 (24.7) | 0.98 (0.6-1.47) | 0.94 |
| | 50-59 | 70 (13.0) | 8 (11.4) | 1.0 (0.44-2.26) | 0.99 | 31 (11.0) | 0.78 (0.5-1.2) | 0.3 | 31 (16.7) | 1.37 (0.8-2.2) | 0.19 |
| | 60 or older | 34 (6.3) | 6 (8.6) | 1.54 (0.60-3.9) | 0.36 | 12 (4.3) | 0.62 (0.3-1.2) | 0.18 | 16 (8.6) | 1.46 (0.7-270) | 0.24 |
| Education level | Illiterate | 16 (3.0) | 3 (4.3) | 1.4 (0.3-5.1) | 0.5 | 10 (3.5) | \| | | 3 (1.6) | \| | |
| | Primary schooling | 37 (6.9) | 12 (17.1) | 2.4 (1.1-5.2) | 0.01 | 14 (5.0) | 0.6 (0.2-1.6) | 0.3 | 11 (5.9) | 1.5 (0.4-6.4) | 0.52 |
| | Secondary schooling | 173 (31.9) | 21 (30.0) | 0.9 (0.5-1.6) | 0.8 | 99 (35.1) | 0.9 (0.4-2.0) | 0.8 | 53 (28.5) | 1.6 (0.4-5.8) | 0.44 |
| | Graduate | 260 (48.3) | 34 (48.6) | \| | | 125 (44.3) | 0.76 (0.3-1.7) | 0.5 | 101 (54.3) | 2.1 (0.5-7.2) | 0.25 |
| | Postgraduate | 52 (9.7) | 0 (0) | 0 | | 34 (12.1) | 1.04 (0.4-2.5) | 0.9 | 18 (9.7) | 1.8 (0.5-7.0) | 0.37 |
| Smoking habits | Yes | 130 (24.2) | 17 (24.3) | 1.00 (0.5-1.8) | 0.98 | 74 (26.2) | 1.11 (0.8-1.5) | 0.5 | 39 (21.0) | 0.83 (0.55-1.2) | 0.37 |
| | No | 408 (75.8) | 53 (75.7) | \| | | 208 (73.8) | \| | | 147 (79.0) | \| | |
| Family history of diabetes | Yes | 362 (67.3) | 40 (57.1) | 0.64 (0.4-1.0) | 0.08 | 192 (68.1) | 1.03 (0.8-1.4) | 0.8 | 131 (70.4) | 1.15 (0.8-1.6) | 0.44 |
| | No | 175 (32.5) | 30 (42.9) | \| | | 90 (31.9) | \| | | 55 (29.6) | \| | |
| If 'yes' than its | Father | 183 (34.0) | 13 (18.6) | 0.35 (0.16-0.76) | 0.008 | 108 (38.3) | 1.26 (0.8-1.9) | 0.32 | 62 (33.3) | 1.02 (0.6-1.7) | 0.91 |
| | Mother | 153 (28.4) | 15 (21.4) | 0.48 (0.22-1.02) | 0.05 | 84 (29.8) | 1.17 (0.7-1.8) | 0.5 | 54 (29.0) | 1.07 (0.6-1.8) | 0.8 |
| | Sibling | 84 (15.6) | 8 (11.4) | 0.47 (0.2-1.1 | 0.1 | 43 (15.2) | 1.0 (0.6-1.8) | 0.74 | 33 (17.7) | 1.19 (0.6-2.1) | 0.56 |
| | Others | 79 (14.7) | 16 (22.9) | \| | | 37 (13.1) | \| | | 26 (14.0) | \| | |
| Physically active | Yes | 84 (15.6) | 16 (22.9) | 1.74 (0.89-3.4) | 0.1 | 42 (14.9) | 0.9 (0.60-1.4) | 0.71 | 26 (14.0) | 0.8 (0.53-1.4) | 0.64 |
| | No | 216 (40.1) | 28 (40.0) | 1.18 (0.67- 2.0) | 0.55 | 111 (39.4) | 0.94 (0.7-1.2) | 0.73 | 77 (41.4) | 1.02 (0.7-1.46) | 0.9 |
| | Not regular basis | 238 (44.2) | 26 (37.1) | \| | | 129 (45.7) | \| | | 83 (44.6) | \| | |
| High blood pressure | Yes | 155 (28.8) | 23 (32.9) | 1.20 (0.7-2.0) | 0.48 | 75 (26.6) | 0.89 (0.6-1.2) | 0.5 | 57 (30.6) | 1.09 (0.7-1.5) | 0.63 |
| | No | 383 (71.2) | 47 (67.1) | \| | | 207 (73.4) | \| | | 129 (69.4) | \| | |
| Previous history of gestation diabetes (Women) | No | 498 (92.6) | 58 (82.9) | \| | | 265 (94.0) | \| | | 175 (94.1) | \| | |
| | Yes | 40 (7.4) | 12 (17.1) | 2.57 (1.3-5.1) | 0.008 | 17 (6.0) | 0.79 (0.4-1.4) | 0.45 | 11 (5.9) | 0.78 (0.39-1.5) | 0.48 |
| BMI | Underweight | 155 (28.8) | 30 (42.9) | 1.6 (0.93-2.9) | 0.08 | 78 (27.7) | 0.87 (0.6-1.2) | 0.45 | 47 (25.3) | 0.98 (0.6-1.5) | 0.94 |
| | Normal | 198 (36.8) | 23 (32.9) | \| | | 114 (40.4) | \| | | 61 (32.8) | \| | |
| | Overweight | 160 (29.7) | 14 (20.0) | 0.75 (0.4-1.5) | 0.42 | 81 (28.7) | 0.87 (0.6-1.2) | 0.47 | 65 (34.9) | 1.3 (0.87-1.9) | 0.18 |
| | Obese | 25 (4.6) | 3 (4.3) | 1.0 (0.28-3.6) | 0.96 | 9 (3.2) | 0.6 (0.28-1.3) | 0.24 | 13 (7.0) | 1.6 (0.81-3.4) | 0.15 |
| High cholesterol | Yes | 94 (17.5) | 21 (30.0) | 0.75 (0.4-1.3) | 0.37 | 49 (17.4) | 0.84 (0.5-1.3) | 0.47 | 24 (12.9) | 2.85 (1.3-6.28) | 0.008 |
| | No | 332 (61.7) | 16 (22.9) | 0.16 (0.08-0.30) | < 0.000 | 164 (58.2) | 0.80 (0.5-1.1) | 0.22 | 152 (81.7) | 5.12 (2.6-10.0) | < 0.0001 |
| | No test report | 112 (20.8) | 33 (47.1) | \| | | 69 (24.5) | \| | | 10 (5.4) | \| | |

**Table IV.** Association of knowledge and behaviors factors with their diabetes awareness level.

| Item | Categories | N (%) | Poor level (70) | Moderate level (282) | Good level (186) | $\chi^2$ ($p$) |
|---|---|---|---|---|---|---|
| Diabetes is a common health problem | Yes | 513 (95.4) | 59 (84.3) | 270 (95.7) | 184 (98.9) | 24.8 (0.000) |
| | No | 25 (4.6) | 11 (15.7) | 12 (4.3) | 2 (1.1) | |
| Type 2 diabetes can be prevented | Yes | 443 (82.3) | 42 (60.0) | 227 (80.5) | 174 (93.5) | 40.7 (0.000) |
| | No | 95 (17.7) | 28 (40.0) | 55 (19.5) | 12 (6.5) | |
| Physically active | Yes | 84 (15.6) | 16 (22.9) | 42 (14.9) | 26 (14.0) | 3.82 (0.43) |
| | No | 216 (40.1) | 28 (40.0) | 111 (39.4) | 77 (41.4) | |
| | Rarely | 238 (44.2) | 26 (37.1) | 129 (45.7) | 83 (44.6) | |
| Drinking lots of soft drinks | Yes | 467 (86.8) | 34 (48.6) | 253 (89.7) | 180 (96.8) | 126.7 (0.000) |
| | No | 30 (5.6) | 21 (30.0) | 6 (2.1) | 3 (1.6) | |
| | Rarely | 41 (7.6) | 15 (21.4) | 23 (8.2) | 3 (1.6) | |
| Consuming lots of animal products | Yes | 179 (33.3) | 15 (21.4) | 111 (39.4) | 53 (28.5) | 38.6 (0.000) |
| | No | 255 (47.4) | 24 (34.3) | 128 (45.4) | 103 (55.4) | |
| | Rarely | 104 (19.3) | 31 (44.3) | 43 (15.2) | 30 (16.1) | |
| Eating lots of candy | Yes | 471 (87.5) | 38 (54.3) | 249 (88.3) | 184 (98.9) | 110.05 (0.000) |
| | No | 44 (8.2) | 26 (37.1) | 16 (5.7) | 2 (1.1) | |
| | Rarely | 23 (4.3) | 6 (8.6) | 17 (6.0) | 0 (0.0) | |
| Eating lots of junk food | Yes | 454 (84.4) | 30 (42.9) | 248 (87.9) | 176 (94.6) | 109.4 (0.000) |
| | No | 38 (7.1) | 19 (27.1) | 15 (5.3) | 4 (2.2) | |
| | Rarely | 46 (8.6) | 21 (30.0) | 19 (6.7) | 6 (3.2) | |
| Eating more vegetables | Yes | 30 (5.6) | 19 (27.1) | 11 (3.9) | 0 (0.0) | 82.06 (0.000) |
| | No | 487 (90.5) | 45 (64.3) | 260 (92.2) | 182 (97.8) | |
| | Rarely | 21 (3.9) | 6 (8.6) | 11 (3.9) | 4 (2.2) | |
| Eating lots of fruits | Yes | 126 (23.4) | 21 (30.0) | 78 (27.7) | 27 (14.5) | 32.9 (0.000) |
| | No | 377 (70.1) | 40 (57.1) | 180 (63.8) | 157 (84.4) | |
| | Rarely | 35 (6.5) | 9 (12.9) | 24 (8.5) | 2 (1.1) | |
| Eating dry fruits | Yes | 163 (30.3) | 27 (38.6) | 93 (33.0) | 43 (23.1) | 58.5 (0.000) |
| | No | 221 (41.1) | 15 (21.4) | 90 (31.9) | 116 (62.4) | |
| | Rarely | 154 (28.6) | 28 (40.0) | 99 (35.1) | 27 (14.5) | |
| Drinking coffee (everyday) | Yes | 84 (15.6) | 20 (28.6) | 35 (12.4) | 29 (15.6) | 35.7 (0.000) |
| | No | 336 (62.5) | 24 (34.3) | 179 (63.5) | 133 (71.5) | |
| | Rarely | 118 (21.9) | 26 (37.1) | 68 (24.1) | 24 (12.9) | |
| Consuming more bakery items | Yes | 429 (79.7) | 54 (77.14) | 227 (80.4) | 148 (79.5) | 25.9 (0.000) |
| | No | 109 (20.2) | 16 (22.85) | 55 (19.5) | 38 (20.4) | |
| Diabetes effect on other body organs | Yes | 448 (83.3) | 41 (58.6) | 232 (82.3) | 175 (94.1) | 46.4 (0.000) |
| | No | 90 (16.7) | 29 (41.4) | 50 (17.7) | 11 (5.9) | |
| Being overweight or obese | Yes | 489 (90.9) | 37 (52.9) | 270 (95.7) | 182 (97.8) | 144.7 (0.000) |
| | No | 39 (7.2) | 25 (35.7) | 12 (4.3) | 2 (1.1) | |
| | Not Sure | 10 (1.9) | 8 (11.4) | 0 (0.0) | 2 (1.1) | |

the world, which found education is a predictive factor for diabetes knowledge[15,27,30]. Despite this fact, most participants had a moderate level of understanding, and thus deficiency and misinformation of diabetes preventive knowledge must be identified and acknowledged. The participants' age ranged between 18 and 39 years, subjects had completed secondary, or university education (89.9%) and the majority believed that T2DM is a common health problem but can be prevented. About 18% of participants said that T2DM could not be prevented, and in such circumstances, needed to receive correct information on diabetic prevention. According to our study and other reports, nondiabetic participants who were older and educated had more diabetes awareness knowledge. However, older participants had four-time more diabetic risk scores than the younger age groups[31]. It was assumed that older participants could miss preventive measures due to the lack of energy, motivation, physical disabilities, and other health barriers. In this study, smoking did not play a significant role in diabetes awareness and diabetes risk score, and this finding was similar to other studies[27,32]. Also, smoking is not a criterion in the ADA risk calculation. However, other studies indicate that smokers are more likely to develop T2DM than nonsmokers[33-35]. The participants with a family history of diabetes had good knowledge of diabetes awareness and higher diabetic risk scores. Similar findings were reported in many previous studies[15,28,36,37]. Surprisingly, diabetes risk scores were more than twice among the participants whose mother or

**Table V.** Association of knowledge and behaviors factors with their diabetes risk levels.

| Item | Categories | N (%) | High Risk (241) | Low Risk (297) | $\chi^2$ (*p*) |
|---|---|---|---|---|---|
| Diabetes is a common health problem | Yes | 513 (95.4) | 239 (99.2) | 274 (92.3) | 14.35 (0.000) |
| | No | 25 (4.6) | 2 (0.8) | 23 (7.7) | |
| Type 2 diabetes can be prevented | Yes | 443 (82.3) | 199 (82.6) | 244 (82.2) | 0.16 (0.49) |
| | No | 95 (17.7) | 42 (17.4) | 53 (17.8) | |
| Physically active | Yes | 84 (15.6) | 32 (13.3) | 52 (17.5) | 9.38 (0.009) |
| | No | 216 (40.1) | 114 (47.3) | 102 (34.3) | |
| | Rarely | 238 (44.2) | 95 (39.4) | 143 (48.1) | |
| Drinking lots of soft drinks | Yes | 467 (86.8) | 222 (92.1) | 245 (82.5) | 12.89 (0.002) |
| | No | 30 (5.6) | 5 (2.1) | 25 (8.4) | |
| | Rarely | 41 (7.6) | 14 (5.8) | 27 (9.1) | |
| Consuming lots of animal products | Yes | 179 (33.3) | 101 (41.9) | 78 (26.3) | 19.5 (0.000) |
| | No | 255 (47.4) | 90 (37.3) | 165 (55.6) | |
| | Rarely | 104 (19.3) | 50 (20.7) | 54 (18.2) | |
| Eating lots of candy | Yes | 471 (87.5) | 217 (90.0) | 254 (85.5) | 6.28 (0.04) |
| | No | 44 (8.2) | 12 (5.0) | 32 (10.8) | |
| | Rarely | 23 (4.3) | 12 (5.0) | 11 (3.7) | |
| Eating lots of junk food | Yes | 454 (84.4) | 216 (89.6) | 238 (80.1) | 11.22 (0.004) |
| | No | 38 (7.1) | 8 (3.3) | 30 (10.1) | |
| | Rarely | 46 (8.6) | 17 (7.1) | 29 (9.8) | |
| Eating more vegetables | Yes | 30 (5.6) | 5 (2.1) | 25 (8.4) | 12.2 (0.002) |
| | No | 487 (90.5) | 223 (92.5) | 264 (88.9) | |
| | Rarely | 21 (3.9) | 13 (5.4) | 8 (2.7) | |
| Eating lots of fruits | Yes | 126 (23.4) | 52 (21.6) | 74 (24.9) | 6.91 (0.31) |
| | No | 377 (70.1) | 166 (68.9) | 211 (71.0) | |
| | Rarely | 35 (6.5) | 23 (9.5) | 12 (4.0) | |
| Eating dry fruits | Yes | 163 (30.3) | 79 (32.8) | 84 (28.3) | 3.76 (0.15) |
| | No | 221 (41.1) | 88 (36.5) | 133 (44.8) | |
| | Rarely | 154 (28.6) | 74 (30.7) | 80 (26.9) | |
| Drinking coffee (everyday) | Yes | 84 (15.6) | 42 (17.4) | 42 (14.1) | 1.33 (0.51) |
| | No | 336 (62.5) | 145 (60.2) | 191 (64.3) | |
| | Rarely | 118 (21.9) | 54 (22.4) | 64 (21.5) | |
| Consuming more bakery items | Yes | 429 (79.7) | 217 (90.04) | 212 (71.4) | 14.5 (< 0.0001) |
| | No | 109 (20.2) | 24 (9.95) | 85 (28.61) | |
| Diabetes effect on other body organs | Yes | 448 (83.3) | 215 (89.2) | 233 (78.5) | 11.05 (0.001) |
| | No | 90 (16.7) | 26 (10.8) | 64 (21.5) | |
| Being overweight or obese | Yes | 489 (90.9) | 223 (92.5) | 266 (89.6) | 1.64 (0.43) |
| | No | 39 (7.2) | 15 (6.2) | 24 (8.1) | |
| | Not Sure | 10 (1.9) | 3 (1.2) | 7 (2.4) | |

father had diabetes. However, a positive association of diabetes incidence with the parental history is a characteristic of genetic inheritance of metabolic disease[38,39]. Diabetes awareness scores in physically active and non-active participants almost equally distributed but physically inactive participants had high risk scores of diabetes[40]. The obstacles that may prevent physical activity in the Saudi population are hot weather during most of the year, lack of facilities for activities, and appropriate social culture[41]. The risk score of diabetes was also significantly high in participants with hypertension and who had high cholesterol levels[42]. Body weight gain could result from a sedentary lifestyle, which makes it harder to engage in physical activity. The obese are highly susceptible to metabolic disease, particularly diabetes. Nearly ~34% of participants were overweight and obese, of which the majority had high diabetes risk scores. The risk of diabetes in obese and overweight participants was increased in other countries[43,44]. Participants who consumed more soft drinks and animal products had high diabetes risk scores than those who consumed the least[45,46]. Consumption of vegetables is likely to prevent or delay the onset of diabetes, and similar finding was reported in other study[46]. Drinking coffee (every day), eating dry fruits, and fruits were not associated with high-risk scores of diabetes. Coffee consumption in moderation is safe and beneficial in both healthy persons as well as in patients with high blood pressure, CVD, or

diabetes[47]. Bakery products are commonly consumed in the KSA. Participants who consume more bakery products had significantly high diabetes risk scores and the findings were supported by local and international reports[48,49]. A meta-analysis of 23 studies reported that dietary modification has effectively delayed or prevented the development of type 2 diabetes[50].

Although the study is conducted at a multicenter and has explored lots of epidemiological data, there are few limitations that need to be addressed. The study was conducted only in one of the biggest cities in Saudi Arabia, Riyadh, and the participants were selected by convenience sampling method. Therefore, the findings of the study could not be generalized. This matter could be investigated. We also do not include participants who do not have medical records. In this study, the association between some risk factors, the prevalence, and awareness of diabetes risk factors were unexpected; this could be attributed due to the convenience sampling nature of the data and potential bias. A nation-wide study with a larger convenience sampling may be required to extrapolate the results.

## Conclusions

According to the study, a large proportion of the Saudi Arabian population had a high risk of diabetes and necessitates evidenced based lifestyle modifications. This could be achieved through public health awareness campaigns, targeting increased diabetes screening, and appropriate suggestions for the prevention. Moreover, persistent, present, and future explorations of these health issues are highly recommended.

### Conflict of Interest

The Authors declare that they have no conflict of interests.

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### Authors' Contribution

Conception or design: HMA. TA Acquisition, analysis, or interpretation of data: MMA, SAA, AHA, ALA, AKA. Drafting the work or revising: HMA, FKA, TA. Final approval of the manuscript: All authors.

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