

# Knowledge and awareness of diabetes mellitus and its risk factors in Saudi Arabia

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## ABSTRACT

**الأهداف:** لتلخيص المنشورات العلمية المحكمة للمعرفة والوعي العام لداء السكري (DM) بين سكان المملكة العربية السعودية.

**الطريقة:** اتبعنا الإرشادات القياسية العلمية PRISMA لإعداد هذه المراجعة المنهجية. في فبراير 2018م أجرينا بحث للأدبيات من PubMed ، Scopus ، BIOSIS Citation ، و Web of Science باستخدام الكلمات الأساسية التالية: «المعرفة» أو «الوعي» و «السكري» و «المملكة العربية السعودية». تم فحص السجلات ، وتم اختيار الدراسات ذات الصلة وتولييفها سرديا .

**النتائج:** اشتملت الدراسة على 19 مقالات في مراجعتنا المنهجية. وشملت هذه الدراسات السكان التالية: مرضى DM (العدد= 13) ، والعاملين في مجال الرعاية الصحية (العدد = 3) ، وطلاب الطب (العدد = 1) ، وطلاب المدارس الثانوية (العدد = 1) ، وعموم السكان (العدد = 1). وجدت معظم الدراسات نقص في الوعي العام لعوامل الخطر ومضاعفات DM. كانت المعرفة حول وبائيات المرض وزاوية حقن الأنسولين ناقصة بين طلاب الطب والعاملين في مجال الرعاية الصحية.

**الخاتمة:** يسلب هذا الاستعراض الضوء على الحاجة إلى زيادة المعرفة والوعي ب DM بين سكان المملكة. يجب دمج وسائل تحسين المعرفة والوعي ب DM في نظم وعمليات الرعاية الصحية القائمة لإعلام المرضى والأسر والمجتمعات بشكل أفضل بهذا المرض المزمن.

**Objectives:** To summarize available peer-reviewed publications about public knowledge and awareness of diabetes mellitus (DM) among the population of Saudi Arabia.

**Methods:** We followed the standard reporting guidelines outlined in the PRISMA statement for the preparation of this systematic review. In February 2018 we conducted literature searches of PubMed, Scopus, BIOSIS Citation Index, and Web of Science using the following keywords: “Knowledge” OR “Awareness” AND “Diabetes Mellitus” AND “Saudi

Arabia.” Records were screened, and relevant studies were selected and synthesized narratively.

**Results:** Nineteen articles are included in our systematic review. These studies included the following populations: DM patients (n=13), healthcare workers (n=3), medical students (n=1), secondary school students (n=1), and general population (n=1). Most studies found a lack of public awareness of the risk factors and complications of DM. Among medical students and healthcare workers, knowledge about the epidemiology of the disease and angle of insulin injection was deficient.

**Conclusion:** This review highlights the need for increased knowledge and awareness of DM among the Saudi population. The means of improving knowledge and awareness of DM needs to be integrated into existing healthcare systems and processes to better inform patients, families, and communities about this chronic disease.

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**D**iabetes mellitus (DM) is a metabolic disorder characterized by a deficit in insulin secretion or action resulting in hyperglycemia. Diabetes mellitus is classified into 3 major types: type 1 (T1DM), type 2 (T2DM) and gestational diabetes. Type 1 DM results from autoimmune destruction of beta cells in the islets of Langerhans, resulting in a decrease in insulin secretion. Type 2 DM results from a decrease in insulin action due to insulin resistance by body tissues, leading to disturbed glucose entry to body cells. Obesity has been found to increase insulin resistance and has therefore been linked to T2DM. This paper will focus on a systematic review of the literature about education and prevention of T1DM and T2DM in Saudi Arabia.

According to the International Diabetes Federation,<sup>1</sup> DM affects about 8.8% of the worldwide population over 20 years of age. Middle Eastern and North African (MENA) countries have a higher prevalence of DM compared to other regions in the world; the prevalence rate was 9.6% in 2017, and the rate is expected to increase to 12.1% by 2045.<sup>1</sup> The high prevalence of DM in the MENA region is attributed to the urbanization process, high obesity rates and the increase in the aging population in these countries.<sup>2</sup> As DM is the most prevalent disease in Saudi Arabia, carrying a substantial economic burden, it is essential that public health interventions consider how to influence behavior in the Saudi population to better prevent and control this disease.

According to the International Diabetes Federation,<sup>1</sup> Saudi Arabia has the highest rate of DM in the MENA region (prevalence rate of 17.7%). The prevalence of T1DM in Saudi Arabia was investigated by Al-Herbish et al<sup>3</sup> in 2008 using a cross-sectional study of 45,682 children and adolescents. They reported a rate of 109.5 patients per 100,000 people. Saudi Arabia has the fourth highest incidence of T1DM in the world, at about 33.5/100,000 persons per year.<sup>1</sup> In 2011, Al-Daghri et al<sup>3</sup> performed a cross-sectional study of 9149 citizens reported a 31.6% prevalence rate for T2DM in Saudi Arabia. Alqurashi et al<sup>4</sup> performed another cross-sectional study in Saudi Arabia to determine the prevalence rate of T2DM using a convenience sampling method. In this study, they reported a prevalence rate for T2DM of 30% in 2009.<sup>4</sup> Approximately 0.78 billion dollars of the total healthcare expenditure of Saudi Arabia was dedicated to managing DM.<sup>5</sup> Given that DM is so prevalent in Saudi Arabia, it is important to ensure that the community has sufficient knowledge and awareness of this disease to enable further promotion of public health interventions to control its prevalence. It is also important for DM patients to

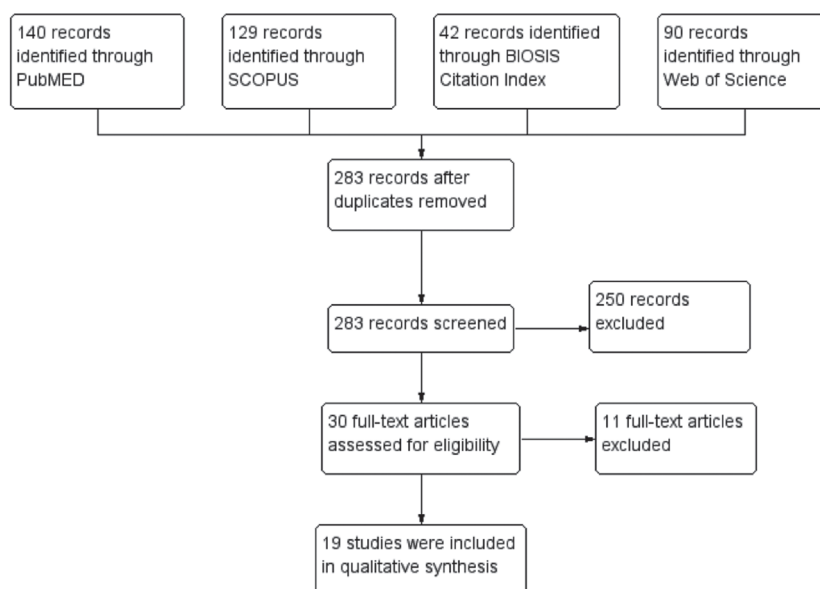
better understand medication and lifestyle modification that may allow for better management of their glucose levels and delay the onset of DM complications. To help DM patients achieve this goal, patients, families, nurses and healthcare physicians need high levels of knowledge and awareness about DM pathology, risk factors, management, and complications. In this article, the literature is systemically reviewed to better understand what is known about DM among the Saudi population.

**Methods.** The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) and Meta-analyses of Observational Studies in Epidemiology (MOOSE) statement guidelines were followed during the preparation of this systematic review.<sup>6,7</sup> All steps were performed in strict accordance with the Cochrane Handbook of Systematic Review and Meta-analysis.<sup>8</sup>

**Literature search strategy.** Throughout February 2018, literature searches of PubMed, Scopus, Biosciences Information Service (BIOSIS) and the Institute for Scientific Information (ISI) Web of Science was conducted using the following keywords (knowledge OR awareness) AND diabetes mellitus AND Saudi Arabia. These keywords used were relevant to the topic area and were the most appropriate terms for the review. The search outcomes from the databases were then limited to English language, peer reviewed, and research articles with no time frame limit.

**Study selection.** Two researchers independently screened the literature search results for relevant studies. They first performed computerized searches on medical databases as described above, producing 401 potential articles. Four hundred and one articles were screened for duplicates resulting in the elimination of 118 articles. The researchers then assessed the titles and abstracts of the remaining 283 articles and determined that 253 of those were not relevant to the present study, leaving 30 potential articles. In the final stage, the researchers carefully reviewed the full text of all articles selected during previous step and remove those not relevant to the topic. Disagreement between researchers about the relevance on an article was resolved through discussion with a third researcher. After this review process, 19 articles were determined to be relevant and were included in the systemic review (Figure 1).

**Eligibility criteria.** Studies satisfying the following criteria were chosen for inclusion in this review: 1) studies that were described as cross-sectional studies, 2) studies in which Saudi Arabia was the population of interest and 3) studies evaluating the knowledge and awareness of the population about T1DM, T2DM or



**Figure 1** - PRISMA flow diagram for the literature search and study selection process.

both. We excluded articles that were 1) in a country other than Saudi Arabia, 2) academic thesis, and 3) conference abstracts.

**Data extraction.** Data were extracted independently by the 2 researchers to a uniform data extraction sheet. The extracted data included: 1) characteristics of the study design, 2) features of the study population and 3) data of the study outcomes.

**Synthesis of results.** Included studies were classified according to the type of the population: 1) studies on the general population, 2) studies on health care professionals and 3) studies on DM patients. Extracted data from each study were tabulated and reviewed narratively.

**Results. Characteristics of included studies.** The search strategy retrieved 283 unique articles. Following eligibility screening, 19 articles met the inclusion criteria and were included in the systematic review. The population of these studies were as follows: DM patients (n=13), healthcare workers (n=3), medical students (n=1), secondary school students (n=1) and general population (n=1). The flow diagram of the study selection process is shown in Figure 1.

**Level of knowledge about DM.** Most studies found a poor level of knowledge of the disease among DM patients in Saudi Arabia. Al-Aboudi et al<sup>9</sup> found that 15% of DM patients had inadequate knowledge of DM while 72% has moderate knowledge. In a study by Binhemd,<sup>10</sup> DM patients in Dammam received low

scores regarding knowledge and attitudes towards DM. In another survey of DM patients by Al Malki et al,<sup>11</sup> the percentage of correct answers to questions about DM was 49%, highlighting a gap in DM knowledge among the population. A summary of cross-sectional studies about DM knowledge among DM patients in Saudi Arabia is shown in Table 1.

Only one third of healthcare staff with a DM diagnosis participated in retinopathy screening in the study by Al-Alawi et al<sup>12</sup> Among health professionals, nurses at Prince Sultan Medical Military City in Riyadh had low knowledge scores about DM (25.5/49), despite having positive views about their level of knowledge (46.9/60), highlighting a gap between their perceived and actual knowledge about DM.<sup>13</sup> Unexpectedly, in the Al Hasa district, physicians also had low knowledge scores (66.6/100), with the biggest weakness in physicians' knowledge being disease epidemiology.<sup>14</sup> Only one third of the physicians surveyed were aware of the correct angle at which to administer insulin injections, and only 28.3% of them were aware of the diagnostic criteria for DM.<sup>14</sup> Similarly, medical students had low scores regarding knowledge about DM, with the main weakness being epidemiology, and 90% of the students were not aware of the correct angle required for administering insulin injections.<sup>15</sup>

Citizens of the Arar region had relatively low knowledge about DM,<sup>16</sup> with only 12.4% acknowledged excess consumption of sweets and obesity as risk factors.<sup>16</sup> A summary of studies focused

**Table 1** - Summary of cross-sectional studies performed in Saudi Arabia about knowledge and awareness of DM among diabetic patients.

Study references	Setting	Population	Sample size	Sampling method	Key outcomes
Al-Aboudi et al <sup>19</sup>	King Abdulaziz University Hospital, Riyadh	DM patients	75	Convenience sampling	14.7% had poor knowledge; 72% had moderate knowledge
Al-Eidi et al <sup>24</sup>	Diabetic Centre, King Salman bin Abdulaziz Hospital, Riyadh	DM patients	302	Convenience sampling	30.5% practiced complementary and alternative medicine: 30.39% using herbs, 20.58% using wet cupping and 17.64% using other nutritional supplements/therapies
Al-Alawi et al <sup>12</sup>	King Khaled Eye Specialist Hospital, Riyadh	Diabetics employed in the hospital	45	Convenience sampling	1/3 received a diabetic retinopathy screening in the previous year; 29% had excellent knowledge about diabetic retinopathy and eye complications of DM
Kamel et al <sup>21</sup>	King Abdulaziz University and King Fahad General Hospitals, Jeddah	DM patients	213	Simple random sampling	64% had previously used herbs to control diabetes; 55.1% preferred herbs over prescription drugs; 75.2% used herbs with prescribed medications
Bahammam <sup>25</sup>	King Abdulaziz University Hospital, Jeddah	DM patients	454	Convenience sampling	Limited awareness about DM and periodontal disease association; 47% knew that gum disease makes it harder to control blood sugar in diabetic patients
Aljoudi et al <sup>19</sup>	Aqrabya Primary Care Centre, Al-Khobar	DM patients	300	Simple random sampling	Education a predictive factor for patients' knowledge about DM; 35.8% stated that obesity was a major risk factor and weight reduction was an effective measure for prevention of DM
Abahussain et al <sup>22</sup>	Girls' schools, Al-Khobar, Eastern Province	Female diabetic school teachers	91	Convenience sampling	25% used herbs for management of DM; 3/4 were overweight/obese; low knowledge of symptoms
Al-Mountashiri et al <sup>18</sup>	Tabuk City	DM patients	100	Convenience sampling	BMI, fast food consumption, fruit consumption and skipping breakfast higher in the diabetic group ( $p < 0.01$ ).
Al Zarea <sup>17</sup>	AlJouf and Hail providences	DM patients	439	Simple random sampling	75.62% aware of diabetes complications of the eye; 73.8% reported that diabetic individuals should perform regular follow-up visits at the eye clinic; 65.1% aware that they should visit the ophthalmologist for eye problems
Al-Saeedi et al <sup>23</sup>	Primary health care centers, Mecca	DM patients	1039	Two-stage stratified random sampling	1/3 used traditional medicine treatment; relationship found between herbal medicine use and gender (female), duration of DM, family history of diabetes, and compliance with diet
Binhemd <sup>10</sup>	Diabetics and Endocrine Centre, Dammam	DM patients	300	Simple random sampling	Low scores for knowledge, attitude, and compliance; levels of glycated hemoglobin showed poor glycemic control, especially in those with T1DM (T1DM: 10.2 vs. T2DM: 9.1, $p = 0.001$ )
Almalki et al <sup>11</sup>	King Abdulaziz Specialist Hospital, Taif City	DM patients	264	Convenience sampling	48.26% of questions correctly answered; 28% thought that A1c reflects blood glucose control over past week; 44.3% did not know what A1c was; 30% believed that diet soda could be used to treat low blood glucose; only 21.6% had good knowledge of DM
Elzubier et al <sup>26</sup>	Primary Health Care Centers, Qassim region	DM patients	975	Convenience sampling	13% knew how to test urine for glucose at home; only 4.6% were familiar with monitoring of blood glucose; 25% were aware of DM complication; 50.6% acknowledged that hypoglycemia is a symptom of DM; 33% knew how to inject themselves with insulin

DM - diabetes mellitus, BMI - body mass index, T1DM - type 1 DM, T2DM - type 2 DM, vs. - versus

on the knowledge of health professionals, students, and the general population is shown in Table 2.

**Knowledge about complications of DM.** Three studies were found that evaluated population knowledge about DM complications.<sup>12,16,17</sup> Al Zarea<sup>17</sup> performed a cross-sectional study on 439 diabetic patients in the cities of AlJouf and Hail and found that most of the patients (75.62%) were aware of diabetes complications of the eyes. Al-Alawi et al<sup>12</sup> conducted a cross-sectional descriptive study on 45 healthcare staff with DM at a

tertiary eye hospital in central Saudi Arabia. They found that in the previous year, only one third of the study population received a diabetic retinopathy screening. Of the participants, 29% had excellent knowledge about diabetic retinopathy and eye complications of DM. However, lack of gender-specific health professionals, the distance to the health center and lack of referral from the health care professionals and family were the main barriers towards not receiving a diabetic retinopathy screening on a regular basis. Menwer et al's<sup>16</sup>

**Table 2** - Summary of cross-sectional studies performed in Saudi Arabia about knowledge and awareness of DM among healthcare workers, students, and the general population.

Study references	Setting	Population	Sample size	Sampling method	Key outcomes
Alotaibi et al <sup>13</sup>	Prince Sultan Medical Military City, Riyadh	Nurses	423	Convenience sampling	Nurses had a positive view of own DM knowledge (46.9/60); actual knowledge was lower (25.4/49)
Khan et al <sup>14</sup>	Healthcare centers, Al Hasa district	Physicians	99	Convenience sampling	KAP mean score was 66.59/100; weakness in knowledge about epidemiology; 34.7% were aware of the correct angle of insulin injection; 28.3% were aware of diagnostic criteria of T2DM
Al Rasheed et al <sup>45</sup>	46 primary-care centers, Riyadh	Primary care physicians	216	Simple random sampling	Mean knowledge score 57/100 (SD=14); defect was found in the screening and follow up of T1DM
Al Wadaani <sup>15</sup>	King Faisal University Medical College, Al Hasa province	Medical students	96	Convenience sampling	Mean knowledge, attitude and practice score was 64.75/100; main weakness in knowledge of the epidemiology of DM; 90% did not know about the angle of insulin injection
Al-Mutairi et al <sup>20</sup>	Secondary schools, Riyadh	Non-diabetic students	426	Convenience sampling	Awareness about the role of body weight in DM was lower in males ( $p=0.037$ ); males less likely than females to recognize risks for T2DM, including obesity ( $p=0.030$ ), heredity ( $p=0.013$ ) and high fat intake ( $p=0.001$ )
Alanazi et al <sup>16</sup>	Arar region	General population	702	Systematic random sampling	12.4% thought DM was due to excessive eating of sweets; 24.5% were aware of retinopathy; 8.3% knew about the loss of sensation and numbness in extremities

DM - diabetes mellitus, T1DM - type 1 DM, T2DM - type 2 DM, KAP - knowledge attitude and practice

cross-sectional study to assess knowledge of risk factors of DM among diabetic patients in the Arar region selected 702 participants by using a systematic random sample method. Of those, 12.4% thought that DM was due to excessive eating of sweets. The knowledge about DM complications was relatively low; only 24.5% were aware of retinopathy, while only 8.3% knew about the loss of sensation and numbness in extremities.

**Knowledge about risk factors of DM.** In the city of Tabuk, Al-Mountashiri et al<sup>18</sup> conducted a cross-sectional study on 100 DM patients; they found that high body mass index (BMI), fast food consumption, fruit consumption and skipping breakfast occurred significantly more frequently among DM patients when compared to the non-DM population. Aljouidi and Taha<sup>19</sup> performed a cross-sectional study on a sample of 300 patients attending the Aqrabya Primary Care Centre in Saudi Arabia. They randomly selected those patients from the attendees to complete surveys about the knowledge of DM risk factors and preventive measures. This study found that age, gender, and education level were associated with the knowledge of DM risk factors and preventive measures ( $p<0.001$ ). Education level was found to be a statistically significant predictive factor for patients' knowledge about DM, and 35.8% of the participants stated that obesity was a significant risk factors for DM and that weight reduction was an effective measure for the prevention of DM. In a cross-sectional study of 426 non-diabetic secondary school students, the authors found higher obesity rates in males than females ( $p=0.013$ ).<sup>20</sup> The male students were also

less aware of the risks of T2DM, such as obesity, family history, and high fat intake. The students acknowledged obesity as the most important risk factor, while weight reduction was recognized as the key preventive measure.

**Use of herbs and alternative medicine.** Beside assessing patients' knowledge and awareness about DM, 3 studies assessed patients' use of herbs and alternative medicine products in relation to DM. One study was conducted in Jeddah, where the investigators found that 64% of DM patients had used herbs as a course of treatment for their condition.<sup>21</sup> Another study was conducted in Al-Khobar, where 25% of diabetic female teachers reported using herbs and about one third were obese.<sup>22</sup> A study carried out in Mecca found that about one third of DM patients used herbal medicine.<sup>23</sup> These studies concluded that the use of herbs was associated with both female gender and longer duration of DM.

**Discussion. Summary of results.** This systematic review has shown that there is generally low knowledge about DM, its risk factors and its complications among the Saudi population. Most DM patients had low to moderate knowledge scores in Riyadh, Jeddah, Al Hasa, Al-Khobar, and Mecca. Obesity was understood to be the most important risk factor, while weight reduction was acknowledged as a preventive measure. Unexpectedly, health professionals in Saudi Arabia also had low knowledge scores about DM, with physicians, nurses and medical students receiving low scores for knowledge about the epidemiology of the disease and the correct angle to administer insulin injections.

*Critical appraisal of the studies included in our review.* It does not escape our notice that the included studies from published literature suffer from some methodological limitations. Some studies had relatively small sample sizes. For example, Al-Aboudi et al<sup>9</sup> included 75 participants and Al-Alawi et al<sup>12</sup> included 45. In addition, most researchers employed a convenience sampling method, rather than a random sampling method, which resulted in limited generalizability to the target population.<sup>9,11,13,18,22,24-26</sup> Kamel et al,<sup>21</sup> Aljoudi et al,<sup>19</sup> and Alzarea<sup>17</sup> selected a random sampling of DM patients at their treatment centers. Alsaedi et al<sup>23</sup> worked in multiple primary health care centers in Mecca; therefore, they employed a 2-stage stratified random sampling strategy.

Another methodological limitation arises from different outcomes assessed across the studies. Alsaedi et al,<sup>23</sup> Al-Eidi et al,<sup>12</sup> Abahussain et al,<sup>22</sup> and Kamel et al<sup>21</sup> aimed to evaluate the knowledge and use of complementary and alternative medicine products. Alzarea<sup>17</sup> and Al-Alawi et al<sup>12</sup> assess knowledge about eye complications of DM. Bahammam assessed the knowledge about periodontal diseases in association with DM.<sup>25</sup> Binhemd evaluated the knowledge about DM and glycemic control.<sup>10</sup>

Moreover, all the studies assessed the knowledge about DM using different questionnaires, while in the survey used by Aljoudi et al,<sup>19</sup> data were collected using a structured face-to-face interview. In most cases, these studies developed their questionnaires and piloted them among the study participants before use. The questionnaires included open-ended questions about the DM risk factors and prevention methods. In the study by Binhemd,<sup>10</sup> participants were interviewed using a pre-structured questionnaire developed by the researchers based on earlier work about the misconceptions of DM among Saudi Arabia population. The most commonly used questionnaire was the brief diabetic knowledge test developed by the University of Michigan Diabetes Research and Training Centre.<sup>27</sup> This questionnaire has been validated in the Saudi Arabian population<sup>28</sup> and has been used by many studies to assess the knowledge of Saudi Arabia population about DM.<sup>9,29-31</sup>

*Importance of DM Education in Saudi Arabia.* This systematic review has identified a considerable gap in knowledge about DM in the Saudi population, including among healthcare workers, medical students, and DM patients themselves. Therefore, more efforts are required to increase knowledge and awareness of DM in Saudi Arabia, especially regarding epidemiology.

As has been shown in other countries, better health education is a powerful tool to control chronic health

problems such as DM. For examples, 2 studies carried out in the United Kingdom by Christie et al<sup>32</sup> and Deeb,<sup>33</sup> reported better education among diabetic patients improves their ability to control the disease, resulting in better patient outcomes and reduced complications.

Therefore, increasing knowledge and awareness of DM in the population will contribute to better community health outcomes. Increased knowledge about DM is needed for patients to optimize their lifestyles and improve their medication habits to get the optimum benefits and delay the onset of long-term complications. Education is also essential to help DM patients' families cope with the necessary lifestyle modifications and provide psychological and dietary support. For healthcare workers, higher levels of knowledge are needed because they provide the first direct source of information and education for patients. Additionally, clinical information, such as the correct angle for insulin injections, is essential for improving clinical outcomes. Therefore, improving knowledge about DM among physicians is imperative, given the prevalence of the disease in Saudi Arabia. Public health centers are considered the best place to provide health education interventions for citizens both with and without DM.

*Risk Factors for DM in Saudi Arabia.* The risk factors of DM can be classified into 2 categories: modifiable and non-modifiable. Modifiable risk factors include diets rich in fat, low physical activity, high BMI, high blood pressure (above 140/90), metabolic syndrome and high plasma levels of triglycerides. Non-modifiable risk factors include age (above 40 years) and family history of DM. The high prevalence of T2DM in the Saudi population is attributed to high levels of obesity as the rapid urbanization of the country has led to physical inactivity and the adoption of a more western diet rich in fat. Midhet et al<sup>34</sup> performed a case-control study to investigate lifestyle-related risk factors of T2DM in Saudi Arabia. They found a strong association between lifestyle and T2DM: a maternal history of diabetes, education level, lack of exercise and dietary habits were significant risk factors. The adjusted odds ratios for these risk factors were: regular eating of Kabsa OR = 5.5 (95% CI 2.3 to 13.5), eating vegetables OR = 0.4 (95% CI 0.2 to 0.7), eating dates OR = 1.8 (95% CI 1.0 to 3.3) and sedentary lifestyle OR = 2.5 (95% CI 1.2 to 5.0).

Murad et al<sup>35</sup> performed a case-control study in Jeddah to investigate the risk factors of T2DM. They found that smoking, hypertension, increased weight/

obesity and age (above 40 years) were significant risk factors for T2DM among the studied population. Alfadhli et al<sup>36</sup> found that older maternal age, high BMI, high blood pressure, previous gestational diabetes (GDM), history of delivering a malformed child and family history of diabetes were the main risk factors for GDM.

**Complications of DM.** Complications of DM involve many body systems. Diabetic neuropathy, nephropathy, retinopathy and coronary artery disease are long-term severe complications of DM that require management and medical treatment.<sup>35-39</sup> A study by Algeffari<sup>37</sup> found that 35% of DM patients in Saudi Arabia suffer diabetic neuropathy. The odds of experiencing diabetic neuropathy was higher in those patients with poor compliance with their treatment plan. Diabetic foot is another major complication and economic burden of DM, as it results in partial disability of the patient.<sup>38</sup> A cross-sectional study of 62,681 DM patients from the Saudi National Diabetes Registry (SNDR) found that about 3.3% of DM patients had diabetic foot complications. Risk factors for diabetic foot include male gender, cerebral vascular disease, poor glycemic control, insulin use and old age.<sup>38</sup>

Diabetic retinopathy is a result of macular edema due to vascular changes in retinal vessels. A study of 690 randomly selected DM patients from King Fahd Hospital at Al-Madinah showed that about 36% of T2DM patients had microalbuminuria.<sup>40</sup> Another cross-sectional study examining 50,464 DM patients from the SNDR showed that about 20% of DM patients had diabetic retinopathy.<sup>39</sup> According to the SNDR, about 10.8% of DM patients in Saudi Arabia had diabetic nephropathy.<sup>39</sup> Diabetic nephropathy starts with microalbuminuria and progresses to end-stage renal disease.<sup>41</sup> Age and DM duration were the most important risk factors for diabetic nephropathy.<sup>41</sup>

**Role of physical activity in DM.** Multiple studies have linked low physical activity with DM in the Saudi population.<sup>42-44</sup> Exercise and physical activity help glucose entry into body cells, which improves the functions of insulin and enhances glucose metabolism. Exercise can indirectly reduce the risk of DM by decreasing body weight and burning fat cells which resist insulin. Midhet et al<sup>34</sup> found that a healthy diet combined with physical activity can reduce the risk of T2DM by 45%, despite having a family history of diabetes. Therefore, health education programs need to promote a healthy lifestyle in the Saudi population to minimize the burden of the disease.

**Strengths and limitations of this review.** This systematic review has multiple strength: First, we

followed the PRISMA statement guidelines during the preparation of this review to ensure a robust process, to explore knowledge of DM in the Saudi population. This is the first attempt to integrate the results of multiple studies about this topic. Second, we included epidemiological studies assessing the knowledge and awareness of the Saudi Arabia population in different geographical locations. Also, these studies represent a wide array of the population groups including DM patients, healthcare professionals, and school children. However, our review is limited by the differences in the outcomes reported by individual studies. Also, the questionnaires used to assess the knowledge and awareness of participants were heterogeneous. Many researchers developed their surveys based on the literature search while others use the validated DKT-2 developed by Michigan University. Finally, the low sample size of some studies and the non-probability sampling methods employed by several studies might limit the generalizability of their findings.

**Implications for health policy.** This systematic review highlighted the lack of knowledge and awareness of DM among the Saudi population. To improve public knowledge and awareness, it is necessary to enhance the education of health professionals regarding the pathology, etiology, risk factors, prevention, management and complications of DM. A greater focus is needed on the responsibility of health professionals in educating patients, families and the community about how a healthy lifestyle can reduce the risk of developing DM and the complications of those living with this chronic disease.

In conclusion, this review highlighted a gap in the knowledge about DM and its risk factors among the Saudi population. Further public health interventions are needed in Saudi Arabia to address the lack of knowledge about DM and its preventive measures.

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