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Review Article

Epidemiology, Technology, and Professional Perspectives on Diabetes in the United Arab Emirate: A Focused Review

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Abstract

Introduction The United Arab Emirates (UAE), among the rest of the Arab Gulf countries, exhibits a high prevalence of diabetes, primarily type 2 diabetes (T2D).

Methods We aimed to provide an overview of the epidemiology, complications, and quality of care, including the use of technology in diabetes care. Also, we wished to explore the challenges of diabetes management and future directions in clinical practice and research. This is a focused review of the literature of selected relevant themes to serve the above objectives of the work.

Results Several epidemiological studies have documented the increased prevalence of diabetes in the native population and expatriates. The vast majority focused on T2D. The prevalence of diabetes in the UAE is estimated at 12.3% for the 20 to 79 age group. Although the high prevalence was recognized and acknowledged as a national priority, several challenges exist in standardizing care across the population. There are gaps in research about the nationwide prevalence of all forms of diabetes. Some research studies have evaluated the role of technology in diabetes care, genetic predilection to complications, and particular aspects such as diabetes during pregnancy, neonatal diabetes, monogenic diabetes, and cardiovascular risk in diabetes. UAE recently became a focal point for health-related Ramadan fasting research, including diabetes.

Conclusions Diabetes in the UAE considerably burdens the health care system. A concerted effort is needed to adopt more uniformity of diabetes care and research nationwide. This should address the use of unified methods to document the nationwide burden, explore possible differences in various epidemiological phenomena, access to health care, and impact on outcomes, and evaluation of the cost-effectiveness of different models of care.

Keywords
- complications
- diabetes
- diabetes care
- epidemiology
- management
- professionalism
- United Arab Emirates

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Introduction

Diabetes is a complex metabolic disorder with an increased risk of morbidity and mortality. Based on the most recent International Diabetes Federation (IDF) data in 2021, diabetes mellitus (DM) affects 537 million and is projected to reach 783 million by 2040.[1] In the Middle East and North Africa region, diabetes affects one in six adults. The total number is expected to increase to 136 million by 2045.

The United Arab Emirates (UAE), like the rest of the Arab Gulf countries, has a high prevalence of type 2 diabetes (T2D). These countries have similar populations and cultural and socioeconomic characteristics (lifestyle, diet, income, language, and religion). The rates of diabetes, primarily T2D, range from 8 to 22%, according to the latest IDF report.[1] Many factors contribute to the high prevalence in this region, particularly obesity and unhealthy lifestyles. As a result of increased wealth and prosperity, Gulf countries now have increased health care expenditures and life expectancy.[2] However, genetic susceptibility and the incidence of T2D among children and young persons are rising. Diabetes has severe implications for the person, family, and society.

The prevalence of diabetes in the UAE is estimated at 12.3% for the 20 to 79 age group (age-adjusted 16.4%).[1] Given its public health importance, we will review the literature on the epidemiology, types, clinical characteristics, complications, and quality of care in this chapter. We will also review the role of technology in diabetes care, the challenges of diabetes management, and future directions in clinical practice and research.

Methods

This is a focused narrative review of the literature on selected aspects of diabetes and diabetes care in the United Arab Emirates. One author took the lead to identify the most relevant aspects. The selected aspects were epidemiology, diabetes care, impact of technology on diabetes care, and professional and patients' perspective (►**Table 1**). Various sections were assigned to different authors who drafted their sections, shared them with other coauthors, and reviewed the other sections. The manuscript was further developed by all the authors through several cycles of discussions. The final product was approved by all the authors.

Epidemiology

Several studies evaluated the epidemiology of diabetes in the UAE. The majority focused on T2D and reported on the prevalence of the disease. However, only some studies reported data from the entire country (►**Table 2**). Malik et al studied the prevalence of diabetes among 5,844 adults (>20 years) between October 1999 and June 2000.[3] Diabetes diagnosis was based on fasting blood glucose (FBG) and 2-hour postoral glucose tolerance test (OGTT) criteria. The overall crude diabetes prevalence was 20%. The age-adjusted diabetes prevalence was higher in UAE nationals (25%) than in expats (16–21%). Of interest, 41% of those with diabetes were undiagnosed before the survey. The prevalence of IFG was 5% in women and 7% in men. Saadi et al surveyed 2,455 adults in 452 houses in Al Ain between December 2005 and November 2006.[4] Of those, 10.2% reported having diabetes. Among the 373 men and nonpregnant women who underwent testing, the age-standardized rate for diabetes was 29% among the 30 to 64 age group. Microvascular complications were present in 35 to 52% of patients with diabetes, while peripheral vascular disease and coronary heart disease were present in 11.1 and 10.5%, respectively. The reported prevalence of prediabetes was 20.2% in this study.

The cardiovascular risk factors were evaluated in 50,138 self-enrolled adults (>18 years) presenting to 25 primary care clinics for the *Weqaya* screening program in the Emirate of Abu Dhabi between April 2009 and June 2010.[5] In this study, the age-standardized prevalence rates of diabetes were 24.6 and 29.5% for prediabetes. Also, the cross-sectional study evaluated the prevalence of diabetes among UAE nationals and expatriates living in the Northern Emirates, Dubai, and Sharjah over 4 years.[6] A total of 3,202 individuals (25% UAE national) were included, and the reported adjusted diabetes prevalence of diabetes was highest in UAE nationals (males 21% and females 23%) and Asian non-Arabs (males 23% and females 20%). Also, the crude diabetes prevalence of 25.1% among 872 adult UAE nationals in the five northern Emirates was observed.[7] The results were derived from the UAE National Diabetes and Lifestyle Study collected in 2013, and diabetes diagnosis was based on hemoglobin (HbA1c) of >6.5%. Undiagnosed diabetes was reported in 14.8% of the participants. The same group reported an age-adjusted diabetes prevalence of 19.1% among 2,724 migrants in the

Table 1 Rationale for the selection of themes of selected for inclusion in the review

Epidemiology	UAE is a typical example for new wealthy societies with rising rates of diabetes in both native and expatriate populations worthy of study.
DM in Special groups	Interplay of increased parity and increased diabetes risk, diabetes in young people
Diabetes care	Demonstration of the impact of diabetes care provided by various models of care.
Cardiovascular disease	Cardiovascular morbidity is the leading cause of dealth in people with diabetes.
Technology in diabetes	UAE embraced advances in diabetes technology and the health system could afford it; lesions could be learned from this unique experience.
Professional aspects	Reflections on how the medical profession responded to increasing burden of diabetes in diabetes care, education and research.

Abbreviations: DM, Diabetes mellitus; UAE, United Arab Emirates.

Table 2 Summary of the T2DM prevalence studies in the UAE

Authors, year	Patient population/setting	Prevalence	Comments
Malik et al 2005[3]	5,844 adults (>20 years) between Oct 1999 and June 2000	Crude 20% Age-adjusted: UAE: 25% Expats: 16–21%	40% of UAE citizens of the cohort; DM Dx: FBG >7 mmol/L and or BG > 11.1 mmol/L post-2h OGTT; Of interest, 41% of those with diabetes were undiagnosed prior to the survey IFG/IGT prevalence: 5%/21% in women, 7%/16% in men.
Saadi et al 2007[4]	Survey of 2,455 adults in 452 houses in Al Ain (Dec 2005–Nov 2006)	29% of 373 people tested; 30–64 years	Microvascular complications were present in 35–52% of patients with diabetes, while peripheral vascular disease and coronary heart disease were present in 11.1 and 10.5%, respectively. PreDM prevalence:20.2%
Hajat et al 2012[5]	50,138 self-enrolled adults at primary care clinics for *weqaya* screening in Abu Dhabi (2009- 2010)	Age-standardized 24.6%	DM Dx: HbA1c> 6.5%, RBG >11.1 mmol/L or history of DM on medications; limitations: selection bias due to self-enrollment of participants, data from Abu Dhabi emirate only, and type of DM not defined; PreDM prevalence:29.5%
Hamoudi et al 2019[8]	3,203 individuals.	UAE nationals (M: 21%/ F: 23%) Asian non-Arabs (M: 23%/ F: 20%).	Results were derived from the UAEDIAB Study. DM Dx: HbA1c> 6.5%, FBG> 7 mmol/L. 25% of UAE nationals in this cohort. Nationals with DM had the highest rate of positive family history of diabetes (64%) compared with other ethnicities. Data from all emirates except Abu Dhabi
Suliman et al 2018[6]	872 adult UAE nationals living in the Northern Emirates.	Crude: 25.1%	Results were derived from the UAEDIAB Study: Diabetes Dx based on HbA1c of >6.5%; Undiagnosed diabetes was reported in 14.8% of the participants; Data from all emirates except Abu Dhabi
Suliman et al 2018[7]	2,724 migrants in UAE	19.1%	Results were derived from the UAEDIAB Study. The cohort was derived from individuals coming to medical centers for visa renewal. The majority were males, Asians, non-Arabs, and 40 years or younger. Data from all emirates except Abu Dhabi
Alawadi et al (2014)[9]	2,245 adults from the Dubai household survey	UAE nationals: 19.3%; Expats: 12.4%	The results are similar to the data from the DHHS 2014/17, with the reported prevalence of 19% for UAE nationals and 14.7% for expats (9).

Abbreviations: DM, diabetes mellitus; Dx, diagnosis; FBG, fasting blood glucose; HbA1c, glycosylated hemoglobin; IFG, impaired fasting glucose; IGT, impaired glucose tolerance; PreDM, prediabetes; RBG, random blood glucose; UAE, United Arab Emirates; UAEDIAB, UAE National Diabetes and Lifestyle Study.

UAE.[8] This cohort was derived from individuals coming to medical centers for visa renewal. The majority were males (81%), Asian non-Arabs (71%), and younger than 40 years (65%).[8] Furthermore, Alawadi et al recently reported on 2,245 adults from the Dubai household survey, indicating an overall prevalence of diabetes. The national prevalence was significantly higher than among expats (19.3 vs. 12.4%).[9] The findings are similar to the 2014/17 data, with a reported prevalence of 19% for UAE nationals and 14.7% for expats.[10]

There is limited information on the incidence of diabetes in the UAE. The incidence of diabetes was studied in a small study among Emiratis in Ajman in 2010.[11] One hundred one patients with a new diagnosis of T2D were included (age 23–78 years and 65% females). The overall incidence was calculated as 4.8/1,000 person-years (PY). Incidence was higher in females than males, and the highest incidence was in the 55 to 59 age group.[11]

Special Populations

Diabetes in Young People

Autoimmune diabetes, defined as diabetes-associated autoantibodies without ketoacidosis or insulin requirement for at least 6 months after diagnosis, was assessed in a study from a large center in Abu Dhabi.[12] Among 17,062 patients with diabetes aged between 30 and 70 years, the prevalence of LADA was at 2.6% in these settings.

The characteristics of neonatal diabetes mellitus (NDM) in patients across pediatric diabetes clinics in Abu Dhabi were studied. Twenty-five cases were identified, and the incidence of NDM was approximately 1:29,000 live births. Of those, 23 had permanent NDM, while 2 had transient NDM.[13] Genetic alterations were detected in 21 cases (9 EIF2AK3 mutations, 6 INS mutations, 2 PTF1A enhancer deletion, 1 KCNJ11 mutation, 1 ABCC8 variant, and four without mutations).

For the transient NDM, the genetic abnormalities were 6q24 methylation defect and homozygous INS c-331C > G mutation.[13]

The prevalence of diabetes and prediabetes among 555 young Emirati female college students was studied in a cross-sectional study in 2021 in Al Ain using HbA1c and fasting plasma glucose (FPG).[14] Their age range was 17 to 25. Based on HbA1c values, the prevalence of prediabetes and diabetes were 24 and 8.6%, respectively. Remarkably lower corresponding estimates were detected using FPG 9.2 and 0.5%, respectively. Abnormal glycemic status was significantly associated with abnormal lipids and increased inflammatory markers. Using FPG to evaluate glycemic control underestimates the burden of undiagnosed diabetes, which could significantly impact clinical practice. On the other hand, Meo et al estimated the prevalence of T2D among men in the Middle East (including the UAE) from a review of 74 studies.[15] From 17 studies included, the prevalence of T2D among men in the UAE was 25.8%. The prevalence in the Gulf was obviously related to the gross domestic product of these states ($p = 0.0005$).

A large cross-sectional study investigated the prevalence of diabetes and risk factors in the school-attending adolescent population of the UAE in 2021.[16] A stratified random sample survey of 151 public and private schools across seven emirates involved 6,365 school-attending adolescents (12–22 years). Overall, diabetes was reported by 0.9%. This was higher in males than females (1.5 vs. 0.5%, respectively). Diabetes status was positively associated with some characteristics of adolescents, including male sex, parental marital status, and smoking/illegal drug use. The high prevalence of smoking and illegal drug use in adolescents with diabetes suggests a need for mental health and behavioral interventions and better parental support and involvement.

Diabetes during Pregnancy

Emirati women, similar to other Arab women, have been identified as carrying a high risk of gestational diabetes and diabetes during pregnancy on several counts. Obesity, ethnicity, and high fertility with pregnancies continue to the third and fourth decades of life.[17,18] The earlier research by obstetricians from UAE, mostly in clinic-based surveys, addressed the overall frequency and the contribution of diabetes to the general outcome of the pregnancy and some specific complications such as macrosomia and shoulder dystocia.[19,20] Also, several studies, particularly from Al Ain, investigated the validity and utility of various strategies for screening and diagnosing gestational diabetes in this high-risk multiethnic population.[21,22]

However, more recent studies are larger and include the epidemiology of diabetes in pregnancy in the UAE, the applicability of several diagnostic guidelines, and the impact of lifestyle management.[23–29] The Mutaba'ah study is the largest multicenter mother and child cohort study in the UAE with an 18-year follow-up. Discrepancies among the diagnostic criteria in identifying gestational diabetes mellitus (GDM) cases were evident emphasizing the need to unify diagnostic criteria to provide accurate and reliable incidence estimates for health care planning, particularly as the agreement with the recommended criteria was not optimal.[23]

The pregnant women's perception and knowledge of the impact of obesity on prenatal outcomes was evaluated in a cross-sectional study using 526 self-administered questionnaires, with a response rate of 72%. Most (81.8%, $n = 429$) entered pregnancy as overweight or obese.[24] The percentage of pregnant women who underestimated their weight category was 12.1% in normal-weight participants, 48.9% in overweight participants, and 73.5% in obese participants ($p < 0.001$). The overweight and obese participants were 13 times more likely to underestimate their weight status and 3.6 times more likely to select their healthy gestational weight gain (GWG) correctly. Women's awareness of pregnancy-related complications from weight varied from 80.3% for diabetes to 44.5% for fetal complications; their awareness of breastfeeding difficulty was the lowest at 2.5%. Moreover, there was a misconception about personal body mass index (BMI) and the appropriate range for GWG. Healthy lifestyle counseling urgently needs to be addressed in preventative health programs such as premarital and preconception counselling. Whether lifestyle intervention in early pregnancy can prevent GDM in high-risk pregnant women in the UAE was addressed in a randomized controlled trial.[25] A open-label, pragmatic, randomized clinical trial included 63 women, with ≤12 weeks of gestation, singleton pregnancy, with ≥ two risk factors for GDM. They were randomly assigned to the lifestyle intervention (LI) group ($n = 30$) kl g and usual care (UC) group ($n = 33$). The LI group received a 12-week, moderate-intensity lifestyle intervention with individualized counseling on diet, physical activity, and behavior change by a licensed dietitian. The UC group received the usual antenatal care. They revealed that a 12-week moderate-intensity lifestyle intervention in early pregnancy could reduce the relative risk of GDM by 41% among high-risk pregnant women in the UAE. These findings could impact public health outcomes in the region.[25]

The maternal early-life risk factors and later gestational diabetes mellitus were the subjects of the cross-sectional analysis of the UAE Healthy Future Study.[26] Three more focused studies on Ramadan fasting, the use of technology by pregnant women, and the outcome of twin pregnancies were also published in the UAE. Hassanein et al[27] explored the safety of fasting in GDM in Ramadan while understating the glycemic variability. Twenty-five patients with GDM who choose to fast were enrolled and provided optimum care that included Ramadan-focused education, and FreeStyle Libre Flash Continuous Glucose Monitoring (FSL-CGM) was utilized for a 2 to 4 weeks assessment period of non-Ramadan days plus 2 to 3 weeks during Ramadan and medication adjustment. The average glucose improved significantly, while time in target and percent above target numerically improved during Ramadan compared with pre-Ramadan. There was a significant increment in the number of hypoglycemic events in Ramadan. The average lowest blood glucose reading was reduced significantly by 14 mg/dL, with the average hypoglycemic event duration increasing significantly by 38.5 minutes. Our study reinforces the importance of

structured education before Ramadan to deliver optimal care for diabetes management. Strikingly, FSL-CGM demonstrated that hypoglycemia significantly increases during Ramadan fasting. There was an effective reflection of hyperglycemic spikes immediately after Iftar.[27] Afandi et al assessed the value of CGM and self-monitoring of blood glucose in patients with GDM during Ramadan fasting in a prospective observational study that recruited GDM patients treated with diet ± metformin. Twenty-five patients were recruited. Thirty-six thousand six hundred twenty-eight readings by the CGM device and 408 readings using glucose meters were captured. The average glucose level was 103 and 113 mg/dL on CGM and glucose meters, respectively. The rates of hyperglycemia were 5.7 and 14.2% and hypoglycemia were 4.4 and 1.5% by CGM and glucose meters, respectively. While all hypoglycemic episodes occurred between 16:00 and 19:00 in both approaches, only 38 (9%) self-monitoring of blood glucose (SMBG) readings were done.[28] Also, a 5-year retrospective review of hospital records of twin pregnancies in 404 women in Al Ain using relevant data was carried out from two major hospitals in the city.[29] They were 30.1 years of age, overweight or obese (66.5%), and multiparous (66.6%). A higher incidence of GDM occurred in twin pregnancies (27.0%). GDM mothers were older and heavier. They were also very likely to have had GDM in their previous pregnancies. The prognosis of mothers with twin pregnancies and GDM leads to independent and increased odds of cesarean section and hospitalization during pregnancy.[29]

Diabetes Care

Diabetes Guidelines

Diabetes requires continuous medical care consisting of multifactorial risk modification strategies, not merely glycemic control. Diabetes care keeps changing with new evidence, therapies, and technologies that may improve the well-being and outcomes of people with diabetes. Consequently, most international bodies concerned with diabetes (e.g., the American Diabetes Association [ADA], European Association for the Study of Diabetes, IDF, etc.) produce and regularly update guidelines that cover all aspects of diabetes care based on the interpretation of the latest available evidence.[30,31] These international guidelines were developed mainly for populations in the Western world. In 2020, the Emirates Diabetes Society (EDS) revised its national EDS consensus guidelines for managing T2D.[32,33] The guidelines considered the screening, diagnosis, and management of T2D in adults and individuals at risk for developing the disease. These guidelines have been adapted for local use to improve the care for people with diabetes by increasing awareness among health care providers practicing in the country.

Goals and Organization of Care

The aim of diabetes management is to prevent complications and maintain a good quality of life.[34–36] To achieve this, hyperglycemia and cardiovascular risk factors should be controlled, necessitating regular follow-up. A patient-centered approach should be adopted to enhance patient engagement in self-care activities. Individualized treatment goals and strategies should be informed by carefully considering patient factors and preferences. Patients with diabetes benefit from the services of coordinated multidisciplinary teams. Such teams include physicians experienced in diabetes management, diabetes educators, dieticians, and podiatrists. Other health care professions, such as pharmacists, ophthalmologists, cardiologists, nephrologists, and vascular surgeons, contribute with their relevant expertise.[34] Glycemic control is usually assessed by HbA1c, which reflects average glycemia over the previous 3 months, SMBG, and more use has been made of CGM.[35] For most patients with diabetes, a target HbA1c of $<7\%$ should be the aim. This target corresponds to SMBG fasting glucose values of 80 to 130 mg/dL and postprandial levels of <180 mg/dL.[35] However, targets should be individualized based on age, hypoglycemic risk, diabetes duration, patients' motivation, and comorbidities, especially cardiovascular disease.[34]

Strategies for Glycemic Management

To achieve the glycemic targets stated above, a comprehensive diabetes care program is required. This program consists of structured education, glucose monitoring, lifestyle modification by physical activity and diet, and appropriately selected pharmacotherapeutic agents.[32–36]

Diabetes self-management education (DSME) in a structured manner should be offered to all patients with diabetes and/or their family members as appropriate. DSME and support should be patient centered and may be offered in group or individual settings. DSME aims to empower the patient with the necessary knowledge, skills, and capabilities needed for confident diabetes self-management and to provide activities that sustain the lifestyle modifications needed to manage the condition in the long term.[36]

All patients with diabetes should have access to a qualified dietician at diagnosis and as needed later (at times of intensification, suboptimal responses, and problems with hypoglycemia, weight gain, etc.). The aim is to provide patients with nutritional recommendations that address specific needs and goals based on personal and cultural preferences and practical tools to adopt healthy eating patterns.

As most patients with T2D are either overweight or obese, nutritional plans should aim for a weight loss of 5% or more to achieve favorable outcomes in optimal control of blood glucose, plasma lipids, and arterial blood pressure.[31,33]

There is not enough evidence to advocate an ideal percentage of calories from carbohydrates, fat, and protein for all people with diabetes. Hence, the distribution of macronutrients should be based on an individualized assessment of metabolic goals, eating patterns, and patient preferences. In general, nutritional advice emphasizes the use of nonstarchy vegetables, minimizes refined grains and added sugars, and gives preference to whole foods over highly processed foods.[34–36]

Dietary plans for UAE patients need to consider the local custom of eating dates.[37,38] For instance, dates are a popular

food item incorporated in stable food and as a dessert. Dates are rich in calories; any meal plan should account for this. Dates were shown to have high fiber content and as a source of antioxidants and minerals.[37] A local UAE study showed that dates have a low glycemic index and may not result in significant postprandial glycemic excursions.[38] Nonetheless, excessive intake of dates is not uncommon, especially in summer, with a negative impact on diabetes control, albeit transiently for many patients.

Regular exercise improves blood glucose control, reduces cardiovascular risk factors, contributes to weight loss, and improves overall well-being and self-esteem.[39] Consequently, international and national guidelines recommend that patients with T2D undertake more than 150 minutes of moderate aerobic exercise per week and two to three sessions of resistance exercise weekly.[33–36] Of particular concern is that a local study found that 3% of patients with T2D in the UAE reported physical activity levels that meet the recommended guidelines. Therefore, much effort is needed to encourage patients with diabetes to exercise and to identify and deal with barriers preventing them from doing so.[39]

Because of the progressive nature of T2D, most patients experience relentless deterioration of β-cell function and rising hyperglycemia. Therefore, lifestyle changes alone will not be enough to maintain euglycemia. For this reason, increasing pharmacotherapy will be needed in most patients.[33,40] Traditionally, first-line therapy starts with metformin and comprehensive lifestyle modification. After metformin, other drugs can be used, including sulphonylureas, DPP4 inhibitors, GLP-1 receptor agonists, SGLT2 inhibitors, pioglitazone, and basal insulin.[33,40] Over the last decade, several cardiovascular outcomes trials have provided evidence that two classes of antidiabetic medications (the GLP-1RAs and the SGLT2 inhibitors) have resulted in cardiovascular and renal benefits beyond their glycemic efficacy.[41] These findings have significantly influenced the latest guidelines on the choice of antidiabetic medications.[33,40]

The national UAE diabetes guidelines have classified patients with T2D into four risk groups: very high, high, moderate, or low, depending on several factors, including CVD or target organ damage, age, diabetes duration, and cardiovascular risks.[33] The guidelines suggested that drugs with proven cardiovascular and renal benefits (i.e., GLP-1RAs and SGLT2 inhibitors) should be offered to patients in the very high-risk category and should be considered for those in the high-risk category regardless of the level of glycemic control. For those at moderate and low risk, the choice of drugs will depend on other factors such as hypoglycemia risk, impact on weight, and cost.[33]

Many patients with T2D eventually require insulin therapy. Patients should be made aware of the progressive nature of T2D, and the use of insulin should be viewed as a phase in the natural progression of the disease and should not be seen as a sign of the personal failure of the patient. With careful patient education and an explanation of the efficacy of insulin in maintaining glycemic control, patients' reluctance to use insulin can be overcome.[27] Health care professionals should avoid clinical inertia, and there should be no delay in recommending treatment intensification for patients not meeting treatment goals.[27]

Cardiovascular Disease and Risk Management

Atherosclerotic cardiovascular disease (ASCVD) encompasses coronary heart disease, cerebrovascular disease, and peripheral arterial disease, presumed to be of atherosclerotic origin. These are the leading causes of morbidity and mortality in patients with diabetes.[41] Established risk factors for ASCVD, such as hypertension and dyslipidemia, are commonly associated with diabetes. Other risk factors for ASCVD include smoking, obesity, albuminuria, chronic kidney disease (CKD), and a family history of premature coronary heart disease. Modifiable risk factors should be identified and treated. In addition to coronary heart disease, heart failure has been more recently recognized as a critical cardiovascular complication in patients with diabetes. There is clear and undisputed evidence that controlling these risk factors prevents or slows the progression of ASCVD in patients with diabetes. For this reason, control of these ASCVD risk factors is vital in the management of patients with diabetes.[41]

CVD risk factors need to be addressed more aggressively in patients with cardiovascular disease in the Middle East as their risk is higher than their counterparts in Western countries. It has been shown that patients who present with acute coronary attacks in the Middle East are 10 to 12 years younger than those in Western countries.[42] Furthermore, patients from the UAE with T2D were found to have a high prevalence of comorbidities such as hypertension, dyslipidemia, and obesity.[43]

Hypertension is a major risk factor for both ASCVD and microvascular complications, and the current targets agreed by most international guidelines are a BP of $<$140/90 mm Hg in patients with low risk for CVD, while a target of $<$130/80 should be aimed for in those with high CV risk.[33,41] Specific antihypertensive drug classes that have been shown to lower cardiovascular events in patients with diabetes include angiotensin-converting enzyme (ACE) inhibitors, angiotensin receptor blockers, dihydropyridine calcium channel blockers, and thiazide-like diuretics. Therefore, for patients with diabetes, ACE inhibitors or angiotensin receptor blockers s should be the first-line medications, especially in the presence of coronary artery disease or albuminuria patients.[33,41]

Low-density lipoprotein cholesterol (LDL-c) has been shown to correlate linearly with the risk of ischemic heart disease; therefore, it is considered the primary lipid parameter to be addressed. Together with lifestyle modification, statins are the drugs of choice for treating dyslipidemia in patients with diabetes. To achieve the appropriate lipid targets, patients should be prescribed high-intensity or moderate-intensity statins.[33,41] Patients with a previous ASCVD event are considered very high risk, whereas those with multiple risk factors are at high risk. The target LDL-c for those at very high risk for ASCVD is $<$55 mg/dL, for high risk $<$70 mg/dL, and for

moderate risk <100 mg/dL. For patients who do not achieve targets on the maximum tolerated dose of a statin, consideration should be given to adding ezetimibe or a proprotein convertase subtilisin/kexin type 9 inhibitor.[33,41]

Aspirin should be prescribed to all patients with diabetes who have had a previous ASCVD event (i.e., for secondary prevention). However, aspirin is generally not recommended for primary prevention, as, for most patients, the risk of bleeding outweighs any ASCVD reduction benefits.[33,41]

Diabetes and Technology in UAE

In the context of diabetes, technology denotes all hardware, devices, and software that people with diabetes use to assist their condition management.[44] Diabetes technology encompasses two main categories: insulin administration tools and blood glucose monitoring.

Insulin is administered by pens or pumps (i.e., continuous subcutaneous insulin infusion). Blood glucose is assessed by SBGM, CGM, and flash glucose monitoring (FGM). However, more advanced diabetes technology includes hybrid devices that monitor glucose and deliver insulin. Some of these devices function automatically. The software also serves as a medical device providing diabetes self-management support. Diabetes technology, education, and close follow-up improve the lives of people with diabetes. However, the complexity and rapid changes in the diabetes technology landscape can hinder patient and health care providers' implementation. Technology has been evolving, using the internet of things for diabetes care.

Digital health or mobile health (mHealth) is defined by the WHO Global Observatory for eHealth as "medical and public health practice supported by several mobile devices." These devices include mobile phones, monitoring devices, personal digital assistants, and other wireless devices.[44] Digital health apps can be generally considered under three categories: (1) those used for tracking wellness, those that function as stand-alone medical devices; (2) those that display, download, and/or use data from medical devices that diagnose, prevent; monitor or treat a condition CGM, insulin pump; or (3) automated insulin delivery system.[45] These devices improve health outcomes and quality of life by coaching patients, supporting healthy behavior, encouraging glucose monitoring even remotely, assisting with interpreting results, maintaining lifestyle modification, guiding dosing, and reducing complications.[46]

Several studies have confirmed that self-care behavior specific to glucose monitoring is essential in managing glycemic levels. Incorporating technology into diabetes management can augment and facilitate self-management. The CGM systems have revolutionized how diabetes is managed.[47–49]

Recent abilities to continuously measure interstitial glucose allow the detection of time in range (TIR), glucose variations, and hypoglycemic events.[50] TIR is a novel concept based on the time in near normal glucose levels, defined as under a range of 70 to 180 mg/dL for most patients. In 2017, an International Consensus on Continuous Glucose Monitoring Standardized the Use of CGM technology. TIR generally refers to the time spent in an individual's target glucose range (usually 70–180 mg/dL but occasionally 70–140 mg/dL. Use of CGM helps promote therapy adjustments in both T1D and T2D, especially for patients with frequent hypoglycemia.[51] Based on current evidence, a TIR of >70% is recommended for most individuals with T1D and T2D. Other metrics derived from CGM technology include mean glucose, glucose variability, and glucose management indicators in addition to time below range and time above range. All metrics should be examined in every patient–physician encounter and appraised against the recommendations.

Technology-Related Studies in UAE

The UAE has been an early adopter of CGM technologies. Glucose monitoring devices are available to most patients with diabetes in both public and private health care facilities. Several groups have published their CGM experience in different patient populations and clinical settings (►**Table 3**).[52–57]

Two studies from the same tertiary care center in the UAE employed FSL-CGM in two high-risk groups fasting during Ramadan (2016).[52,53]The first prospective interventional study included 25 patients with T2D and CKD stage 3.[52] FSL-CGM data showed significantly longer duration and more frequent hypoglycemic episodes during Ramadan than non-Ramadan. The mean BG readings were also significantly lower during Ramadan than in the nonfasting period. The renal function showed no significant change due to fasting. Therefore, in patients with diabetes and CKD-stage 3, RF under close supervision and optimal diabetes care were not associated with worsening HbA1c and renal function. The other study was a prospective study aiming to determine the safety of fasting in coronary heart disease (CHD) patients with diabetes who insisted on fasting.[53] Twenty-one patients with T2D with stable known CHD were recruited. Similarly, FSL-GCMS data showed a higher frequency of hypoglycemia during Ramadan fasting. However, there were no associated adverse cardiovascular effects with fasting in patients with stable CHD under optimal diabetes care.

In a different patient population, Afandi et al assessed the frequency, timing, and severity of hypoglycemia in 21 adolescents (mean age 16 years) with T1D while fasting during Ramadan.[55] They were monitored using the FSL-CGM system. The data were analyzed by times of the day and night and the eating pattern during Ramadan. The authors demonstrated that hypoglycemia is typically encountered during the early evening immediately before the iftar time, suggesting that basal insulin reduction is needed to minimize the risk of hypoglycemia.[54]

Ehtisham and Adhami investigated whether the sensor-estimated HbA1c over 90 days accurately predicted the measured HbA1c and whether its accuracy correlated with the percentage of sensor data captured in 24 children with T1DM who were wearing a glucose sensor (20 Freestyle Libre and 4 Dexcom G5).[56] The mean measured HbA1c was 7.9%, and the mean predicted HbA1c was 7.7%. Estimated HbA1c tended to be lower than the measured HbA1c, but the mean difference (MD) was negligible. There was no correlation

Table 3 Summary of the studies on CGM and telemonitoring conducted in the UAE

Authors, year [ref]	Patient population (*N*)	Clinical setting	Technology used	Summary of findings
Alawadi et al., 2019[53]	High-risk patients with diabetes and chronic kidney disease stage 3 (CKD 3) *N* = 25	Ramadan fasting (RF.)	FSL-CGM	RF under close supervision and optimal diabetes care was not associated with worsening of HbA1c and renal function. More frequent and prolonged hypoglycemic episodes occurred during RF.
Hassanein et al 2019[54]	Patients with T2D with stable known CHD *N* = 21	During and after RF.	FSL-CGM	No associated adverse cardiovascular effects with RF in patients with stable CHD under optimal diabetes care. A higher frequency of hypoglycemia occurred during RF.
Afandi et al., 2018[55]	Children with T1D (*N* = 24)		Freestyle Libre or Dexcom G5	Hypoglycemia is typically encountered during the hours preceding *Iftar*, indicating an over-effect of basal insulin; hence, basal insulin reduction is necessary to minimize hypoglycemia risk.
Ehtisham and Adhami 2019[56]	Children with T1D	Routine follow-up	Comparison of FSL-CGM-derived estimated HbA1c (eHbA1c) with measured HbA1c (mHbA1c)	eHbA1c tended to be lower than the mHbA1c, with no relationship between sensor wear time and HbA1c. eHbA1c was within 0.75% of the mHbA1c 79.2% of the time.
Farooqi et al 2022[57]	Lost-to-follow-up T2D patients. *N* = 38	Routine follow-up	home-based Telemonitoring (TM) devices	TM significantly improved overall DM outcomes (glycemic control and body weight), indicating its effectiveness in a challenging population previously lost to follow-up.
Ashraf et al 2021[58]	T2D adults *N* = 21	COVID lockdown	FSL-FGM	Despite reduced exercise and the psychological stress of the COVID-related lockdown period, FGM-derived markers of glycemic control were improved.

Abbreviations: CGM, continuous glucose monitoring; CHD, coronary heart disease; COVID, coronavirus disease; e-HbA1c, estimated HbA1c; FL-FGM, FreeStyle Libre Flash Glucose Monitoring; HbA1c, glycosylated hemoglobin; MhbA1c, measured HbA1c; RF, Ramadan fasting; T1D, type 1 diabetes; T2D, type 2 diabetes.

between lower sensor wear time and HbA1c. With the increasing sensor accuracy, the estimated HbA1c may eventually replace the three monthly HbA1c blood tests.

Farooqi et al evaluated the impact of telemonitoring devices on glycemic control and compliance in 38 previously lost-to-follow-up patients with T2D in an interventional single-center study in Dubai.[57] Patients were provided with home-based telemedicine devices at the initial visit. The mean HbA1c decreased significantly from 10.3% at baseline to 7.4% at the end of 3 months of follow-ups (MD of −2.9%). The authors concluded that TM significantly improved overall diabetes outcomes indicating its effectiveness in a challenging population of T2D patients who had previously been lost to follow-up. Another group from Abu Dhabi described their experience with telemonitoring.[57] They described data on 21 individuals using FSL-CGM who were remotely connected to the diabetes clinic. Overall, glycemic control improved during the coronavirus disease 2019 (COVID-19) lockdown compared with the weeks before. They demonstrated that despite the reduced exercise and the lockdown-associated psychologic stress, there was an improvement in FGM-derived markers of glycemic control.

These few studies in our region show how integrating technology into diabetes management can improve the care of people with diabetes, particularly in ethnically relevant issues such as Ramadan fasting. The technology continues to be refined and upgraded; health care providers will have access to tools that can monitor patients more accurately and provide real-time recommendations on management. Improvements in monitoring have the potential to translate into a better quality of life with fewer diabetes-related complications. UAE has been at the forefront of embracing these advances.

Insulin delivery systems are valuable tools for diabetes management. However, not every patient with diabetes may be eligible for pump use. Identifying candidates is the first step. The ADA recommends a list of questions to be answered when choosing a given approach for insulin therapy (i.e., pump versus multiple dose injections).[44] These need to be addressed under regional circumstances to get the best possible approach for the individual patient within his or her skills, financial means, and access to professional support.

Professional and Patients' Perspectives

Since 2007, when the DM prevalence in the UAE was ranked the 2nd highest in the world (19.5%) according to the IDF annual report, there has been a significant public, governmental and professional interest in the challenges of diabetes.[1] Several epidemiological studies have documented the increased prevalence of diabetes in both the native population and expatriates.[3–11] Centers of excellence for diabetes care were established as stand-alone (such as Rashid Center of Diabetes and Research, Imperial College London Diabetes Center, and Dubai Diabetes Center [ICLDC]) or within the major health facilities (Sheikh Khalifa Medical City, Dubai Hospital, and Tawam Hospital). Diabetes care received appropriate prominence in all public and private health care facilities. An increasing volume of research has been

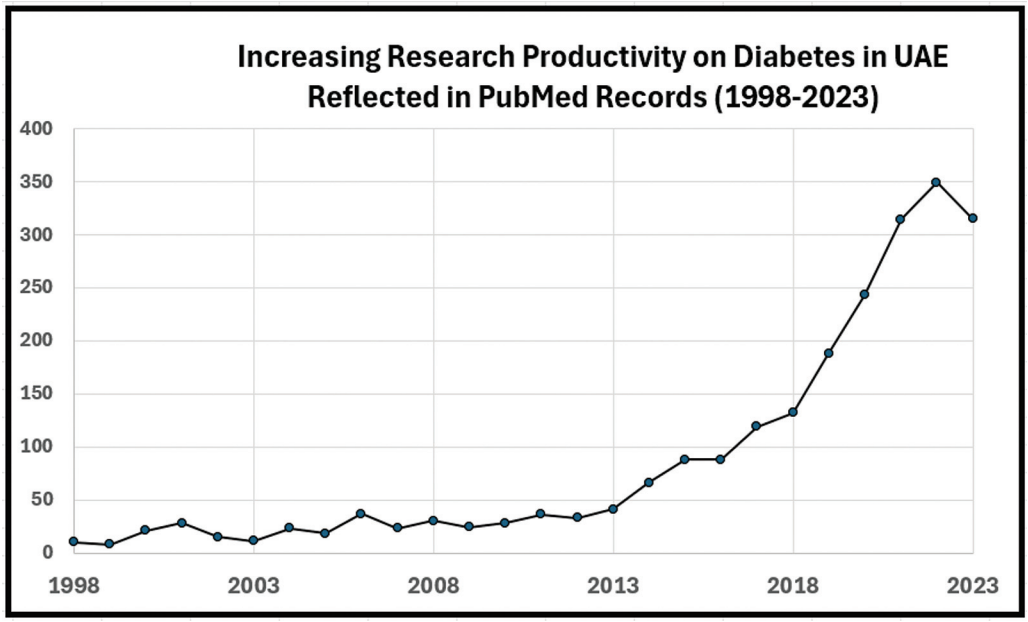

Fig. 1 The increasing scientific research on diabetes in the UAE is reflected in the increasing number of articles identified by the search term (Diabetes AND Emirates) in the abstract or title fields of the PubMed database (January 1, 1998–December 31, 2023). They were retrieved on March 6, 2024.

published (►**Fig. 1**). Several annual and occasional conferences on diabetes have been conducted by the EDS, Gulf Chapter of the American Association of Clinical Endocrinologists (Now Gulf Association of Endocrinology and Diabetes [GAED]) to improve the understanding and management of diabetes.[58–61]

UAE recently became a focal point for health-related Ramadan fasting research, including diabetes.[62–64] Furthermore, to support more physicians' knowledge and expertise, several international universities providing postgraduate education in diabetes, particularly from the UK (Cardiff, Warrick, and Leicester), have extended their presence in the UAE. A national university (Sharjah University) recently provided its MSc degree in diabetes care. In addition, an endocrinology fellowship program was established in Abu Dhabi as a collaboration between ICLDC and SEHA hospitals (three years of training, one in UAE and two in the UK). Another endocrinology fellowship program started at Dubai Hospital in 2022. Two medical journals specializing in diabetes and endocrinology are in the UAE (Dubai Diabetes and Metabolism Journal by Dubai Health Authority and Journal of Diabetes and Endocrine Practice by GAED). This may encourage more locally conducted research to find its way to publication. In addition, the Arab Society of Pediatric Endocrine and Diabetes has its headquarters in the UAE and runs many of its activities locally.[65]

UAE pioneered early access to the latest types and therapies, including modern pharmacological classes, shortly after their approvals in their manufacturing countries. Also, health insurance schemes widely support adopting high technology, such as CGM and insulin pump therapy, as discussed above. Trained and qualified diabetes educators increasingly support patients. There is a single layperson patients' society named Friends for Diabetes Association based in Sharjah, which plays a vital role in patient advocacy and conducts regular activities.

Conclusions

The review focused on a few pertinent aspects of diabetes and diabetes care in a young nation that experienced a rapid increase in wealth and prosperity. The burden of diabetes impacted both native and expatriate populations. We identified the interplay between diabetes risk during pregnancy and youth. It underscored the increased cardiovascular risk in people with diabetes as an example of long term complication. Diabetes care challenges, guidelines, and professionals in routine care and in centers of excellence provide lots of experiences being implemented under different health care systems and models.

The incidence of T2D among UAE nationals who are overweight or obese was 16.3 per 1,000 PY. Age above 44 years obesity in women and prediabetes in men predicted the development of diabetes.[66] Metabolic syndrome among adults in the UAE is approximately 37%. Age, sex, ethnicity, age, sex, educational level, marital status, and BMI were positively associated with metabolic syndrome.[67] Microalbuminuria is highly prevalent (61%) among patients with diabetes in the UAE. The rate was higher in men, those with higher BMI, and in the setting of other diabetes-related microvascular complications.[68] Over one-third of all deaths in adult UAE nationals with DM could be attributed to nonoptimal glycemic control.[69]

A remarkable volume of the literature emphasizing on diabetes and diabetes care in the UAE has been analyzed over the last three decades (►**Fig. 1**). However, the available literature has some notable limitations.[70] Several studies are based on a single city or locality rather than a more comprehensive national basis. Also, some outcome studies

are based on the data collected from different health care systems with differing levels of coverage and access to conventional and advanced resources. These may introduce methodological and conceptual cofounders that prevent the generalization of conclusions on a national level and direct comparisons due to the different methods employed in various settings. Many studies are limited to observational methodology rather than reflections on quality improvement exercises. There are limited data on the incidence of diabetes in the UAE, particularly T1D and monogenic forms of diabetes. Also, there are different models of health care provision (national health services, independent sector, and employer-associated provision) and financing (national, insurance-based, and out-of-pocket).

A concerted effort is needed to evaluate diabetes nationwide using the unified methodology. Specifically, documenting the nationwide burden, exploring possible differences in various epidemiological phenomena, and accessing health care are crucial. These should ascertain the impact on outcomes and evaluate the cost-effectiveness of care using different models.

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Conflict of Interest

None declared.

References

1 International Diabetes Federation. IDF Diabetes Atlas, 10th edition. 2021. Accessed July 27, 2022 at: https://www.diabetesatlas.org/en/resources
2 Khalil AB, Beshyah SA, Abdella N, et al. Diabesity in the Arabian Gulf: challenges and opportunities. Oman Med J 2018;33(04): 273–282
3 Malik M, Bakir A, Saab BA, King H. Glucose intolerance and associated factors in the multi-ethnic population of the United Arab Emirates: results of a national survey. Diabetes Res Clin Pract 2005;69(02):188–195
4 Saadi H, Carruthers SG, Nagelkerke N, et al. Prevalence of diabetes mellitus and its complications in a population-based sample in Al Ain, United Arab Emirates. Diabetes Res Clin Pract 2007;78(03): 369–377
5 Hajat C, Harrison O, Al Siksek Z. Weqaya: a population-wide cardiovascular screening program in Abu Dhabi, United Arab Emirates. Am J Public Health 2012;102(05):909–914
6 Sulaiman N, Mahmoud I, Hussein A, et al. Diabetes risk score in the United Arab Emirates: a screening tool for the early detection of type 2 diabetes mellitus. BMJ Open Diabetes Res Care 2018;6(01): e000489
7 Sulaiman N, Albadawi S, Abusnana S, et al. High prevalence of diabetes among migrants in the United Arab Emirates using a cross-sectional survey. Sci Rep 2018;8(01):6862
8 Hamoudi R, Saheb Sharif-Askari N, Saheb Sharif-Askari F, et al. Prediabetes and diabetes prevalence and risk factors comparison between ethnic groups in the United Arab Emirates. Sci Rep 2019; 9(01):17437
9 Alawadi F, Hassanein M, Sulaiman E, et al. The prevalence of diabetes and prediabetes among the population: finding from Dubai household survey 2014 and 2017. Dubai Diabetes Endocrinol J 2020;26(02):78–84
10 Al Awadi F, Hassanein M, Hussain HY, et al. Prevalence of diabetes and associated health risk factors among adults in Dubai, United Arab Emirates: results from Dubai Household Survey 2019. Dubai Diabetes Endocrinol J 2020;26:164–173
11 Sreedharan J, Muttappallymyalil J, Al Sharbatti S, et al. Incidence of type 2 diabetes mellitus among Emirati residents in Ajman, United Arab Emirates. Korean J Fam Med 2015;36(05):253–257
12 Maddaloni E, Lessan N, Al Tikriti A, Buzzetti R, Pozzilli P, Barakat MT. Latent autoimmune diabetes in adults in the United Arab Emirates: clinical features and factors related to insulin-requirement. PLoS One 2015;10(08):e0131837
13 Deeb A, Habeb A, Kaplan W, et al. Genetic characteristics, clinical spectrum, and incidence of neonatal diabetes in the Emirate of Abu Dhabi, United Arab Emirates. Am J Med Genet A 2016;170 (03):602–609
14 Mohamad MN, Ismail LC, Stojanovska L, et al. The prevalence of diabetes amongst young Emirati female adults in the United Arab Emirates: a cross-sectional study. PLoS One 2021;16(06):e0252884
15 Meo SA, Sheikh SA, Sattar K, et al. Prevalence of type 2 diabetes mellitus among men in the Middle East: a retrospective study. Am J Men Health 2019;13(03):1557988319848577
16 Barakat C, Yousufzai SJ, Booth A, Benova L. Prevalence of and risk factors for diabetes mellitus in the school-attending adolescent population of the United Arab Emirates: a large cross-sectional study. BMJ Open 2021;11(09):e046956
17 Beshyah SA, Blouza-Chabchoub S. Diabetes and pregnancy. In: Lakhdar AA & Gill GV, eds. Diabetes in The Arab World. Cambridge: FSG Communications Ltd.; 2005:249–67.
18 Al-Rifai RH, Majeed M, Qambar MA, Ibrahim A, AlYammahi KM, Aziz F. Type 2 diabetes and pre-diabetes mellitus: a systematic review and meta-analysis of prevalence studies in women of childbearing age in the Middle East and North Africa, 2000-2018. Syst Rev 2019;8(01):268
19 Abdulrazzaq YM, Bener A, Dawodu A, et al. Obstetric risk factors affecting incidence of low birth weight in live-born infants. Biol Neonate 1995;67(03):160–166
20 Hughes PF, Morrison J. Pregnancy outcome data in a United Arab Emirates population: what can they tell us? Asia Oceania J Obstet Gynaecol 1994;20(02):183–190
21 Hughes PF, Agarwal M, Newman P, Morrison J. Screening for gestational diabetes in a multi-ethnic population. Diabetes Res Clin Pract 1995;28(01):73–78
22 Agarwal MM, Hughes PF, Ezimokhai M. Screening for gestational diabetes in a high-risk population using fasting plasma glucose. Int J Gynaecol Obstet 2000;68(02):147–148
23 Bashir MM, Ahmed LA, Elbarazi I, et al. Incidence of gestational diabetes mellitus in the United Arab Emirates; comparison of six diagnostic criteria: The Mutaba'ah Study. Front Endocrinol (Lausanne) 2022;12(13):1069477
24 Khair H, Bataineh MF, Zaręba K, et al. Pregnant women's perception and knowledge of the impact of obesity on prenatal outcomes —a cross-sectional study. Nutrients 2023;15(11):2420
25 Sadiya A, Jakapure V, Shaar G, Adnan R, Tesfa Y. Lifestyle intervention in early pregnancy can prevent gestational diabetes in high-risk pregnant women in the UAE: a randomized controlled trial. BMC Pregnancy Childbirth 2022;22(01):668

26 Juber NF, Abdulle A, AlJunaibi A, et al. Maternal early-life risk factors and later gestational diabetes mellitus: a cross-sectional analysis of the UAE Healthy Future Study (UAEHFS). Int J Environ Res Public Health 2022;19(16):10339

27 Hassanein M, Abuelkheir S, Alsayyah F, et al. Evaluation of optimum diabetes care on glycemic control of patients with gestational diabetes during Ramadan fasting. Diabetes Res Clin Pract 2021;173:108669

28 Afandi B, Hassanein M, Roubi S, Nagelkerke N. The value of continuous glucose monitoring and self-monitoring of blood glucose in patients with gestational diabetes mellitus during Ramadan fasting. Diabetes Res Clin Pract 2019;151:260–264

29 Alkaabi J, Almazrouei R, Zoubeidi T, et al. Burden, associated risk factors and adverse outcomes of gestational diabetes mellitus in twin pregnancies in Al Ain, UAE. BMC Pregnancy Childbirth 2020; 20(01):612

30 Buse JB, Wexler DJ, Tsapas A, et al. 2019 update to: management of hyperglycemia in type 2 diabetes, 2018. A Consensus Report by the American Diabetes Association (ADA) and the European Association for the Study of Diabetes (EASD). Diabetes Care 2020;43(02):487–493

31 Cosentino F, Grant PJ, Aboyans V, et al; ESC Scientific Document Group. 2019 ESC Guidelines on diabetes, pre-diabetes, and cardiovascular diseases developed in collaboration with the EASD. Eur Heart J 2020;41(02):255–323

32 UAE National Diabetes Committee. National diabetes guidelines: United Arab Emirates 2009. Abu Dhabi, UAE: The UAE National Diabetes Committee. 2009

33 Alawadi F, Abusnana S, Afandi B, et al. Emirates diabetes society consensus guidelines for the management of type 2 diabetes mellitus—2020. Dubai Diabetes Endocrinol J 2020 (e-pub ahead of print). Doi: 10.1159/000506508

34 American Diabetes Association Professional Practice Committee. 4 Comprehensive medical evaluation and assessment for comorbidities: standards of medical care in diabetes—2022. Diabetes Care 2022;45(Suppl 1):S46–S59

35 American Diabetes Association Professional Practice Committee. 6. Glycemic targets: standards of medical care in diabetes—2022. Diabetes Care 2022;45(Suppl 1):S83–S96

36 American Diabetes Association Professional Practice Committee. 5 Facilitating behavior change and well-being to improve health outcomes: standards of medical care in diabetes—2022. Diabetes Care 2022;45(Suppl 1):S60–S82

37 Al-Farsi MA, Lee CY. Nutritional and functional properties of dates: a review. Crit Rev Food Sci Nutr 2008;48(10):877–887

38 Alkaabi JM, Al-Dabbagh B, Ahmad S, Saadi HF, Gariballa S, Ghazali MA. Glycemic indices of five varieties of dates in healthy and diabetic subjects. Nutr J 2011;10:59

39 Al-Kaabi J, Al-Maskari F, Saadi H, Afandi B, Parkar H, Nagelkerke N. Physical activity and reported barriers to activity among type 2 diabetic patients in the United Arab Emirates. Rev Diabet Stud 2009;6(04):271–278

40 American Diabetes Association Professional Practice Committee. 9 Pharmacologic approaches to glycemic treatment: standards of medical care in diabetes—2022. Diabetes Care 2022;45(Suppl 1): S125–S143

41 American Diabetes Association Professional Practice Committee. 10 Cardiovascular disease and risk management: standards of medical care in diabetes—2022. Diabetes Care 2022;45(Suppl 1): S144–S174

42 Gehani AA, Al-Hinai AT, Zubaid M, et al; INTERHEART Investigators in Middle East. Association of risk factors with acute myocardial infarction in Middle Eastern countries: the INTERHEART Middle East study. Eur J Prev Cardiol 2014;21(04): 400–410

43 Alzaabi A, Al-Kaabi J, Al-Maskari F, et al. Prevalence of diabetes and cardio-metabolic risk factors in young men in the United Arab Emirates: a cross-sectional national survey. Endocrinol Diab Metabol 2019;2(Suppl 4):e00081

44 American Diabetes Association Professional Practice Committee. 7. Diabetes Technology: Standards of Medical Care in Diabetes-2022. Diabetes Care. 2022(01);45(Suppl 1):S97–S112

45 WHO. 2011mHealth: new horizons for health through mobile technologies. Based on the findings of the second global survey on eHealth. Global Observatory for eHealth Series – Volume 3. WHO, Geneva. Accessed September 17, 2018 at: www.who.Int/goe/publications/goe_mhealth_web.pdf.

46 Elenko E, Speier A, Zohar D. A regulatory framework emerges for digital medicine. Nat Biotechnol 2015;33(07):697–702

47 AADE. AADE7 self-care behaviors. Diabetes Educ 2008;34(03): 445–449

48 Dungan K, Verma N, Reddy N. Monitoring Technologies–Continuous Glucose Monitoring,. Mobile Technology, Biomarkers of Glycemic Control, Endotext, South Dartmouth, MA 2015

49 Mcgarraugh G, Bragg R, Weinstein R. FreeStyle Navigator Continuous Glucose Monitoring System with TRUstart algorithm, a 1-hour warm-up time. J Diabetes Sci Technol 2011;5(01):99–106

50 Welsh JB, Gao P, Derdzinski M, et al. Accuracy, utilization, and effectiveness comparisons of different continuous glucose monitoring systems. Diabetes Technol Ther 2019;21(03):128–132

51 Wright LA, Hirsch IB. Metrics beyond haemoglobin A1C in diabetes management: time in range, hypoglycemia, and other parameters. Diabetes Technol Ther 2017;19(S2):S16–S26

52 Danne T, Nimri R, Battelino T, et al. International consensus on the use of continuous glucose monitoring. Diabetes Care 2017;40 (12):1631–1640

53 Alawadi F, Rashid F, Bashier A, et al. The use of Free Style Libre Continues Glucose Monitoring (FSL-CGM) to monitor the impact of Ramadan fasting on glycemic changes and kidney function in high-risk patients with diabetes and chronic kidney disease stage 3 under optimal diabetes care. Diabetes Res Clin Pract 2019;151:305–312

54 Hassanein M, Rashid F, Elsayed M, et al. Assessment of risk of fasting during Ramadan under optimal diabetes care, in high-risk patients with diabetes and coronary heart disease through the use of FreeStyle Libre Flash Continuous Glucose Monitor (FSL-CGMS). Diabetes Res Clin Pract 2019;150:308–314

55 Afandi BO, Kaplan W, Majd L, et al. Rate, Timing, and Severity of hypoglycemia in adolescents with Type 1 diabetes during ramadan fasting: A study with FreeStyle Libre Flash Glucose Monitoring System. Ibnosina J Med Biomed Sci 2018;10:9–11

56 Ehtisham S, Adhami S. Accuracy of Glucose Sensor Estimate of HbA1c in Children with Type 1 Diabetes. ESPE Abstracts 2019;92: RFC7.1

57 Farooqi MH, Abdelmannan DK, Al Buflasa MM, et al. The impact of telemonitoring on improving glycemic and metabolic control in previously lost-to-follow-up patients with type 2 diabetes mellitus: a single-center interventional study in the United Arab Emirates. Int J Clin Pract 2022;2022:6286574

58 Ashraf T, Helal R, Majeed M, et al. An analysis of flash glucose monitoring (FGM) data on insulin-treated patients with diabetes: effects of COVID-19 lockdown. Endocrine Abstracts 2021 (e-pub ahead of print). doi. Doi: 10.1530/endoabs.73.AEP161

59 Al Kaabi JM, Alsayed N, Al-Ozairi E. Abstracts of the Free Communications of the Fifth Clinical Congress of the Gulf Chapter of the American Association of Clinical Endocrinologists. J Diab Endocr Pract 2018;1(01):35–54

60 AlSayed N, Saleh Y, Aljuhani N. Gulf association of endocrinology and diabetes is born: history in the making. J Diab Endocrine Pract 2021;4(01):41–42

61 Elbarbary N, Deeb A, Habeb A, Beshyah SA. Management of diabetes during Ramadan fasting in children and adolescents: a survey of physicians' perceptions and practices in the Arab Society for Paediatric Endocrinology and Diabetes (ASPED) countries. Diabetes Res Clin Pract 2019;150:274–281

62 Deeb A, Elbarbary N, Smart CE, et al. ISPAD Clinical Practice Consensus Guidelines: fasting during Ramadan by young people with diabetes. Pediatr Diabetes 2020;21(01):5–17
63 Beshyah SA. IDF-DAR practical guidelines for management of diabetes during ramadan. Ibnosina J Med Biomed Sci 2016;8(03):58–60
64 Beshyah SA, Hafidh K. Highlights of the Ninth Diabetes and Ramadan International Alliance conference (mena-zone virtual), January 21–22, 2021 Ibnosina. J Med Biomed Sci 2021;13(02):95–100
65 Kenz S, Abusahmin H, Elmalti A, et al. The 8th Diabetes and Ramadan International Alliance Conference: January 23–24, 2020, Dubai, United Arab Emirates. Ibnosina J Med Biomed Sci 2020;12:62–67
66 Beshyah SA, Rashid F, Abdelghader LI. Highlights of the 11th Emirates Diabetes & Endocrine Virtual Congress (EDEC21), 4–6 March 2021. Dubai Diabetes Endocrinol J 2022;28:1–19
67 Regmi D, Al-Shamsi S, Govender RD, Al Kaabi J. Incidence and risk factors of type 2 diabetes mellitus in an overweight and obese population: a long-term retrospective cohort study from a Gulf state. BMJ Open 2020;10(07):e035813
68 Mahmoud I, Sulaiman N. Prevalence of metabolic syndrome and associated risk factors in the United Arab Emirates: a cross-sectional population-based study. Front Public Health 2022;9:811006
69 Al-Maskari F, El-Sadig M, Obineche E. Prevalence and determinants of microalbuminuria among diabetic patients in the United Arab Emirates. BMC Nephrol 2008;9:1
70 Al-Shamsi S, Govender RD, Soteriades ES. Mortality and potential years of life lost attributable to non-optimal glycaemic control in men and women with diabetes in the United Arab Emirates: a population-based retrospective cohort study. BMJ Open 2019;9(09):e032654

