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PUBLIC HEALTH AUTHORITY

Saudi Health Promotion and Prevention Guideline for Diabetes Mellitus

For Health Professionals and Health Educators

First Edition 2025-2026

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TABLE OF CONTENTS

TABLES AND FIGURES

Building a healthy population is at the core of our aspirations, a goal that requires a strong emphasis on health promotion and protection in the context of sustainable development. In line with our national commitment to Vision 2030, the Public Health Authority has prioritized the prevention, early detection, and control of key health challenges. Among these, Diabetes Mellitus remains one of the most pressing public health concerns in Saudi Arabia, significantly contributing to morbidity, mortality, and healthcare costs.

The Public Health Authority, through the Department of Health Improvement and Promotion, is dedicated to proactively fostering a culture of health and enhancing community well-being. As part of this commitment, a wide range of programs have been developed to prevent and control diabetes, including high-impact interventions aimed at reducing the non-communicable disease Standardized Mortality Rate (SMR).

This guideline provides an effective, evidence-based framework that unifies the best national knowledge for healthcare professionals, policymakers, and health educators. It consolidates best practice recommendations for diabetes prevention, with the goal of influencing and supporting conscious, informed decisions regarding healthy living. By promoting healthy lifestyles, supporting diabetes prevention, and empowering individuals with tools for informed decision-making, we aim to prevent, detect, and control this disease and thereby promote the best possible lives for our community.

The Saudi Health Promotion and Prevention Guidelines for Diabetes Mellitus offers a comprehensive, evidence-based roadmap for the prevention and early detection of diabetes. Diabetes is a significant public health burden, but its progression can be prevented or delayed through proactive interventions and modifiable lifestyle changes at every stage of life. The aim of these guidelines is to empower healthcare professionals and the community with the knowledge and tools for effective prevention and management of diabetes.

The Saudi Public Health Authority remains dedicated to protecting and promoting the health of all citizens and residents. Through ongoing collaboration and commitment, we aspire to support a healthier society where everyone has the opportunity to lead longer, healthier, and more fulfilling lives.

Dr. Abdullah Rashoud Algwizani
Chief Executive Office
Public Health Authority

3

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ACKNOWLEDGEMENT

1. INTRODUCTION:

Diabetes mellitus stands as an epidemic in Saudi Arabia, posing a significant public health challenge. The rising prevalence of diabetes mellitus, inclusive of Type 1 Diabetes Mellitus (T1DM), Type 2 Diabetes Mellitus (T2DM), and Gestational Diabetes Mellitus (GDM), substantially adds to the burden of non-communicable diseases within the country. Recognizing the pressing need for effective preventive measures, the meticulously designed national diabetes prevention guideline aims to address the distinctive healthcare landscape of Saudi Arabia. As a multifaceted condition, uncontrolled diabetes mellitus heightens the risk of severe health complications, including microvascular and macrovascular problems.

It is crucial to emphasize that diabetes mellitus encompassing GDM, is not only a manageable condition but, in many instances, preventable through targeted interventions. Despite continuous efforts to screen for all forms of diabetes, a notable percentage of individuals with the condition remain undiagnosed, emphasizing the critical necessity for a comprehensive national diabetes screening guideline. Moreover, for those already diagnosed, there is a pressing concern related to poorly controlled diabetes and complications that often go unnoticed due to inadequate screening measures. This underscores the guideline's imperative focus on early detection and effective management and prevention of diabetes-related complications. This guideline is a robust framework, offering evidence-based recommendations tailored to the Saudi context. It is envisioned as a valuable resource for healthcare providers, policymakers, and the general public, supporting them on strategies to prevent and control the associated complications of T1DM, T2DM, and GDM. The overarching goal of this guideline is to alleviate the burden of diabetes and reduce the incidence of associated health complications across the country. The potential benefits encompass reducing the prevalence of diabetes or delaying its onset, screening for diabetes-related complications, decreasing healthcare costs, improving the quality of life for individuals with diabetes, and leading to an overall reduction in diabetes mortality.

The guideline actively promotes the implementation of effective Interventions that encourage the adoption of healthy habits to mitigate modifiable risk factors such as physical inactivity, unhealthy eating preferences, and obesity. It recognizes the need for sustained efforts to instill lasting changes and emphasizes the importance of tailored recommendations for the Saudi population, including strategies to address GDM. Furthermore, The guideline emphasizes the critical importance of structured, evidence-based diabetes prevention as a national health priority in Saudi Arabia for all forms of diabetes—type 2, type 1, and gestational diabetes. It calls for targeted interventions to reach individuals at high risk, such as those with prediabetes, obesity, or a family history of diabetes, through sustained lifestyle modification—including dietary change, regular physical activity, and weight management—that can help prevent or delay the onset of type 2 diabetes. At the same time, healthcare providers are urged to recognize that risk reduction and early identification are essential across the diabetes spectrum, including supporting healthy behaviors in children and young adults at risk for type 1 diabetes and screening for gestational diabetes in pregnant women. These prevention efforts are to be delivered at the primary care level, with support from multidisciplinary teams, and must be reinforced by ongoing monitoring, education, and community engagement. The guideline underscores the need for healthcare providers to implement strategies developed or endorsed by the Saudi Public Health Authority, ensuring broad access and culturally appropriate care for all at-risk populations. In addition to these general prevention strategies, the guideline highlights the value of adapting recommendations to address the unique needs of individuals at risk for or living with any form of diabetes—For example, promoting healthy eating and regular activity for children at risk of diabetes, or providing targeted counseling and follow-up for women with a history of gestational diabetes. Locally developed, evidence-based guidelines that reflect regional resources and cultural context can help improve patient outcomes, ensure equitable access to care, and promote the efficient use of available resources. By focusing on comprehensive prevention and regional adaptation, these initiatives are expected to help reduce the future burden of all forms of diabetes across the Kingdom and contribute to the achievement of broader public health objectives.

2. SCOPE OF THE GUIDELINE:

2.1 PRIMARY OBJECTIVES:

This guideline provides medical and public health professionals in Saudi Arabia with evidence-based practices for diabetes prevention and control, including gestational diabetes mellitus (GDM), and ensures standardized screening for its complications.

2.1 TARGETED POPULATION AND CONTEXT:

The recommendations serve all age groups in Saudi Arabia, emphasizing inclusivity for children, adolescents, adults, and pregnant women, the latter to highlight the focus on GDM. These guidelines are intended for healthcare professionals, public health initiatives, and policymakers, providing evidence-based, actionable strategies to prevent diabetes and improve health outcomes across communities. Broad adoption and implementation of these recommendations are strongly encouraged to ensure equitable access to diabetes prevention and care throughout Saudi Arabia, ultimately fostering better diabetes-related health across the population.

2.1 CONCISENESS AND PRACTICALITY:

Striking a balance between thoroughness and usability, the document distills the best available research into concise, actionable prevention strategies for the Saudi population, including a specific focus on GDM. It is designed to be user-friendly and informed by a comprehensive literature review without delving into excessive detail.

2.1 PREVENTION AND EARLY DETECTION FOCUS:

In addition to prevention, there is a strong emphasis on standardized screening for diabetes and its complications—such as cardiovascular diseases (including myocardial infarction), neuropathy, retinopathy, nephropathy, and Metabolic dysfunction-associated Steatotic Liver Disease (MASLD) to enable early detection and timely management. By identifying these conditions as early as possible, the guideline aims to minimize their impact on overall health and wellbeing, including complications arising from gestational diabetes mellitus (GDM). This comprehensive approach ensures that both common and emerging diabetes-related complications are systematically addressed across all age groups.

2.1 SCOPE LIMITATIONS:

This guideline excludes recommendations regarding tertiary prevention and long-term management of established diabetes, including the treatment of chronic complications. It also does not address the prevention or management of other cardiometabolic risk factors, such as dyslipidemia, hypertension, smoking, and obesity, except as they directly relate to diabetes prevention. In addition, rare forms of diabetes, including monogenic diabetes syndromes and secondary diabetes, are not discussed. The focus remains on actionable, population-level recommendations for the primary and secondary prevention and early detection of type 1, type 2, and gestational diabetes in Saudi Arabia. Detailed implementation protocols and clinical management pathways are beyond the scope of this guideline and are left to the discretion of relevant health authorities and clinical care providers.

2.1 GUIDING QUESTION (PICO):

For the population of Saudi Arabia, what health promotion and prevention interventions, implemented at individual and population levels, are most effective for preventing the onset or enabling early detection of diabetes mellitus and GDM, including standardized screening for complications?

2.1 ANTICIPATED OUTCOMES:

Application of this guideline is expected to promote diabetes prevention and control, enhance early detection of complications from diabetes and GDM, and improve diabetes- related public health outcomes across Saudi Arabia.

3.   METHODOLOGY OF EVIDENCE REVIEW:

Focus:
The guideline prioritizes preventive strategies for T1DM, T2DM, and GDM, with adaptations tailored to the unique epidemiological and cultural context of Saudi Arabia, with a keen focus on the early detection of diabetes-related complications to enhance overall health and well-being.

Search Strategy:
A comprehensive literature search on PubMed/MEDLINE included keywords related to the screening s prevention and screening for T1DM, T2DM, and GDM; risk factors; early detection of complications; lifestyle interventions; and genetic, environmental, and socioeconomic factors affecting diabetes risk.

Inclusion/Exclusion Criteria:
Studies focused on the prevention or screening for T1DM, T2DM, and GDM complications involving human subjects, published in English, and listed in MEDLINE, adhering to recommended screening practices. Studies outside this scope or not published in English were excluded.

Review Process: A multidisciplinary expert group—including members of the Diabetes Prevention Committee and specialists across diabetes-relevant fields—collaborated to ensure a comprehensive, inclusive approach to guideline development.

Landmark Trials and Evidence:
The review included landmark trials and essential evidence defining diabetes prevention and management efficacy, including lifestyle interventions and early detection methods for diabetes and its complications.

Existing Guidelines:
Acknowledging existing guidelines, this document distinguishes itself by focusing specifically on the prevention of T1DM, T2DM, and notably GDM—a critical aspect sometimes overlooked. It customizes prevention strategies for Saudi Arabia and underscores the importance of early detection of diabetes complications to optimize health outcomes.

This methodology affirms a commitment to an extensive and inclusive evidence review process, forming a solid foundation for developing effective diabetes prevention and management strategies within Saudi Arabia's unique context.

Table 1: Classes of recommendations

Class	Criteria	Definition	Wording
I	Benefit >>> Risk	Evidence and/or general agreement that a given intervention is beneficial, useful, and effective.	• Is recommended. • Is indicated/effective
II	Benefit ≥ Risk	Conflicting evidence and/or a divergence of opinion about the usefulness/efficacy of a given intervention.	
IIa	Benefit >> Risk	Weight of evidence/opinion is in favor of usefulness/efficacy.	• Is reasonable. • Can be useful/effective
IIb	Benefit ≥ Risk	usefulness/efficacy is less well established by evidence/opinion.	• May/might be considered. • May/might be reasonable
III	Benefit < Risk	Evidence/general agreement that the intervention is not useful/effective, and may be harmful.	• Is not recommended. • Potentially harmful

4. CLASSES OF RECOMMENDATION AND LEVELS OF EVIDENCE:

Table 2: Levels of evidence

Level of evidence A	Clear evidence from well-conducted, generalizable randomized controlled trials (RCTs), including multicenter trials or meta-analyses with quality ratings; compelling nonexperimental evidence with "all or none" rule; supportive evidence from well-conducted RCTs at one or more institutions.
Level of evidence B	Supportive evidence from well-conducted cohort studies or meta-analyses of cohort studies; supportive evidence from well-conducted case-control studies.
Level of evidence C	Supportive evidence from poorly controlled or uncontrolled studies, RCTs with major flaws, or observational studies with high bias (case series, historical controls); conflicting evidence with the weight supporting the recommendation.
Level of evidence E	Expert consensus or clinical experience.

Source: Adapted from American Diabetes Association Professional Practice Committee. Standards of Care in Diabetes—2025. Diabetes Care 2025;48(Suppl 1):S1–S99

5. CLASSIFICATION AND DIAGNOSIS OF DIABETES MELLITUS:

Table 3: Criteria for Diagnosis and Classification of Diabetes Mellitus

Test	Normal	Prediabetes	Diabetes	Gestational DM
HbA1c*	< 5.7	5.7 – 6.4	≥6.5	At **24-28 week**** **After 75-g OGGT**, if plasma glucose met or exceeded: Fasting: 92 mg/dL (5.1 mmol/L) 1-hr:180 mg/dL (10 mmol/L) 2-hrs: 153 mg/dL (8.5 mmol/L) One reading is enough for diagnosis.
Fasting plasma glucose*	< 100	100-125 mg/dL 5.6-6.9 mmol/L	>=126 mg/dL 7 mmol/L	
Random plasma glucose**	< 140	140- 199 mg/dL 7.8-11 mmol/L	>=200 mg/dL 11.1 mmol/L	
Oral glucose tolerance ***	< 140	140- 199 mg/dL 7.8-11 mmol/L	>=200 mg/dL 11.1 mmol/L	

* In the absence of hyperglycemia symptoms, diagnosis needs two abnormal tests simultaneously (e.g., FPG & A1C) or at different times.

**One random plasma glucose reading is enough for the diagnosis in the presence of hyperglycemia symptoms.

*** 2-hours Plasma glucose ≥200 mg/dl during OGTT is diagnostic of diabetes. The test should be performed as described by the WHO, using a glucose load containing the equivalent of 75-g anhydrous glucose dissolved in water.

**** Before week 15 of pregnancy, test individuals with risk factors of diabetes **(Table 6)** and consider testing all individuals for undiagnosed diabetes at the first prenatal visit using standard diagnostic criteria if not screened before pregnancy**.**

Table 4: Symptomatic presentation and features of T1DM and T2DM

Characteristics	T1DM	T2DM
Onset/presentation	Sudden/ symptomatic	Slow/ Asymptomatic
	weight loss, polyuria, polydipsia.	Family history of T2DM, obesity, PCOS, history of GDM
Age*	**Any age**, often children/adolescents	**Any age**, but more often adults.
Obesity*	Usually thin, >30% overweight/obesity	Majority have obesity but can be overweight or normal weight.
Ketosis	Common at diagnosis	Rare, unless ketosis-prone phenotype
Antibodies	Frequently positive (ICA, GAD65, IA2, ZnT8); 5–10% negative	Negative

* Age and obesity may not always definitively differentiate between T1DM and T2DM. While T1DM can manifest after age 40 and young-onset T2DM is becoming more common, both age groups can also include individuals with obesity. It's important to consider the full clinical picture of symptoms, risk factors, and laboratory tests for accurate diagnosis.

6. PREVALENCE OF DIABETES IN SAUDI ARABIA

Diabetes presents a significant and escalating health challenge in Saudi Arabia. The latest international and national data confirm that the prevalence of diabetes mellitus in adults aged 20–79 years is among the highest in the world, with estimates ranging from 23.1% to 23.7% in 2024–2025 [1]. This equates to approximately 5.3 million adults living with diabetes in the country [2]. The burden is expected to rise—projections suggest 9.5 million adults with diabetes by 2050 if current trends continue. Notably, nearly half (43.6%) of cases are undiagnosed, underscoring the need for intensified screening [2].

Alarmingly, nearly half (43.6%) of people with diabetes remain undiagnosed, highlighting the urgent need for intensified screening, public awareness, and early intervention [2]. The highest prevalence rates are found among older adults, but diabetes affects all age groups, and the incidence among adolescents and young adults is increasing rapidly, particularly in association with rising obesity rates. Type 2 diabetes (T2DM) accounts for the vast majority of cases, while type 1 diabetes (T1DM), though less common, remains an important clinical concern, especially in children and adolescents [5].

6.1. PREDIABETES

Prediabetes—defined by glucose levels above normal but below the threshold for diabetes—substantially increases the risk of developing type 2 diabetes (T2DM). In Saudi Arabia, the most recent nationally representative data estimate the prevalence of prediabetes among adults at approximately 27.2%—among the highest rates globally and a clear indicator of the public health challenge posed by abnormal glucose metabolism in the Kingdom [3]. Early detection of prediabetes through targeted screening is essential, as global evidence from systematic reviews and prospective cohort studies indicates that up to 10% of individuals with prediabetes progress to diabetes annually without intervention [4]. Comprehensive lifestyle intervention programs—including weight management, dietary modification, and regular physical activity—can reduce the risk of progression by up to 58% [6], highlighting the critical role of early and structured preventive care.

6.2. TYPE 2 DIABETES MELLITUS (T2DM)

Type 2 diabetes mellitus (T2DM) is the leading form of diabetes in Saudi Arabia, currently affecting approximately 23.1% of adults aged 20–79 years—one of the highest national prevalence rates worldwide. An alarming trend is the increasing incidence of T2DM among adolescents and young adults, a development strongly associated with rising rates of obesity. These findings have been well documented in recent national studies and highlight the urgent need for ongoing surveillance and a deeper understanding of both incidence and prevalence rates as the country addresses this public health challenge. [1,2]. Projections indicate that, if current trends continue, the number of adults with diabetes in Saudi Arabia could reach 9.5 million by 2050. This scenario underscores the critical importance of scaling up evidence-based prevention, early detection, and management strategies—including lifestyle modification and public health education—to mitigate the growing burden of T2DM. [2,3].

6.3. TYPE 1 DIABETES MELLITUS (T1DM)

Type 1 diabetes mellitus (T1DM) constitutes a major and escalating public health challenge in Saudi Arabia. The annual incidence of T1DM among Saudi youth has surged to 31.4 per 100,000, reflecting a nearly ninefold increase over the past decade, making it one of the highest national rates globally. This rapid rise is corroborated by recent data demonstrating that Saudi Arabia now ranks among the world's top ten countries for newly diagnosed T1DM in children and adolescents. Within the broader context of an exceptionally high national diabetes prevalence—23.1% among adults—T1DM represents a small, but clinically significant, proportion of the overall diabetes burden [7]. The mean age at T1DM diagnosis in Saudi patients is typically between 6 and 10 years, and poor glycemic control is common in children and adolescents. Ongoing challenges in T1DM management have prompted calls for early detection and screening programs, especially in at-risk children, to improve outcomes and reduce complications. Given the rising incidence, high risk of complications, and chronic management burden, T1DM continues to be a major clinical priority for Saudi health authorities [7].

6.4. GESTATIONAL DIABETES MELLITUS

Gestational diabetes mellitus (GDM) remains a substantial public health challenge in Saudi Arabia, with recent nationally representative data reporting a prevalence of 18.5% among pregnant women—the highest rates observed in women aged 30–39 years and those with obesity [8]. Some clinic-based studies, reflecting selected populations, have reported rates as high as 51.7% [9].

7.   RISK FACTORS OF DIABETES MELLITUS

Diabetes mellitus is a complex, multifactorial disease whose rising prevalence in Saudi Arabia and globally is driven by a mix of modifiable and non-modifiable risk factors. Genetic susceptibility, family history, and advancing age are major non-modifiable contributors. Modifiable factors—such as obesity, physical inactivity, unhealthy diets, high blood pressure, smoking, and metabolic syndrome—play a particularly significant role in the development of type 2 and gestational diabetes [10], each of them will be discussed separately below.

Table 5: Significant risk factors for T1DM, T2DM, GDM

DM subtype	Modifiable Risk Factors	Relatively non-modifiable factors
Type 1 DM	Consanguinity	Family history / genetics
		Infections
		Autoimmune Predisposition
Type 2 DM	Overweight / Obesity	Age
	Smoking	PCOS
	sedentary lifestyle, unhealthy diet	Family history/Genetics,
	hypertension	Socio economic status
	dyslipidemia	
Gestational DM	Obesity	Family history of T2DM,
	Smoking	History of GDM
	Maternal age	History of congenital malformation,
	hypertension/pregnancy-related hypertension	History of fetal demise, multiparity

8.   TYPE 1 DIABETES MELLITUS:

8.1. GENETIC:

T1DM (Type 1 Diabetes Mellitus) is caused by the autoimmune destruction of βcells in the pancreas leading to insulin deficiency. It is strongly associated with Human leukocyte antigen (HLA) genes on chromosome 6, contributing to half of the familial T1DM [12,13]. The combination of HLA genes DR4-DQ8 and DR3-DQ2 is particularly associated with increased risk in certain populations. However, the prevalence and strength of these genetic associations can vary between populations and are not universally found in 90% of affected children. [14]. These genetic factors make T1DM inheritable, and it most commonly appears in childhood.

In Saudi Arabia, the prevalence of T1DM has increased over the past decade, especially among children and young adults [15,16]. Studies conducted in the country suggest that this rise is due to the prevalence of HLA genes and their homozygosity, commonly passed down through consanguinity [17,18]. This risk for T1DM is further increased if there is a history of autoimmune disorders in the family, such as hypothyroidism, celiac disease, or pernicious anemia.

8.2. INFECTIONS:

Coxsackie virus and other enteroviruses are suspected factors for T1DM [19]. Latest research also shows that the gut microbiota of 1-year-old infants can be a predictive factor for the development of T1DM. Infants with a higher count of Enterococcus, Gemella, Bacteroides, and Porphyromonas were found to be at a higher risk of T1DM. This is due to the involvement of these bacteria in immune responses, which is associated with a corresponding lower level of butyrate-producing bacteria. This combination of microbiota then leads to inflammation and immune responses which can result in B cell destruction and eventual T1DM development during adulthood [20].

8.3. OBESITY:

There is growing evidence suggesting that obesity may contribute to the incidence of T1DM. The rising prevalence of obesity among individuals with T1DM complicates the management of diabetes and is linked to various obesity-related complications. However, further research is essential to fully comprehend the relationship between obesity and T1DM [21,22,23,24].

9. TYPE 2 DIABETES MELLITUS

9.1. GENETIC:

Twin studies show that genetics play a significant role in Type 2 Diabetes Mellitus (T2DM) [25]. The hereditary predisposition to T2DM is strong and inherited across generations, with genes contributing to its development scattered throughout the genome [26]. T2DM heritability ranges from 20% to 80% [27], and is 40% likely if one parent is affected and 70% if both parents are diagnosed with T2DM.

9.2. AGING:

The general onset of senescence and impaired physiological mechanisms with increasing age show a higher rate of other comorbidities and complications in adults with DM.
As T2DM is often referred to as "adult-onset DM," an increasing age is often correlated as a risk factor for this condition [28,29].

9.3. OBESITY, SEDENTARY LIFESTYLE AND PREDIABETES:

In Saudi Arabia, the rate of obesity is currently at 33.7%, with a higher prevalence of individuals who are overweight [30]. A significant correlation has been established through a meta-analysis in the Kingdom, highlighting that a Body Mass Index (BMI) over 25 is closely linked to an increased risk of developing Type 2 Diabetes Mellitus (T2DM), as well as to an earlier onset of this condition [31,32,33]. It is observed that a considerable number of people with T2DM have abnormal adiposity. Local studies in Saudi Arabia point out that the majority of T2DM patients are diagnosed with obesity, often in connection with a sedentary lifestyle and a history of pre-diabetes [34,35,36]. Moreover, various interventions targeting obesity have been shown to lead to a reduction in the incidence of T2DM [37]. Taken together, these findings strongly emphasize obesity as the primary risk factor for T2DM.

9.4. POLYCYSTIC OVARIAN SYNDROME:

Research indicates a significant link between PCOS and T2DM. Women with PCOS are often 30% less insulin sensitive than those without, a condition exacerbated by higher BMI and lower sex hormone-binding globulin (SHBG) levels [38]. Furthermore, the increased incidence of higher BMIs, elevated testosterone, and lower SHBG levels in women with PCOS contributes to a heightened risk of T2DM development [39,40,41].

9.5. SMOKING:

It has been found that the likelihood of developing T2DM increases by 16% for every 10 cigarettes smoked per day. However, it is important to note that the risk of developing T2DM decreases significantly over time once smoking is stopped. A study conducted in the Gulf region discovered that T2DM is becoming more prevalent, and it was found that various smoking habits, including passive smoking, were significant contributing factors to this increase [42,43].

9.6. HYPERTENSION AND SLEEP:

The link between high blood pressure with T2DM and sleep with T2DM is being researched upon since the current association between these factors may be possibly due to other confounding factors. Studies have found a relationship of T2DM causing hypertension and other cardiometabolic disorders [44], however, a causal association of hypertension as a risk factor for T2DM isn't well established and

requires further evidence. Studies also show that lack of sleep-in terms of chronic insufficient hours of sleep, poor quality sleep and sleeping disorders result in higher circulating levels of inflammatory markers and altering melatonin and cortisol levels [45]. These have been shown to result in a higher risk of T2DM and a poorer prognosis of the disease [45].

9.7. SOCIOECONOMIC STATUS:

In Saudi Arabia, poor socioeconomic status is linked to a higher prevalence of T2DM, attributed to factors like limited education, low awareness, stress, and an unhealthy lifestyle [46,47]. Concurrently, international studies support these findings, emphasizing the global impact of socioeconomic factors on diabetes rates [48]. Additionally, a Saudi study indicates a decrease in DM rates with higher education levels [49], emphasizing the critical role of education in shaping diabetes prevalence in the country and internationally. These insights underscore the importance of targeted interventions to address socioeconomic disparities.

10. GESTATIONAL DIABETES MELLITUS

10.1. OBESITY:

In Saudi Arabia, GDM impacts approximately 40% of pregnancies [17,18]. Obesity is a significant risk factor, with pregnant women having a pre-pregnancy BMI ≥30 kg/m2 more likely to experience GDM and an elevated risk of macrosomia in their offspring [50]. Additionally, these women face an increased risk of developing post-partum T2DM [51,52].

10.2. MATERNAL AGE AND MULTIPARITY:

Maternal age, particularly above 30 years, is a significant risk factor for Gestational Diabetes Mellitus (GDM), with a peak prevalence observed in Saudi women delivering at 40 years [53]. The increased risk is attributed to age-related physiological changes, compounded by multiparity at advanced maternal ages [11,54,55].

10.3. FAMILY HISTORY/ HX OF GDM:

A history of GDM in previous pregnancies, macrosomia in childbirth, and a family history of T2DM significantly increase the risk of GDM in subsequent pregnancies [56,57]. Studies within Saudi Arabia corroborate these risk factors [58]. Additionally, births involving macrosomia not only may precipitate GDM but also heighten the mother's risk for T2DM later [59]. The increased incidence of GDM among the Saudi population is further linked to the trend of older maternal age at conception [60].

10.4. SMOKING:

Smoking during pregnancy can increase the risk of developing gestational diabetes and type 2 diabetes in women compared to non-smoking mothers [61,62]. Research suggests that smoking during pregnancy significantly raises the likelihood of developing gestational diabetes [63]. Recent studies also reveal that exposure to second-hand smoke during pregnancy can increase the risk of developing gestational diabetes by 1.42 times [64].

11. SCREENING FOR DIABETES MELLITUS AND RELATED COMPLICATIONS

11.1.   FOR ASYMPTOMATIC T2DM:

Table 6: Screening for asymptomatic T2DM, high-risk individuals

Population/High-Risk Group	Screening Method	Timing	Special Notes / EMR Flag & Education
All adults with BMI ≥25 kg/m² or obesity + ≥1 additional risk factor	FPG, HbA1c, or RBG	Begin at 18 years; repeat every 3 years if normal	Risk factors: Physical inactivity, first-degree relative with DM, history of macrosomic baby (>4 kg) or GDM, BP ≥140/90 or on therapy, HDL <35 mg/dL or TG >250 mg/dL, PCOS, IGT/IFG or HbA1c ≥5.7%, history of CVD, other insulin resistance conditions (e.g., severe obesity, acanthosis nigricans, MASLD). Consider annual testing if additional risk factors arise.
Prediabetes	FPG, HbA1c	Annually	—
Pregnant women (no prior DM)	2-hr 75-g OGTT	At 24–28 weeks of gestation	For diagnosis of GDM: Use OGTT with pregnancy-specific cutoffs. Do not use HbA1c for GDM diagnosis during pregnancy; OGTT is the gold standard.
Women with history of GDM (postpartum and long-term follow-up)	75-g OGTT (preferred) or FPG	Mandatory at 6–12 weeks postpartum; repeat annually if normal; at least every 3 years thereafter; before future pregnancy; more often if additional risk factors	OGTT is preferred for early postpartum screening (more sensitive than HbA1c in the first 6 months postpartum). If initial OGTT/FPG is normal, reassess annually for at least 10 years; if prediabetes, test annually. EMR flag (e.g., Sehatty) for all women with history of GDM; educate patient and provider on long-term diabetes risk; integrate screening into maternal-child health visits.
All other adults (no risk factors)	FPG, HbA1c, or RBG	Begin at 35 years; repeat every 3 years if normal	Consider more frequent testing if additional risk factors arise.
High-risk individuals (any group, regardless of age)	As above	Per above	Monitor closely; consider individualized follow-up based on risk profile.

11.2.   ACCURACY OF SCREENING TESTS:

Diabetes diagnosis relies on A1C criteria, fasting plasma glucose (FPG), and 2-hour glucose (2-h PG) during a 75-g oral glucose tolerance test (OGTT), or random glucose accompanied by hyperglycemic symptoms or crises. FPG, 2-h PG, and A1C are suitable for diagnostic screening, with detection rates varying in populations and individuals, reflecting diverse aspects of glucose metabolism [65,66,67].
The advantage of glucose testing (FPG & 2-H PG) lies in its cost-effectiveness and widespread availability. However, limitations, including diurnal glucose variation and fasting requirements, may impact accuracy due to fasting difficulties or misreporting. An advantage of 2-h PG during 75-g OGTT is its increased sensitivity, diagnosing more individuals with prediabetes and diabetes compared to FPG and A1C cut points [67].

HBA1C presents conveniences such as no fasting requirement, preanalytical stability, and less vulnerability to daily changes in nutrition and illness. Yet, it has lower sensitivity at designated cut points, increased cost, and limited accessibility in certain regions [80]. Moreover, HBA1C is influenced by different diseases like thalassemia, sickle cell, and folate deficiency, necessitating careful consideration [65]. Gestational Diabetes Mellitus (GDM) diagnosis employs either a one-step 75g OGTT or a twostep approach (50g followed by 100g OGTT). Both methods have supporting evidence and could identify

long-term risks for both mothers and offspring, providing flexibility for healthcare providers based on experience and institutional infrastructure [68].

11.3.   BENEFITS OF EARLY DETECTION OF DIABETES:

The proactive identification of prediabetes facilitates the initiation of diverse interventions, such as lifestyle changes and pharmacotherapy, which can potentially reverse the condition to normoglycemia after achieving a weight reduction of 5% [69,70,71]. Implementing strategies such as dietary modifications for weight control and enhancing physical activity, in conjunction with the use of effective pharmacological treatments like metformin or GLP-1 agonists, has proven to be highly effective. Remarkably, the addition of Semaglutide 2.4 mg to lifestyle interventions and behavioral therapy has led to the reversion of 84-87% of individuals with prediabetes to normoglycemia, in contrast to the 48-70% success rate with lifestyle modifications alone [72], and Tirzepatide has shown a conversion efficacy of 95.3% to normoglycemia as opposed to 61% with a placebo. [73] The early detection and management of prediabetes are vital in reducing the risk of prediabetes-associated complications and in the prevention or delay of the onset of Type 2 Diabetes Mellitus (T2DM) [73].

11.4.   TYPE 2 DIABETES MELLITUS (T2DM):

Timely Treatment Initiation is crucial for better glycemic control and reducing the risk of diabetes complications [74]. Early detection allows for prompt initiation of treatment, such as lifestyle modifications, medications, or bariatric surgery, potentially achieving remission with a 10-15% weight loss [70]. Identifying undiagnosed individuals is important, as implementing treatment strategies in the early stage of T2DM can help mitigate the higher risk of microvascular and macrovascular complications, especially in young-onset type 2 diabetes [75].

11.5.   TYPE 1 DIABETES MELLITUS (T1DM):

Early detection in high-risk populations allows for proactive trials aiming to prevent or delay the onset of T1DM and to prevent diabetic ketoacidosis at presentation [76,77].

11.6.   GESTATIONAL DIABETES MELLITUS (GDM)

Early detection and appropriate management of gestational diabetes mellitus (GDM) can significantly improve maternal and fetal health outcomes by reducing the risk of obstetric and perinatal complications. Additionally, identifying GDM provides a unique opportunity for interventions aimed at reducing the risk of developing type 2 diabetes mellitus (T2DM) in the future [78].

12. DM ACROSS DIFFERENT STAGES OF PREVENTION:

12.1. TYPE 2 DIABETES MELLITUS (T2DM) LEVEL OF PREVENTION

To structure the prevention of Type 2 Diabetes Mellitus (T2DM) across different stages of primordial, primary, secondary, and tertiary prevention, the following strategies can be employed:

I. Primordial Prevention:

This stage focuses on preventing the risk factors for T2DM. It involves promoting a healthy environment and lifestyle from a young age, including regular physical activity, a balanced diet, and maintaining a healthy body weight to prevent obesity. Smoking should also be avoided or minimized [79,80].

II. Primary Prevention:

This stage targets individuals with prediabetes. Strategies include intensive lifestyle interventions, such as dietary modifications to reduce calorie intake and increase physical activity to at least 150 minutes of moderate-intensity exercise per week. Metformin for the prevention of T2DM may be considered in individuals at high risk, as demonstrated in the Diabetes Prevention Program (DPP) [81]. This is particularly applicable to adults aged **25–59 years** who meet one or more of the following criteria:

- BMI ≥35 kg/m^2
- Higher FPG (e.g. ≥ 110 mg/dl)
- Higher A1c (e.g ≥ 6 %)
- In individuals with prior GDM.

III. Secondary Prevention:

This stage aims at identifying and managing established T2DM to prevent diabetes complications. This includes individualized diabetes control and regular screening for diabetes complications as recommended in the coming sections.

IV. Tertiary Prevention:

This stage refers to the management of established complications of Type 2 Diabetes Mellitus (T2DM) to prevent them from worsening and to improve the patient's quality of life. It involves optimizing glucose control, regular screening, and follow-up for T2DM-related complications such as neuropathy, nephropathy, and retinopathy, and any necessary lifestyle modifications, medications, or interventions for existing complications. It also includes monitoring and managing co-existing conditions such as hypertension and dyslipidemia [79,80].

12.2. TYPE 1 DIABETES MELLITUS (T1DM) LEVEL OF PREVENTION

Type 1 diabetes (T1DM) is a heterogeneous disease and progresses over different stages. Prevention of T1DM is an evolving field encompassing primary, secondary, and tertiary prevention strategies.

Primary Prevention: Efforts toward primary prevention aim to intervene before the onset of T1DM in individuals at risk. Genetic screening and identification of high-risk groups, such as first-degree relatives of individuals with T1DM, serve as key components. While current clinical guidelines recommend screening for at-risk individuals, achieving global universal screening remains a long-term goal [81].

Secondary Prevention: Secondary prevention focuses on delaying or preventing the progression of preclinical stages to overt diabetes. The identification of stages in T1DM progression, as outlined in recent International Society for Pediatric and Adolescent Diabetes Clinical Practice Consensus Guidelines, provides a valuable framework for intervention [82]. Understanding the heterogeneity and endotypes in T1DM further refines secondary prevention approaches, allowing for targeted strategies [83].

Tertiary Prevention: Tertiary prevention is directed at individuals already diagnosed with T1DM, to minimize complications and enhance overall well-being. Recent studies, such as the PROTECT trial, explore novel interventions like teplizumab to preserve β-cell function in newly diagnosed T1DM cases [84]. Semaglutide, as investigated by Dandona et al., showcaes the exploration of innovative therapies for early T1DM [86]. In summary, the progress in preventing T1DM is complex, involving genetic screening, comprehension of disease progression stages, and the exploration of innovative interventions. Considering that 85% of T1DM patients lack a family history of the condition, the global focus on universal screening and continuous research initiatives is shaping the dynamic field of T1DM prevention.

13. COMPREHENSIVE CARE FOR THE RELATED COMPLICATIONS WITH DIABETES.

A comprehensive approach to diabetes management leads to the reduction of diabetes complications. This includes glycemic control, hypertension treatment, dyslipidemia treatment, and utilization of medications with cardiovascular and kidney benefits.

13.1. HYPERTENSION (HTN):

The co-occurrence of diabetes and hypertension presents a significant public health challenge, particularly in Saudi Arabia due to their high prevalence within the population [86,87]. This bidirectional relationship necessitates a comprehensive approach to address both conditions for optimal health outcomes.

Evidence has established that hypertension control in individuals with diabetes significantly reduces the risk of both macrovascular and microvascular complications of diabetes [88].

Routine measurement: Consistent blood pressure measurement during every clinical encounter is crucial for timely identification and monitoring.

For individuals presenting with mildly elevated blood pressure (systolic BP120-129 mmHg, diastolic BP <80 mmHg), confirmation through serial measurements on separate visits is advised for accurate diagnosis.

Hypertension diagnosis: Hypertension is formally diagnosed when an average SBP ≥130 mmHg or DBP ≥80 mmHg is obtained across multiple readings on distinct occasions.

In cases of significantly elevated blood pressure (≥180/110 mmHg) coupled with documented cardiovascular disease, a single-visit diagnosis of hypertension may be justified.

Individualized blood pressure target: Achieving a target of 130/80 mmHg remains a standard clinical goal for most individuals with diabetes, provided good tolerability to treatment exists [89].

13.2. DYSLIPIDEMIA:

Comprehensive Strategy: In individuals with diabetes, proactive management of dyslipidemia is critical to mitigate cardiovascular disease (CVD) risk. This multi-pronged approach is influenced by patient age, ASCVD risk profile, and LDL-C levels [90,91,92].

Cardiometabolic Risk Assessment and Prevention:

Individuals with diabetes should receive a comprehensive evaluation of their cardiovascular and metabolic risk profile, including the routine estimation of 10-year atherosclerotic cardiovascular disease (ASCVD) risk using validated risk calculators. This risk assessment should guide the intensity of preventive interventions, especially lipid-lowering therapy and lifestyle modification.

According to the Saudi Clinical Preventive Guideline (2023), clinicians should prescribe statins for the primary prevention of CVD in adults aged 40 to 75 years who have one or more CVD risk factors (such as dyslipidemia, diabetes, hypertension, or smoking) and a 10-year CVD risk of 10% or greater. Clinicians may also selectively offer a statin to adults in the same age range with the same risk factors but with a 10-year CVD risk of 7.5% to less than 10%.

The guideline also advises screening for high blood pressure in all adults 18 years and older and checking for a fasting lipid profile. Blood pressure should be checked annually for individuals at increased risk, including adults 40 and older, and those who are overweight or obesity. Less frequent checks (every 3 to 5 years) are appropriate for adults aged 18 to 39 years who are not at increased risk. The guideline does not mention specific blood pressure targets, the use of SGLT2 inhibitors or GLP-1 receptor agonists, or the assessment for metabolic dysfunction-associated steatotic liver disease (MAFLD) [93].

Lifestyle Modifications as the Cornerstone:

13.3. WEIGHT MANAGEMENT:

Weight management is a fundamental component of diabetes prevention, with achieving and maintaining a healthy weight through lifestyle interventions being crucial. Even a modest, sustained weight loss of 3–7% of initial body weight can significantly reduce the risk of developing type 2 diabetes. Effective weight management strategies should be comprehensive and tailored to the individual, emphasizing nutritional therapy that focuses on healthy eating patterns and portion control, as well as increased physical activity, which not only aids in weight loss but also improves overall metabolic health. To help individuals sustain these changes, behavioral strategies such as goal setting, self-monitoring,

and problem-solving are essential. Health coaching and regular follow-up with healthcare professionals provide the ongoing support and guidance necessary to achieve long-term success in weight management and diabetes prevention [90,91].

13.4. DIETARY PATTERNS:

Adopting a healthy dietary pattern is a cornerstone of diabetes prevention and management. The Mediterranean diet, characterized by a high intake of fruits, vegetables, whole grains, and lean proteins, along with limited saturated and trans fats, has been demonstrated to improve lipid profiles and enhance overall metabolic health. Similarly, the Dietary Approaches to Stop Hypertension (DASH) diet complements these principles and is effective in reducing cardiometabolic risk factors, which are especially important for individuals at risk of or living with diabetes. Achieving sustained dietary changes requires comprehensive behavioral support and health coaching to assist individuals in setting realistic goals, developing personalized meal plans, and maintaining motivation through ongoing encouragement and accountability. Employing behavioral strategies such as goal setting, self-monitoring of food intake, and problem-solving enables individuals to overcome challenges associated with dietary changes and enhances the likelihood of long-term success in diabetes prevention. Integrating these evidence-based dietary approaches with structured behavioral interventions optimizes health outcomes and supports effective diabetes risk reduction [89,91].

13.5. PHYSICAL ACTIVITY:

Engaging in regular physical activity is a crucial component of diabetes prevention. It plays a significant role in optimizing metabolic health and improving lipid profiles. The guideline recommends engaging in at least 150 minutes per week of moderate-intensity aerobic physical activity, or 75 minutes per week of vigorous-intensity aerobic activity. This should be distributed over at least 3 days a week, with no more than 2 consecutive days without activity. Additionally, incorporating resistance training (strength training) on 2 to 3 nonconsecutive days per week is recommended to improve insulin sensitivity and glucose control [89].

Table 7: Tailored Statin Therapy for primary prevention of ASCVD in DM

Ages 40-75 without ASCVD:	Moderate-intensity statins, combined with lifestyle modifications, are recommended. [91]
Ages 20-39 with Additional ASCVD Risk Factors:	Initiation of statins alongside lifestyle changes may be considered based on individual risk assessment. [91]
Ages 40-75 with Higher Cardiovascular Risk (≥1 ASCVD Risk Factor):	High-intensity statins are recommended, targeting an LDL-C reduction of ≥50% and achieving an LDL-C goal of >70mg/dL (<1.8 mmol/L). [91]
High-Risk Individuals (Multiple ASCVD Factors and LDL-C ≥70mg/dL):	In addition to maximally tolerated statin therapy, consideration of other lipid-lowering medications may be required. [91]
Contraindications:	Statin therapy is contraindicated in pregnancy. [89]

13.6. METABOLIC DYSFUNCTION-ASSOCIATED STEATOTIC LIVER DISEASE (MASLD)

Diabetes mellitus is a recognized risk factor for metabolic dysfunction-associated steatotic liver disease (MASLD), which was formerly known as non-alcoholic fatty liver disease (NAFLD). MASLD can potentially lead to advanced fibrosis and poorer liver outcomes. The rising global prevalence of MASLD emphasizes the need for effective screening and risk stratification strategies in individuals with diabetes, particularly those at increased risk of progressive liver disease. Early identification and management are crucial for preventing long-term complications [92,94,95].

13.7. SCREENING RECOMMENDATIONS (SCREENING FOR LIVER FIBROSIS IN PATIENTS WITH DIABETES):

The Fibrosis-4 (FIB-4) index is a validated, noninvasive tool recommended for the early detection of liver fibrosis in individuals with diabetes. It is calculated using commonly available clinical parameters: age, aspartate aminotransferase (AST), alanine aminotransferase (ALT), and platelet count. The formula is:

FIB-4 = (Age [years] × AST [U/L]) ÷ (Platelet count [10^9/L] × √ALT [U/L]).

This index is effective even in patients with normal liver enzyme levels, making it broadly applicable in clinical practice. For people with diabetes, a FIB-4 score of 1.0 or higher indicates an increased risk of significant liver fibrosis and should prompt further evaluation. Scores of 2.67 or above suggest advanced fibrosis and warrant urgent referral to a specialist for comprehensive assessment, which may include imaging or liver biopsy. Implementing this risk-stratified screening approach enables timely identification and management of progressive liver disease in patients with diabetes, optimizing outcomes and preventing complications. Regular use of the FIB-4 index supports early intervention in this high-risk population without reliance on invasive or specialized testing [95].

FIB-4 Interpretation :

Refer to Table 1 and Fig 3 for detailed risk stratification based on FIB-4 values and their association with adverse liver outcomes .

Key Points :

FIB-4 < 1.3: Low risk of advanced fibrosis (F3-F4) and complications. (Repeat test in 2-3 years) FIB-4 1.3-2.67: Intermediate risk requiring further evaluation .

FIB-4 > 2.67: High risk of advanced fibrosis and adverse outcomes .

Consider slightly higher FIB-4 cutoffs (1.9-2.0 instead of >1.3) for individuals with diabetes aged ≥65 years.

High-Risk Group: Individuals with type 2 diabetes and an indeterminate or high FIB-4 score should undergo further assessment using liver stiffness measurement by transient elastography and referral to a gastroenterologist for a comprehensive evaluation and appropriate workup.
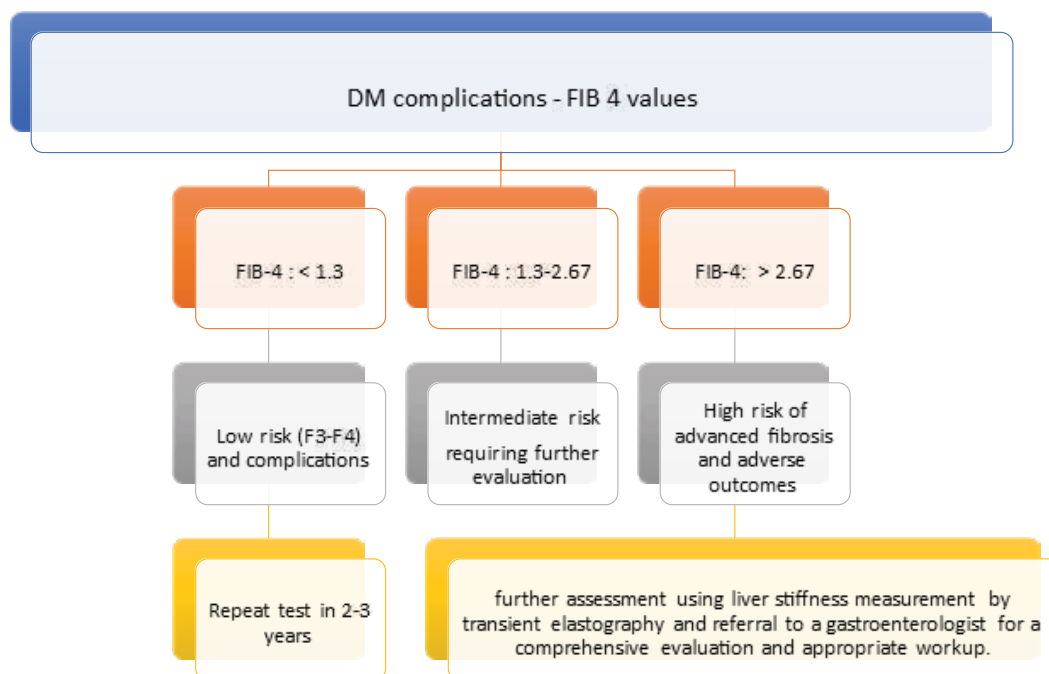

Figure 1: Risk stratification of individuals with MASLD based on FIB-4 values with suggested interventions.

13.8. OSTEOPOROSIS:

Bone health is pivotal in diabetes management, with increased hip fracture risks in T1DM and T2DM patients, exacerbated by longer DM duration and poor glycemic control [97,98,99]. Routine fracture risk assessment in older adults with diabetes should consider specific risk factors and comorbidities. Monitoring through dual-energy X-ray absorptiometry (DXA) is advised for at-risk individuals, particularly those over 65 and younger patients with multiple risk factors, at intervals of every 2–3 years.

The Saudi Fracture Risk Assessment Tool (FRAX) has been developed for tailored osteoporosis treatment decisions for the Saudi population [100]. Selection of glucose-lowering medications should prioritize bone health, avoiding drugs that adversely affect bone density. Glycemic goals must be individualized to reduce fall and fracture risks, favoring treatments with a low hypoglycemia risk. Ensuring adequate intake of calcium and vitamin D is recommended for those at risk of fracture [89].

13.9. AUTOIMMUNE DISEASES IN T1DM:

Individuals with T1DM exhibit an increased susceptibility to developing other autoimmune disorders. Recent studies focusing on Saudi Arabian T1DM populations have revealed a concerning trend of high co-occurrence of autoimmune diseases, particularly thyroid and celiac disease.

The prevalence of these conditions appears to be significantly higher compared to global averages. [101,102] Furthermore, the presence of these comorbidities has been associated with a heightened risk of complications such as hypoglycemia, nephropathy, and cardiovascular disease [101,102].

- It is recommended to screen for autoimmune thyroid disease soon after T1DM diagnosis, followed by periodic evaluations thereafter. This approach is particularly relevant in the Saudi context given the observed high prevalence of autoimmune thyroid disease.

- Additionally, it is recommended to screen for celiac disease soon after T1DM diagnosis. In adults, targeted screening should be conducted for those who show symptoms indicative of celiac disease, such as diarrhea, malabsorption, and abdominal pain, or signs like osteoporosis, vitamin deficiencies, iron deficiency anemia, or unexplained hypoglycemia [89].

14.1. RECOMMENDATIONS AT AN INDIVIDUAL LEVEL AND LIFESTYLE MODIFICATIONS

Prevention is better than cure. A focus on the most prevalent risk factors of DM, especially in families with a positive history, is essential to reduce its prevalence and maintain control. The Kingdom of Saudi Arabia has focused on Non-Communicable diseases, including DM, and them prevention and control, as part of the Kingdom's Vision 2030, "Health and Well Being for All."   These include national strategies such as the Obesity Control and Prevention Strategy, Diet and Physical Activity Strategy, and National Executive Plan for Diabetes Control among others [103].

Data from the national and international databases reveal that Diabetes Mellitus affects an estimated 23.1% to 23.7% of the adult population as of 2024–2025 in Saudi Arabia [1], with a significant portion of these cases being uncontrolled. This prevalence is comparable to international rates of undiagnosed diabetes, underscoring a substantial area for improvement Prevention is more effective than treatment. Addressing the most prevalent risk factors for diabetes mellitus (DM), particularly among individuals and families with a positive history, is essential to reduce its prevalence and maintain effective disease control. The Kingdom of Saudi Arabia places a strong emphasis on the prevention and management of non-Communicable diseases (NCDs), including diabetes, as a key priority within the framework of the Kingdom's Vision 2030. In response, the Public Health Authority has set ambitious goals to effectively diagnose, treat, and manage the majority of individuals with diabetes by 2030 [104]. The importance of meeting these targets is underscored by the fact that even a modest reduction in HbA1C can substantially decrease DM morbidity and mortality. Without targeted interventions, mortality from diabetes and its complications is expected to rise significantly by 2030 [105, 106]. Therefore, early detection and expanded screening efforts are vital to identify more individuals at risk or with undiagnosed diabetes, allowing for timely interventions and management.

Targeted interventions focusing on early detection, individualized treatment, and sustained lifestyle modifications—including healthy nutrition, physical activity, weight management, and behavioral support—are crucial. These efforts should be supported by strong health system engagement and multisectoral collaboration to ensure comprehensive prevention and care for individuals at risk of or living with diabetes and related chronic conditions [104, 105, 106].

21

Saudi Health Promotion and Prevention Guideline for Diabetes Mellitus
For Health Professionals and Health Educators - First Edition 2025-2026

Table 8: Individual- level Recommendations for prevention of DM

Individual level Recommendations for the Prevention and Control of Diabetes Mellitus		
Class of Recommendation	Level of evidence	Recommendations
I	A	Obesity control is recommended by an upward weight centric approach involving the reduction of BMI via lifestyle modifications and other modalities [107,110]. This has been proven to result in T2DM remission, reducing the risk factors of CVDs and T2DM complications. [86,123,137,138]
I	A	A healthy balanced diet, is recommended which is rich in fruits, vegetables, whilst avoiding processed foods [119,121,139-144]
I	A	Physical activity is recommended with a target of 150 minutes of moderate activity per week or 75 minutes of vigorous-intensity physical activity [90,107]
I	A	Smoking cessation is recommended by exercising selfcontrol with aid of behavioral support groups and social support [42,43]
I	B	Monitoring of blood sugar is recommended especially in those with high risk for diabetes in the screening recommendations. [123]
I	B	Stress management is recommended by practicing meditation, deep breathing exercises and a healthy engagement with hobbies for relaxation [127]
I	B	Maintaining healthy sleep is recommended with quality sleep of 7-9 hours per night [119,128,129]

Key strategies for the prevention of both T1DM, T2DM and GDM in both high-risk individuals and the general population involve the following:

14.2. OBESITY MANAGEMENT

Obesity is a major risk factor for the increasing prevalence of type 2 diabetes mellitus (T2DM) and significantly impacts the development and management of gestational diabetes mellitus (GDM) and type 1 diabetes mellitus (T1DM). Therefore, tackling obesity and achieving weight loss are crucial strategies for preventing and managing these conditions.

Losing even a small amount of weight can significantly lower the risk of T2DM in the prediabetes stage. Furthermore, a sustained weight loss of around 10% of body weight can lead to dose-dependent remission of T2DM. This remission can be pursued through comprehensive lifestyle interventions, including dietary calorie restriction and regular physical activity, which have been shown to lead to significant improvements in the diabetes epidemic over time [103]. Additionally, a comprehensive weight loss strategy may combine lifestyle changes with pharmacological treatments (such as metformin or GLP-1 analogs), bariatric surgery, and behavioral therapy[109 ,108].

The successful outcomes of weight loss, including remission of T2DM, have been demonstrated in clinical trials. For instance, the "Diabetes Remission Clinical Trial" (DiRECT) showed that 46% of participants achieved remission of T2DM after 12 months through a non-surgical weight loss program [110, 111]. The US's Diabetes Prevention Program (DPP) RCT study further supported these findings, showing that lifestyle modifications led to a delay in the development of T2DM [90]. A weight-centric approach, aiming for a minimum of 15% body weight loss, is more effective than a glucocentric approach, as it not only helps prevent and manage T2DM but also improves prognosis and protects against microvascular complications associated with diabetes, hypertension, and dyslipidemia [74].

The American Diabetes Association (ADA) recommends an optimal weight loss of 1-2 pounds per week, with caloric goals set according to initial patient weight and a daily caloric reduction of 500-1,000 calories [114].

14.3. LIFESTYLE MODIFICATIONS

Maintaining a balanced and healthy diet is crucial for preserving a healthy weight and overall wellbeing. Diets rich in fruits, vegetables, and whole grains, which are fundamental elements of the Mediterranean diet, are highly recommended [115, 116,117,118]. Success in achieving weight loss largely depends on the adherence to the chosen diet, regardless of the dietary approach selected. Studies indicate that the effectiveness of these diets in terms of weight loss is similar after one year. Therefore, it is essential to develop a personalized diet plan that considers individual factors such as age, socioeconomic status, health conditions, physical activity and more, to ensure successful long-term dietary changes [89,115,119,120].

In parallel, the significance of regular exercise, muscle strengthening and maintaining an active lifestyle cannot be overstated. Meta-analysis studies highlight an inverse association between physical activity and T2DM risk, attributed possibly to the reduction of body adiposity through physical exertion, which concurrently lowers the risk of comorbidities including cardiovascular diseases (CVDs) [30,51,107,108,120].

Nutritional guidelines according to ADA indicate a reduction in total dietary fat and calories. Since no evidence exists for ideal specific levels of carbohydrate, protein or fat in diet, the macronutrient distribution should be according to individual preference and metabolic goals. [53,114] Observational studies show the significance of a low carbohydrate, vegetarian, plant-based diet, and DASH (Dietary Approaches to Stop Hypertension) in minimizing the risk for T2DM [89,121,122].

The comprehensive approach to lifestyle modification, which includes both dietary and physical activity considerations, is a fundamental aspect of preventing and managing Type 2 Diabetes Mellitus. This approach also reduces the risk of gestational diabetes in future pregnancies and may play a role in reducing the incidence of and improving control of Type 1 Diabetes Mellitus. It is important to note the significance of personalized strategies in promoting adherence and achieving meaningful health outcomes.

14.4. MONITORING OF BLOOD SUGAR

This is a key prevention factor to be practiced by individuals with a high risk of DM, and healthcare providers is to adhere to the Saudi guideline of diabetes screening to diagnose prediabetes or diabetes early. While known patients with GDM, T2DM & T1DM need to monitor their blood glucose to improve glycemic control and reduce known complications [123]. Available new technologies for continuous glucose monitoring can enhance the control of diabetes, especially in T1DM, elderly T2DM on insulin, and GDM patients on insulin [124,125]. Digital technology to provide awareness for diabetes screening via telecom companies, virtual education tools and official ministry apps like Sehhaty and telemedicine like Seha Virtual Hospital [104].

14.5. SMOKING CESSATION

Smoking shows a strong correlation with an increased risk of type 2 diabetes mellitus (T2DM) [63, 86, 89] and gestational diabetes mellitus (GDM) [64]. Therefore, discouraging smoking is a crucial public health strategy. This can be achieved through mass media campaigns and public awareness initiatives that highlight the harmful effects of tobacco use on metabolic health. Encouraging support groups and providing resources for behavioral changes at the individual level are also essential for helping people quit. Recent studies have shown that a dual approach combining smoking cessation and weight control can lead to a decrease in T2DM cases [126]. This dual strategy is particularly effective because both smoking and obesity are significant, modifiable risk factors for diabetes. A holistic approach that addresses both behaviors simultaneously is more likely to yield positive long-term health outcomes.

14.6. STRESS MANAGEMENT

Psychological stress is a recognized risk factor linked to the development of type 2 diabetes mellitus (T2DM) [127]. This is because stress can lead to an increase in hormones like cortisol, which can elevate blood glucose levels and promote insulin resistance. Therefore, incorporating effective stress control activities into lifestyle and behavioral modification strategies is crucial for diabetes prevention. Activities such as mindfulness meditation, deep breathing exercises, and engaging in healthy hobbies for relaxation can help mitigate the physiological effects of stress. By managing stress, individuals can improve their overall well-being and reduce their risk of developing T2DM. Implementing structured stress management programs as part of a comprehensive prevention guideline is essential for providing individuals with the tools they need to cope with daily stressors and maintain metabolic health.

14.7. SLEEP CONTROL

Epidemiological cohort studies have established a link between short sleep duration and the development of obesity and type 2 diabetes mellitus (T2DM) [128, 129]. Furthermore, sleep abnormalities are also associated with a higher risk of developing T2DM] [119].

Aiming for 7-9 hours of quality sleep per night is essential, as research has shown that poor sleeping habits can lead to insulin resistance and increase the risk of T2DM. Implementing strategies to improve sleep hygiene, such as maintaining a consistent sleep schedule, creating a relaxing bedtime routine, and optimizing the sleep environment, can be a vital component of diabetes prevention guidelines. These behavioral changes, when combined with other lifestyle modifications and policy interventions, can empower individuals to make remarkable improvements in their health.

14.8. POLICY INTERVENTIONS AT THE POPULATION LEVEL:

Policy interventions introduced at the population level aim to bring about a change in the general health of the entire population, decreasing exposure to specific disease risk factors especially with varying social determinants of health and motivating and incentivizing healthy behavioral changes at an individual level. Major roles at the population level are that of mass media, healthcare professionals and the public and governmental institutions of setting policies and legislatures that encourage and promote healthy behaviors and lifestyles by default.

Table 9: Population-level Recommendations for prevention of DM

Population level Recommendations for Prevention and Control of Diabetes Mellitus				
Level of intervention	Risk factor prevention via	Class of Recommendation	Level of evidence	Actions
Government al policies	**Obesity control and physical activity**	I	C	Strategic development of road and building infrastructure to include more pedestrian friendly paths and enhance physical activity. Recreational centers, parks, walking tracks to be planned and developed in well-accessible areas of the city [103,105,137,138].
	Healthy diet	I	B	Saudi Food and Drug Authority (SFDA) to make regulations regarding the composition of foods [138,139].
		I	C	Restriction of the marketing of unhealthy junk foods and sugary drinks [143,144].
		I	C	Policies to ensure schools provide students with healthy meals and ensure hydration of children [142,143].
	Smoking	I	C	Banning smoking in public spaces, and workspaces to avoid passive smoking and discourage smoking in general [42,43].
		IIb	C	Limitation of granting opening allowance to shisha branches and cafes and limiting their opening hours. [42].
	Diabetes Screening Expansion	IIb	C	Regular screening to be carried out of all adults ≥ 35 years without diabetes at health clinics [104].
		IIb	C	Community pharmacies conduct free screening tests at stalls for the entire population [104].
		IIb	C	Digital technology to provide awareness for diabetes screening via telecom companies, virtual education tools and official ministry apps like Sehhaty and telemedicine like Seha Virtual Hospital

24

Saudi Health Promotion and Prevention Guideline for Diabetes Mellitus
For Health Professionals and Health Educators - First Edition 2025-2026

			25	[104].
		IIb	C	Professional training of healthcare staff to be adept at the periodic diabetes screening to be provided with financial incentives upon performance excellence and the number of patients screened [104].
		IIb	C	Enhancement of primary care facilities with availability of required equipment and health care professionals [104].
		IIb	C	establishment of operational monitoring units to see the implementation of regulations across the healthcare setups [104].
		IIa	B	National laws to be established make it a policy for government health providers and health insurance companies to provide free diabetes screening by ensuring cost coverage in adults above a certain cut-off age and high-risk individuals. (Table 6) This was done in the USA for colorectal cancer screening by covering colonoscopy costs by insurance and helped reduce colorectal cancer rates in the country [152].
Media, education, Information	**Obesity control and physical activity**	II a	C	Multisectoral collaboration with the media industries, news agencies, and official national social media channels to educate people and raise awareness regarding obesity management and maintaining a healthy lifestyle [107,108,137,141,138].
		IIa	C	Integration of health, well-being, and behavioral decision-making into the curricula of schools and universities [133, 134,137,150].
		II a	C	Promotion of exercise by health practitioners just like they prescribe medications to patients [134,137].
	Healthy Diet	II a	C	Incorporation of individualized nutrition education into school and university curricula [144,150].
		II a	C	Social media campaigns and TV advertisements to promote healthy foods and alternatives to unhealthy ones [144].
		II a	C	Essential labelling of composition foods, calories, and quantities on food packaging on front of packs [137].
	Smoking	IIa	C	Launching social media campaigns and TV advertisements to highlight the detrimental effects of smoking, ensuring that warnings are prominently displayed across all channels, TV shows, and movies that feature smoking scenes [144,150].
		IIa	C	Placement of warnings detailing the harmful effects of smoking on the front of cigarette packages [122,140].
		IIa	C	Raising educational awareness about lung cancer and the adverse effects of smoking, including shisha, through targeted information campaigns [134,137,144].

Economic incentives	Obesity control and physical activity	II b	C	Implementing gym subscription plans with special health discounts for individuals at higher risk and students to make access more feasible [145-149,138].
		IIa	C	Offering financial incentives or rewards to patients who consistently engage in healthy behaviors [104, 145-149].
	Healthy diet	I	B	Taxes on foods high in sugar and sweet beverages [119,138-142].
		I	B	Price reduction for healthier foods and raising for ultra-processed foods [138-141,151].
	Smoking	IIa	C	Tax and embargoes on the tobacco industry to limit production and selling [34,151].
		IIa	C	Tobacco taxing on cigarette packs to limit purchase by consumers and decrease demand [43].

15. NATIONAL INTERVENTIONS AND COMMUNITY PROGRAMS:

With the help of policies introduced at the national level and enacted by the Ministry of Health, pre-existing programs which aim to target the UN Sustainable Developments such as Goal 3 "Health and Well Being for All," and the Kingdom Vision 2030 plan regarding the health sector, can be effectively evaluated, modified and strategized on a scale suitable to the size of the current DM epidemic. These all must bring initiatives to the community and unite the population to end the diabetes epidemic by multisectoral collaboration and strengthening the grounds for research relevant to DM within KSA [103].
Current programs include:

- Obesity Control and Prevention Strategy
  - Diet and Physical Activity Strategy
  - National Executive Plan for Diabetes Control
  - Healthy Food Strategy by SFDA
  - National Plan for Tobacco Control

15.1. PUBLIC AWARENESS CAMPAIGNS:

Media is the most powerful tool of the 21st century for information dissemination and public awareness. By launching campaigns across national television, newspapers, and social media, the general population of all age groups across the country can be targeted at large to promote health literacy regarding DM types including GDM and enhance patient self-care, glycemic control knowledge, awareness of healthy behaviors and diets, and risk factor and complications awareness [103].

15.2. IMPROVING ADHERENCE

Nonadherence, the deviation from following recommended health guidelines, treatments, or lifestyle adjustments, can significantly impact health outcomes. Factors influencing adherence include the nature of the disease, patient education, and the challenges inherent in altering lifestyle habits. In addressing this, the Kingdom aims to enhance patient engagement and commitment to prescribed treatments, targeting an increase in treatment adherence rates. This strategic approach underscores the importance of patient adherence in improving health outcomes and the overall effectiveness of healthcare interventions.

Table 10: Improving Adherence to Diabetes Mellitus Prevention and Treatment Strategies

Recommendation	Class	Level	Rationale/Detail
Promote behavioral changes in lifestyle, including healthy diet, physical activity, and weight loss	I	A	Supported by randomized controlled trials (RCTs) and meta-analyses.
Implement motivational strategies (e.g., goal setting, feedback, peer support) to encourage smoking cessation and healthy lifestyle adoption	IIa	B	Supported by cohort and intervention studies; enhances long-term adherence.
Offer personalized counseling and regular follow-up to reinforce adherence to medication and lifestyle interventions	IIa	B	Personalized approaches shown to improve outcomes in observational and real-world data.

15.3. STRATEGIES TO IMPROVE ADHERENCE TO LIFESTYLE MODIFICATION:

Table 11: Improving adherence to lifestyle modifications for DM control.

	Intervention	Reference #
Mass media campaigns	Emphasizing the importance of healthy living, including a balanced diet and regular physical activity, is crucial. Additionally, fostering a culture of body positivity and addressing societal stigmas associated with body shaming are essential steps towards promoting overall wellness	135,138, 144,150
Education	Integrating the principles of a healthy lifestyle into the educational curricula at all levels, from schools to universities, underscores its importance.	134,137,150
Support networks and peer support groups	Creating support networks and peer groups for those with Diabetes Mellitus offers a space to share experiences and management tips, promoting a multidisciplinary approach to diabetes care	104, 134, 135,137,150
Family and social support	Healthcare providers should emphasize the importance of family and social support as key to successfully managing and preventing Diabetes Mellitus and other diseases.	134,135, 136,
Personalized care plans	Patients, particularly those at higher risk for Diabetes Mellitus, should receive personalized care plans from their GPs or doctors. These plans should detail SMART (specific, measurable, achievable, relevant, and time-bound) goals focused on maintaining a healthy lifestyle and adherence to the management plan.	135,137
Counselling	Healthcare providers should offer behavioural interventions and counselling to identify and address barriers to lifestyle modifications, including psychosocial challenges. Conversations should occur in a supportive, private setting, allowing individuals to openly discuss the physical and mental obstacles to lifestyle changes and explore personalized strategies for overcoming these barriers.	89, 108,137

Improving the adherence of the general population to the screening process of T1DM and T2DM and the medication for diagnosed individuals is essential to control prediabetes and the severity and mortality owing to DM itself.

Besides the points mentioned above regarding lifestyle modification, strategies for adherence include:

Table 12: Recommendations for Improving Screening Adherence and Intervention Uptake for Diabetes Mellitus

Recommendation	Class	Level	Rationale/Detail
Offer free, accessible community-based screening (e.g., in pharmacies, workplaces, shopping centers)	I	A	Reduces barriers and increases participation; supported by high-quality evidence.
Utilize digital health solutions (telemedicine, mobile apps, text messaging) for referrals, reminders, and result delivery	I	A	Digital platforms improve workflow, tracking, and engagement.
Raise awareness through mass media, social media, and targeted campaigns emphasizing the importance of early detection	I	A	Evidence shows improved knowledge and screening uptake with structured campaigns.
Implement culturally adapted screening invitations, educational materials, and community health worker outreach	I	B	Culturally tailored strategies increase trust and uptake, especially in underserved groups.
Collaborate with NGOs, municipalities, schools, and community leaders to expand reach and trust	IIa	B	Community partnerships enhance legitimacy and extend coverage.
Offer subsidized or free screening and interventions for low-income populations and people with disabilities	IIa	B	Financial support reduces non-adherence; subsidies help close care gaps.
Develop and deploy mobile clinic models for screening in rural and remote areas	IIa	B	Improves geographic access, addresses rural and elderly needs.
Integrate reminder and follow-up systems within primary care and chronic disease clinics	I	A	Systematic reminders and follow-up protocols increase completion rates for screening and interventions.

15.5. SCREENING FOR MACROVASCULAR AND MICROVASCULAR COMPLICATIONS OF DIABETES:

During the prediabetes phase, patients are susceptible to both macrovascular and microvascular complications. The incidence of macrovascular complications, including myocardial infarction and cerebrovascular accidents (strokes), is heightened among the diabetic population. Such complications may present asymptomatically in their initial stages, emphasizing the need for healthcare practitioners to proactively identify these conditions early in the course of disease management.

Microvascular complications, like diabetic nephropathy, neuropathy, and retinopathy, exhibit a direct correlation with glycemic control. Screening for these microvascular complications constitutes an integral component of the diabetes management protocol [130,131,132].

The recommended timing for the screening of microvascular complications diverges between patients with T1DM) and those with T2DM.

Additionally, patients diagnosed with T1DM bear an increased risk of concomitant autoimmune disorders. As such, comprehensive screening for additional autoimmune diseases is advocated for this subgroup, further details of which will be delineated in the subsequent table.

Table 13: Screening for different complications of DM

Complication	Screening Method	Timing
Retinopathy	• Dilated eye exam	Within 5 years of T1DM diagnosis. At the time of T2DM diagnosis. Before or in early pregnancy for T1DM & T2DM, then with each trimester.
Diabetic Kidney Disease	• Urine albumin-to-creatinine ratio (UACR). • Serum creatinine with estimated glomerular filtration rate (eGFR). • Follow-up with 2-3 UACR samples over 3-6 months is required due to test variability.	Annually for all T2DM patients starting at diagnosis, and for T1DM patients after 5 years of diagnosis.
Diabetic Foot	• Vascular inspection (pedal pulses, skin, temperature, etc.) • Monofilament test	Annual comprehensive foot exam to check for active lesions and assess the risk of amputation. Refer to a podiatrist if abnormalities are found.
Obstructive Sleep Apnea (OSA)	• STOP-BANG score	Screening as needed, particularly in patients with a history of snoring, tiredness, observed apnea, or high blood pressure, and in patients who are obese, older than 50, or male.
Osteoporosis	• Bone density scan	Age > 65.
Metabolic-Associated Steatotic Liver Disease (MASLD)	• FIB-4 score	Screening as needed.
Psychosocial and Cognitive	• Depression (PHQ-9) and Cognitive Dysfunction (Mini-Mental State Examination)	Screening as needed.
Autoimmune Diseases	• Thyroid and celiac screening • Adrenal insufficiency screening	For T1DM: at diagnosis and then periodically. Other autoimmune diseases are screened for based on symptoms.

16. LIMITATIONS AND FUTURE DIRECTIONS

The guideline from the Saudi Public Health Authorities aims to bolster the prevention and control of Diabetes Mellitus in the Kingdom of Saudi Arabia. Despite leveraging the best available evidence, the management of diabetes in KSA encounters several barriers that impede effective control and treatment. These challenges, categorized for clarity, reveal critical areas needing improvement:

Limitations in Diagnosis: A significant hurdle in the early detection of DM is the lack of systematic screening programs, which are essential for identifying the disease and its complications at an early stage. Additionally, the unavailability of diabetes tests in some centers and clinics further contributes to delayed diagnosis. This issue is exacerbated in rural areas, where there is a pronounced shortage of healthcare professionals trained to screen for DM. Moreover, patient reluctance to undergo testing due to fear or lack of awareness aggravates the situation, leading to missed opportunities for early intervention.

Limitations in Management: Effective diabetes management is hampered by the unavailability of critical tools such as glucometers for blood glucose monitoring and monofilaments for neuropathy screening, particularly in many cities and villages. The scarcity of specialists, such as ophthalmologists for fundoscopy, restricts the management of diabetes-related eye complications. Additionally, the limited availability of a wide range of medications, especially newer therapeutic options, hinders comprehensive diabetes care.

Limitation in Clinical Assessment: The deficiency in healthcare professional training and specialized programs for diabetes care limits the quality of clinical assessment and management. The challenge is further compounded by the limited availability of higher medical centers that can provide specialized screening and follow-up for diabetic patients, especially in less urbanized regions.

Variation in Healthcare Delivery: The healthcare system in the Kingdom of Saudi Arabia faces challenges due to its dispersed nature, which can lead to a lack of cohesive care and a limited availability of comprehensive patient data. This issue is exacerbated by the country's extensive geographical landscape, potentially impacting uniform access to healthcare services and leading to variations in diabetes care outcomes. Addressing these challenges is critical, and one pivotal solution is the establishment of a centralized health record system. Implementing such a system is essential for enhancing both the continuity and the quality of healthcare services. It would ensure the availability and accessibility of patient data and treatment histories across various healthcare providers, thereby facilitating more effective monitoring of treatment results and patient compliance.

Research Gap in the Saudi Context: Establishing a dedicated research committee is pivotal for closing the gap in diabetes research specific to the Saudi context. This committee should focus on generating data on the prevalence of DM, its economic impact, and the effectiveness of current diabetes policies in KSA.

Addressing these challenges through strategic interventions, such as the establishment of screening programs, improved access to medical supplies and specialists, enhanced training for healthcare professionals, and targeted research, is essential. The implementation of a unified health record system and a focus on localized research can not only enhance diabetes management in the kingdom but also position Saudi Arabia as a global leader in diabetes care and research.

17. COUNSELLING

Effective counselling is an essential component of diabetes prevention and management. Healthcare providers should adopt evidence-based behavioral change strategies tailored to individual patient needs. Counselling sessions must be patient-centered, culturally sensitive, and designed to empower individuals to take an active role in preventing or managing diabetes.

Objectives of Counselling:

Increase awareness of diabetes risk factors and complications.

Motivate and support individuals to adopt healthy behaviors.

Address barriers to lifestyle changes, including social, psychological, and environmental factors.

Encourage adherence to screening schedules and follow-up appointments.

Approaches:

Motivational interviewing to explore and resolve ambivalence toward behavior change.

Individual and group education sessions focusing on nutrition, physical activity, and weight management.

Stress management techniques including mindfulness and relaxation exercises.

Family-based counselling to engage household members in supporting lifestyle changes.

Advice Skills:

To maximize the effectiveness of counselling, healthcare providers should develop and utilize the following skills:

1. **Active listening**: Demonstrate empathy, avoid interruptions, and validate patient concerns.
2. **Clear communication**: Use simple, non-technical language and visual aids where necessary.
3. **Tailored advice**: Adapt recommendations based on patient's age, culture, health literacy, and socioeconomic status.
4. **Goal setting**: Collaboratively set realistic and measurable health goals.
5. **Problem-solving**: Assist patients in identifying challenges and developing practical solutions.
6. **Positive reinforcement**: Recognize patient achievements to build confidence and sustain behavior change.

Follow-up and Reinforcement:

Provide regular follow-up sessions to review progress and adjust recommendations.

Utilize digital health tools (e.g., SMS reminders, mobile apps) to enhance adherence.

Recognize and reward milestones achieved in lifestyle modification.

Implementation:

Counselling should be delivered by trained healthcare providers (nurses, dietitians, health educators) within primary care and community settings.

Ensure availability of culturally appropriate educational materials.

Integrate counselling services into routine diabetes screening and prevention programs

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34

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36

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40

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For Health Professionals and Health Educators - First Edition 2025-2026