



## Review Article

# Preventive Diabetology: A Proactive Approach to Care

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### Abstract:

Globally, diabetes mellitus has a significant impact on public health and the socioeconomic development of countries. It is a healthcare challenge that is a consequence of demographic transitions and the chronic nature of the disease. As the burden of diabetes continues to rise, it is critical to develop an approach that is preventive, promotive, and most importantly, proactive. The novel concept of “preventive diabetology” is proposed, adapted from the fundamental principle of preventive cardiology, that the intensity of risk-reduction measures should match the baseline risk of the disease. This article explores the management of diabetes with a paradigm shift from the current reactive and curative approach to a proactive approach. It focuses on preventive strategies at all levels, i.e., primordial, primary, secondary, and tertiary prevention, as well as quaternary and quinary prevention. The proactive approach, so presented, promises a consistent, preventive, and promotive outlook to providing care before diabetes development and at all stages of the disease. This article further recommends translating this philosophy into daily clinical practice for managing the burden of diabetes.

**Key words:** Prevention, Diabetes Mellitus, Primordial, Primary, Secondary, Tertiary

**Key Messages:**

Preventive diabetology offers a proactive, promotive approach to diabetes care, encouraging early interventions at individual and population levels. A paradigm shift from curative to preventive strategies, supported by healthcare professionals and policymakers alike, is vital to reduce the growing burden of diabetes. Social determinants of health must be integrated into policies and practices to achieve a meaningful, long-term impact.

**Introduction**

Globally, diabetes mellitus (DM) poses a major public health and socioeconomic challenge, driven by demographic shifts and its chronic nature. Currently, 537 million people live with DM, a figure projected to rise to 783 million by 2045. While the global population is expected to increase by 20%, the DM burden will grow by 46%[1].

Aging is a key driver behind the 16% global increase in DM prevalence, with developing countries witnessing sharper rises [1]. Type 2 diabetes mellitus (T2DM) arises from a mix of genetic, environmental, biological, and behavioral factors [2]. DM is linked to high mortality from infections, cardiovascular, cerebrovascular, renal complications, and cancer [3]. The economic burden is expected to reach USD 2.1 trillion by 2030, rising from 1.8% of global GDP in 2015 to 2.2%, outpacing GDP growth, highlighting the urgency for preventive, rather than curative, strategies [4].

An online Google Scholar search from 2017–2025 showed 17,200 results for “prevention of diabetes” versus 57,200 for “treatment of diabetes,” indicating a research bias toward treatment. (Search date: Jan 23, 2025, 01:14 p.m.) While literature exists on preventing prediabetes progression, the global impact of these prevention efforts remains modest [5–9].

Yet, prevention programs have yielded promising results. The US Diabetes Prevention Program reported a 58% reduction in incidence via intensive lifestyle changes. Many programs focus on weight loss of  $\geq 5\%$ , which correlates with reduced T2DM risk. The Prediabetes Informed Decision and Education study showed that participation improves patient activation. Digital programs have enhanced engagement and weight loss outcomes. The long-term impact of lifestyle changes was further validated in the Diabetes Prevention Program Outcomes Study. Collectively, these findings emphasize the effectiveness of prevention programs in reducing risk, encouraging weight loss, and improving patient involvement, supporting broader adoption in healthcare systems [10].

Despite current approaches being essential for diabetes management, they remain reactive. The authors argue for a shift

to a proactive, preemptive model. Comprehensive care requires integrating primordial, primary, secondary, and tertiary levels of prevention, and, in today’s context, quaternary and quinary prevention as well. With DM prevalence rapidly rising, this is a crucial period to adopt a preventive, promotive, and proactive care model.

Inspired by preventive cardiology principles, which tailor risk-reduction strategies to individual risk levels, the authors propose a new model: preventive diabetology [11]. This concept emphasizes prevention at all disease stages, normal glycemia, prediabetes, diabetes without complications, and diabetes with complications, across all levels of prevention. It promotes the belief that “prevention is treatment.”

Hence, the authors propose a refined definition as “a preemptive and proactive approach to prevent diabetes or its complications according to the different stages of an individual’s diabetic condition.” This approach integrates scientifically backed preventive strategies across healthcare levels and providers. This paper focuses on T2DM and advocates a paradigm shift, from reactive and curative care to one that is proactive and preventive.

**The current philosophy of diabetes care**

As per the 2023 standard of medical care in diabetes and the consensus from the European Association for the Study of Diabetes and the American Diabetes Association, T2DM management is person-centric with 13 core principles, which are as follows: [12-14]

- The language used in diabetes care should be neutral and fact-based, free of stigma, and focus on strengths (highlighting what is working). It should foster respect, inclusivity, and collaboration, and focus on the individual’s needs.
- Must involve shared decision-making.
- Must consider local healthcare settings and resources.
- Surveillance and monitoring for complications are essential to identify potential complications and prevent morbidity and mortality.
- Health behavior modification: Encouraging healthy behaviors is key to the comprehensive management of T2DM. Its integration must be considered at diagnosis and through the disease course. Health behaviors must be examined and considered when glycemic goals are not reached, and also when new treatments or procedures, such as metabolic surgery, are introduced.
- Monitoring and ongoing reviews are integral for quality-of-life enhancement in individuals with DM.
- Reducing hypoglycemia risk: HbA1c levels should be reduced safely, without posing substantial hypoglycemia risk or other harmful side effects

- **Effective practice and organization of care:** Each tier of the healthcare system has a part to play and a duty to improve DM management. The structure of care should be implemented at every level, ranging from national policies to local practices.
- **Must consider the underlying physiology of T2DM.**
- **Therapeutic inertia prevention:** Therapeutic (or clinical) inertia refers to the failure to escalate treatment when desired targets or objectives are not achieved. It also includes failure to reduce treatment intensity when individuals are overtreated. Reassessments and achievement of individual glycemic targets regularly are crucial in T2DM management.
- **Social determinants of health:** Studies indicate that factors such as income level, community surroundings, living conditions, access to nutritious food, healthcare services, and social circumstances are connected to outcomes related to T2DM. Disparities in living, employment, and environmental circumstances directly impact the biological and behavioral results linked to preventing and controlling diabetes [15].
- **Psychosocial:** Psychosocial support must be provided in collaboration with patient-centered therapy to enhance health outcomes and quality of life [16].
- **Structured education and support for diabetes:** Structured education and support should be provided as an ongoing process. Key junctures are during diagnosis, yearly, with a rise in complications, and with a change in life circumstances or care schedule.
- **Emphasis on weight loss:** Weight loss should be given equal importance, similar to glycemic control, cardiovascular disease, heart failure, and renal disease [17].

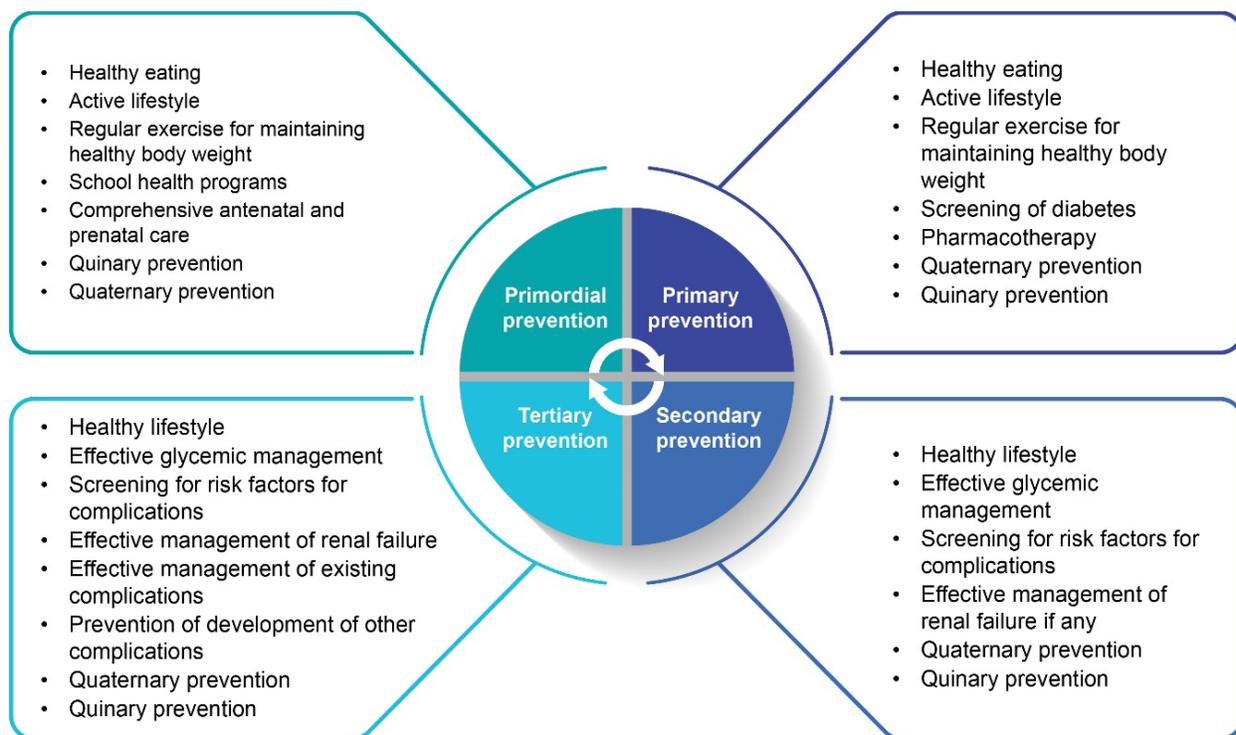
As per updated ADA guidelines, [12] diabetes care extends beyond glycemic control to address comorbidities like cardiovascular, kidney, and mental health conditions. Lifestyle interventions, including weight management, physical activity, and healthy eating, are essential and supported by technology. Poor sleep hygiene often coexists with T2DM, worsening HbA1c and quality of life; early diagnosis and regular sleep patterns are important [18]. Medication guidance includes insulin, oral agents, and GLP-1 receptor agonists for cardiorenal protection. Patient education in self-management and a multidisciplinary team approach are key to comprehensive care [12].

### **Preventive diabetology—A proactive approach to care**

The upstream–downstream model is a well-known analogy in preventive health [19]. Downstream efforts focus on managing disease and complications, while upstream approaches emphasize prevention. Though traditionally applied at the population level, this framework is equally relevant to individual patient care. Current diabetes strategies largely remain downstream, treating symptoms and complications. An upstream shift would require physicians to embed prevention across all levels of care: primordial, primary, secondary, and tertiary. This shift is practical and impactful, as individual efforts by healthcare providers can lead to broader, healthier patient populations. Adopting this mindset could meaningfully reduce the diabetes burden both locally and globally.

### **Concept of preventive diabetology**

The concept of preventive diabetology revolves around a combination of primordial, primary, secondary, and tertiary prevention in a proactive approach toward managing the disease (Figure 1).



**Figure 1:** Concept of preventive diabetology

## Levels of prevention

### Primordial prevention

This level focuses on preventing the development of disease risk factors within a population [20]. In diabetes care, this refers to a population with normal glycemia and no existing risk factors. To achieve this, populations must be encouraged to practice healthy eating and active lifestyles right from early childhood. A study in 2021 found that 16.7% of all live births were associated with some form of hyperglycemia during pregnancy [1]. Pregnancy should be considered an opportune moment for the primordial prevention of diabetes. A focus on preventing gestational diabetes is a key strategy to achieve this [21]. At every level of prevention, the inclusion of quinary and quaternary prevention is critical for a holistic preventive strategy.

a) **Quinary prevention:** This aims at preventing misinformation related to a disease or condition (e.g., bitter melon and coriander juice cures diabetes, repeated testing for diabetes causes diabetes, oral antidiabetes drugs are harmful and can cause multiorgan damage). Healthcare professionals should be aware of advancements in diabetes treatment technologies and the latest diabetes-associated research evidence. They should disseminate information that is scientifically true to promote self-care and prevent diabetes in populations [22]. This is very relevant in

the current scenario, where the dissemination of information is rampant with the widespread use of social media.

b) **Quaternary prevention:** This is defined as the “action taken to identify patients at risk of overmedication, to protect them from unnecessary medical interventions, and to suggest interventions which are ethically acceptable [23]” This will help in preventing unnecessary screenings, overdiagnoses, and avoidable treatments, which is particularly important in pregnant women [24].

### The prevention strategies comprise:

**1. School health programs:** Effective diabetes care in schools relies on comprehensive training, emphasizing education for nurses, nonmedical personnel, and teachers. Enhancing the experiences of staff involved in diabetes care is crucial, and it is equally important to maintain frequent communication among healthcare providers, school staff, and parents, especially during emergencies. Encouraging parent engagement and allocating sufficient resources will ensure consistent care while fostering a supportive school environment with relevant policies that prevent discrimination and uphold students’ well-being [25].

**2. Body weight:** Reaching and maintaining a healthy body weight helps enhance insulin sensitivity, control blood glucose levels, and improve overall metabolic health. Furthermore, weight loss can reduce reliance on diabetes medications and, in certain instances, lead to the remission of the condition [26].

### 3. Comprehensive antenatal and prenatal care:

Gestational DM can be detected when the 2-hour postprandial glucose level is >140 mg/dL. The risk of gestational DM can be identified by early screening and blood tests in the first trimester to allow for lifestyle changes [27]. Preconception education must involve educating the mothers regarding healthy nutritional choices, including body weight management, supplementation, and dietary regulations. Lifestyle modifications such as regular physical activity in moderation, adequate sleep, and avoiding hyperthermia should be implemented [17].

### 4. Comprehensive child and adolescent care:

The American Academy of Pediatrics technical report recommends that youth with T2DM should practice weight and nutrition management according to the guidelines set by the Academy of Nutrition and Dietetics. Children and adolescents are recommended to participate in a minimum of 1 hour of moderate to intense physical activity daily and limit nonacademic screen usage to less than 2 hours per day [28].

### 5. Comprehensive care for the elderly:

Low physical activity and obesity with aging are linked to diabetes. The sedentary lifestyle further decreases metabolic and physical function, leading to frailty due to relative sarcopenia. Preventive measures in the elderly should include aerobic exercises to reduce body fat and improve cardiovascular health, resistance training to enhance muscle strength and maintain physical function, and improve overall quality of life [29].

Across all stages, a life course approach, commonly referred to as from womb to tomb, might help reduce the global disease burden. A systematic process is required to identify preventative strategies and overcome the disease [30]. As technology use is drastically rising, healthcare professionals must update themselves on current research and raise awareness on all kinds of media to promote good self-management and public health practices [22].

## Primary prevention

Primary prevention focuses on the removal of or avoidance of risk factors for a disease when the disease itself has not occurred. Hence, primary prevention should be considered for patients with normal glycemia and prediabetes [20].

### a) Normal glycemia (fasting plasma glucose <100 mg/dL or HbA1c level <5.7%):

In these individuals, the common risk factors for the development of diabetes include positive family history in an immediate family member, age >45 years, gestational diabetes history, a body mass index (BMI) >25 kg/m<sup>2</sup>, high-risk race or ethnicity, inactivity, history of hypertension and cardiac disease, dyslipidemia, and polycystic ovarian syndrome. Preventive strategies in such individuals should focus on lifestyle modifications, exercise, diet, and weight control. A review of the HbA1c and fasting plasma glucose levels every 2–3 years is also recommended.

### b) Prediabetes (fasting plasma glucose between 100–126 mg/dL or HbA1c level in the range of 5.7%–6.4%):

The major risk factors for prediabetes are positive family history in an immediate family member, age >45 years, gestational diabetes history, BMI >25 kg/m<sup>2</sup>, high-risk race or ethnicity, sedentary lifestyle, inactivity, history of hypertension and cardiac disease, dyslipidemia, and polycystic ovarian syndrome. Preventive strategies at the individual level include (i) repeat testing to confirm fasting plasma glucose or HbA1c levels; (ii) promoting lifestyle changes; and (iii) pharmacological interventions.

Moreover, prediabetes is also considered a conglomeration of multiple diseases. Those with isolated impaired fasting glucose have high chances of conversion to T2DM. They are more resistant to change than those with impaired glucose tolerance (IGT).

Pre-IGT serves as a preliminary indicator of dysmetabolism in T2DM. A study reported endothelial dysfunction among participants with pre-IGT. However, the study failed to report any pronounced variability in the cardiovascular risk factors causing endothelial dysfunction [31]. A cross-sectional study concluded that endothelial dysfunction develops at the early pre-IGT stage.

While a positive correlation was observed between brachial artery flow-mediated dilatation, serum insulin, and blood pressure, the correlations were not significant [32]. In early T2DM, in the absence of cardiovascular disease risk factors, an association between high HbA1c levels, hyperinsulinemia, and endothelial dysfunction was observed in a similar study [33]. Another study reported a 36% prevalence of nonalcoholic fatty liver disease in patients with pre-IGT [34]. A study showed that people with pre-IGT reported substantially higher 2-hour blood glucose and insulin levels, and higher HbA1c compared to the normoinsulinemic patients with normal oral glucose tolerance [35].

Comprehensive lifestyle interventions are effective means to prevent T2DM in individuals at risk in low- and middle-income countries [36–39]. A consensus report on nutritional therapy among those with diabetes and prediabetes recommended that intensive lifestyle modifications focusing on healthy eating habits, moderate physical activity of at least 150 minutes/week, and attaining a 7%–10% reduction in weight can be helpful in staving off progression [40]. The diabetes prevention program study concluded that if lifestyle modifications do not result in improvement in the prediabetic status of an individual, in younger adults, or individuals with a BMI >35 kg/m<sup>2</sup>, metformin can be prescribed [41]. Sheng et al. concluded that lifestyle modification and metformin can reduce the occurrence of diabetes with an average relative risk reduction of 20% [42].

**Exercise:** A meta-analysis of 13 studies on exercise in the form of aerobic exercise training (AET), resistance training, and controlled training among individuals with prediabetes showed that AET

or AET and resistance training improved glycemic control and reduced insulin resistance [46]. Yoga has also been associated with improvements in the levels of fasting and postprandial blood glucose, total cholesterol, low-density lipoprotein, triglycerides, and HbA1c. Furthermore, yoga effectively reduces body weight and hypertension [47].

**Diet:** A healthy diet lowers diabetes incidence. Diets rich in whole grains are inversely correlated with the occurrence of diabetes. However, diets high in red or processed meat and bacon are linked to an increased incidence of diabetes. Sweetened beverages are also linked to an increased incidence of diabetes. Beverages such as coffee, yogurt, tea, and vegetable fats are associated with a decreased occurrence of diabetes [48]. The Mediterranean diet is associated with better glycemic control [49]. A 2019 consensus on nutritional therapy for adults with diabetes or prediabetes recommended that healthcare providers focus on common dietary considerations, such as additional inclusion of nonstarchy foods and reduction in added sugars, refined grains, and processed foods in the diet [40].

**Smoking:** Smoking is associated with an increased incidence of diabetes. Current smokers have a 1.38 times higher risk of developing T2DM than nonsmokers. The risk of developing T2DM increases by 16% for every 10-cigarette increment per day [50].

**Obesity:** Excessive weight is a key contributor to the development of prediabetes and T2DM [51]. GLP-1 receptor agonists such as liraglutide are approved for the treatment of obesity [52]. In the STEP 2 trial, a 2.4 mg, once-a-week dose was administered along with a lifestyle modification intervention. Semaglutide was found to be efficacious in weight management compared to a placebo [53]. However, the STEP 4 trial suggested that the withdrawal of this drug may lead to weight gain [54]. Many newer drugs, such as tirzepatide, cagriSema, and retatrutide, based on incretin and glucagon physiology, have shown promising results for massive weight reduction. Bariatric surgery has also been found to be beneficial in managing diabetes [55].

**Screening for diabetes:** Regular screening for diabetes is recommended every 3 years for individuals aged 40 to 75 years with at least one risk factor, while annual screening is recommended for patients with prediabetes. The diagnostic test should include fasting and 2-hour plasma glucose and HbA1c analyses [56].

**Maintenance of healthy body weight:** Moderate weight loss (5% or more) is beneficial for diabetes prevention, blood pressure reduction, and improved cardiovascular health. Strategies for maintaining a healthy body weight include ongoing support from

health professionals or peers, comprehensive behavioral programs, and the adoption of sustainable healthy behaviors [56].

**Pharmacotherapy for T2DM:** Metformin is considered the first-line pharmacological drug in the management of T2DM because of its established efficacy, safety, and tolerability profile. It is recommended as an initial pharmacological intervention for most individuals with T2DM, particularly for those who are overweight or obese, unless contraindicated or not tolerated. In supplementing the primary metformin approach, acarbose and pioglitazone provide nuanced interventions, addressing specific facets of T2DM. These medications exhibit tailored benefits, contributing to the comprehensive management of metabolic risk factors. Their inclusion reflects the recognition of the diverse nature of T2DM and the need for individualized treatment strategies to optimize outcomes [56].

Recent developments have introduced SGLT2 inhibitors and GLP-1 receptor agonists, showcasing promising roles beyond glycemic control. These newer classes of antidiabetic medications demonstrate potential cardiovascular and renal protective effects, expanding the horizon of T2DM management [56]. The American Association of Clinical Endocrinology Clinical Practice Guidelines emphasize a personalized approach and underscore the importance of considering the specific needs and comorbidities of individuals with T2DM in selecting pharmacological interventions. This evolving landscape reflects a commitment to tailored strategies that go beyond glycemic management, ensuring a holistic approach to diabetes care.

The American Association of Clinical Endocrinologists has stated that pharmacologic interventions may be required to prevent prediabetes from progressing to diabetes if the decline in pancreatic  $\beta$ -cell function is due to factors other than obesity. However, the Food and Drug Administration has not yet approved any drug specifically to prevent T2DM. Metformin and acarbose are known to lower the risk of diabetes development by 25%–30%. In clinical trials, thiazolidinediones effectively protected 60%–75% of patients with prediabetes from progressing to diabetes. However, these should only be considered in patients in whom metformin treatment has been unsuccessful, as thiazolidinediones have stronger adverse effects than metformin [57]. Quinary prevention is critical at this stage, and it is the responsibility of healthcare professionals to provide accurate information to the patients. Similarly, overtreatment should be avoided to ensure no harm to the patient. Hence, at this stage, quinary and quaternary preventions remain critical (Table 1).

Study year	Population	Intervention	Control	Outcome	Conclusion
Da Qing IGT and Diabetes Study Pan XR, et al. 1997 [43]	577 IGT patients	Diet, exercise, diet + exercise	Control group	Cumulative diabetes incidence Control group: 67.6% Diet group: 43.8% Exercise group: 41.1% Diet + exercise group: 46%	Diet and/or exercise interventions led to a significant decrease in the incidence of diabetes.
FDPS Uusitupa M, et al. 2000 [6]	523 obese, IGT patients	Diet and exercise	General information	At 1 year, the intervention group showed significantly greater reductions in 2-hour glucose and fasting glucose levels, systolic and diastolic blood pressure, and serum triglycerides. Weight reduction was -4.6 kg in the intervention group.	Demonstrated the efficacy and feasibility of lifestyle interventions in patients with IGT
DPP trial DPP research group 2002 [7]	3234 nondiabetic individuals with elevated fasting and post-load plasma glucose concentrations	Metformin (850 mg twice daily) or a lifestyle-modification program with the goals of at least 7% weight loss and at least 150 minutes of physical activity per week	Placebo	Lifestyle interventions reduced the incidence of diabetes by 58% and metformin intervention reduced diabetes incidence by 31% percent.	Both lifestyle changes and treatment with metformin reduced the incidence of diabetes in individuals at high risk. The lifestyle intervention was more effective than metformin in reducing the incidence of diabetes.
STOP_NIDDM Chaisson JL 2002 [8]	1492 IGT patients	Acarbose (100 mg) 3 times daily	Placebo 3 times daily	Acarbose reversed impaired glucose tolerance to normal glucose tolerance (p<0.0001).	Acarbose can be used either as an alternative to or in addition to changes in lifestyle to delay the development of T2DM in patients with impaired glucose tolerance.
XENDOS Torgerson JS 2004 [44]	3305 patients BMI >30 kg/m <sup>2</sup> , IGT or normal glucose tolerance	Lifestyle modification + orlistat (120 mg)	Lifestyle modification + placebo	Risk of incidence of diabetes reduced by 37.3% in the orlistat group.	Orlistat plus lifestyle changes resulted in a greater reduction in the incidence of T2DM over 4 years.
IDPP-1, Ramachandran A, et al. 2006[45]	531 IGT patients	Lifestyle modification (LSM), Metformin (MET), LSM+MET	Control	LSM alone reduced the relative risk of diabetes development by 28.5% (95% CI: 20.5–37.3, p<0.018), MET reduced the risk by 26.4% (95% CI: 19.1–35.1, p<0.029), and LSM+MET reduced the risk by 28.2% (95% CI: 20.3–37.0, p<0.022).	Both LSM and MET significantly reduced the incidence of diabetes in Asian Indians with IGT; there was no added benefit from combining them.

EDIPS- Newcastle, Penn L 2009 [9]	102 IGT patients	The intervention included individual motivational interviewing aimed at weight reduction; increase in physical activity, fiber, and carbohydrate intake; and reduction of fat intake (secondary outcomes).	Control group	The overall incidence of diabetes was reduced by 55% in the intervention group (95% CI: 0.2–1.2)	T2DM can be prevented by lifestyle changes in adults with IGT.
CI: Confidence interval; BMI: Body mass index; DPP: Diabetes prevention program; EDIPS: The European Diabetes Prevention Study; FDPS: Finnish Diabetes Prevention Study; IDPP: Indian Diabetes Prevention Program; IGT: Impaired glucose tolerance; mg: Milligram; p: p-value; STOP_NIDDM: Study to Prevent Non-Insulin Dependent Diabetes Mellitus; T2DM: Type 2 diabetes mellitus; XENDOS: XENical in the prevention of diabetes in obese subjects.					

**Table 1:** Landmark trials on primary prevention among individuals at risk of developing T2DM.

### Secondary prevention—Diabetes without complications

The focus of secondary prevention is early detection and prompt treatment of the disease. Secondary prevention as a multifactorial and intensive approach can alter the prognosis of a condition and is critical in patients diagnosed with diabetes. The main approaches to secondary prevention are remission of T2DM through diet, individualized pharmacotherapy, and targeted screening.

#### Diabetes remission through diet

T2DM remission has been defined as “a healthy clinical state characterized by the achievement of HBA1c levels below the targeted level that are maintained for at least 6 months, with or without the continued use of lifestyle modifications and/or metformin, provided that this is not due to complications, comorbid conditions, or concomitant therapy [58].” A study on remission concluded that among patients with T2DM, fasting plasma glucose normalized within 7 days after following a low-calorie diet [59]. The study also emphasized that this shift happened even after discontinuing metformin treatment and that within 8 weeks, glucose-stimulated insulin release returned to baseline levels. More recently, Taheri et al. (2020) reported that 60% and 33% of people with diabetes for <3 years could achieve remission and normoglycemia on a low-calorie formula diet, respectively. The study highlighted that a critical requirement for achieving these results was to ensure a minimum gap between the energy required and the calories consumed. The body utilizes stored energy when there is a deficit in the calories consumed. It is now understood that the removal of excess fat from the liver and pancreas can normalize hepatic insulin responsiveness, and in patients with

early diagnosis,  $\beta$ -cell function can improve [59-61].

Similarly, the DiRECT trial validated these findings by reporting that 46% of their primary care group remained diabetes-free for 1 year in the course of a planned, low-calorie weight reduction program [62]. A systematic review and meta-analysis of hypocaloric diets in people with T2DM reported that very-low-calorie diets or formula replacement meals were most effective in facilitating weight loss, whereas Mediterranean, high-protein, vegetarian, low-glycemic index, and high-monounsaturated fatty acid diets achieved minimal change [63].

#### Individualizing pharmacotherapy

An essential part of T2DM management is individualized pharmacotherapy, and various approaches have been discussed in the literature. Metformin has been used as an efficacious and safe first-line therapy for managing T2DM. However, its impact on cardiovascular outcomes remains limited. Hence, the continued use of metformin as a first-line therapy for managing diabetes is debated [64].

The UKPDS trial suggested that using sulfonylureas or insulin over 20 years could result in intensive glucose control, which in turn could lower overall mortality, diabetes-related deaths, and myocardial infarctions [65]. The VERIFY trial focused on early intervention with combination therapy (vildagliptin and metformin) and concluded that the combination provided greater long-term benefits than the current standard of care, which uses metformin monotherapy for those newly diagnosed with T2DM [66]. Another approach to managing diabetes addresses the pathophysiological

role of progressive  $\beta$ -cell deterioration in T2DM and the inability of current antidiabetic drugs to prevent this deterioration. Short-term intensive insulin therapy could modify diabetes progression by improving  $\beta$ -cell function and leading to long-term glycemic remission; such results have been observed following intensive insulin therapy [67,68].

Holman et al. (2008) found that individuals who received intensive insulin therapy experienced fewer vascular complications and negative clinical outcomes over time than those who received standard treatment, even though both groups had similar HbA1c levels in long-term follow-ups. These findings support the idea that establishing early and intensive metabolic control over glycemic levels can have enduring beneficial effects in managing T2DM; the authors termed this a “legacy effect [69].” These observations are consistent with the concept that the early glycemic environment is remembered by the body. The authors of the Diabetes Control and Complications Trial named this concept “metabolic memory [70].” A study also examined hypertensive patients with T2DM and segregated them into “tight” or “less tight” blood pressure control groups to assess the benefits of lowering blood pressure in managing diabetes; it reported that the use of an angiotensin-converting enzyme (ACE) inhibitor (captopril) or  $\beta$ -blocker (atenolol) affected diabetes management positively [71]. ACE inhibitors and angiotensin receptor blockers both have a comparable and notable effect in reducing the incidence of T2DM in patients with elevated blood pressure, coronary disease, and heart failure. While this does not seem to influence the incidence of cardiovascular, cerebrovascular, or mortality outcomes in the immediate future, extended benefits may arise from the prevention of new-onset diabetes [72].

In high-risk individuals with diabetes, newer drugs such as sodium-glucose cotransporter 2 inhibitors and GLP-1 receptor agonists have shown beneficial effects when used individually. These benefits include the prevention of cardiovascular events, better glycemic control, weight loss, and reduced adverse kidney-related outcomes. This has been proven in several studies [73,74].

The Steno-2 study demonstrated that a multifactorial approach with statins, renin-angiotensin inhibition, aspirin, and strict glucose control substantially lowered the risk of cardiovascular deaths, T2DM, and microalbuminuria [75]. The study also demonstrated that early implementation of statin treatment led to risk reduction. Hence, preventive approaches involving statin treatment as a component of a comprehensive strategy are a cornerstone of modern treatment for diabetes patients [75].

Contrary to these results, some concerns exist about elevations in blood glucose levels caused by statins. It is now known that there is no evidence to support this claim, and it is hypothesized that statin therapy may only reveal diabetes in individuals who are

already at risk for the condition. The enhanced survival benefits of statin treatment may allow individuals at risk of diabetes to live long enough for the disease to be identified, while those not on statins may succumb before developing or being diagnosed with diabetes [76].

Besides pharmacotherapeutic support, clinicians must offer patients certain co-manuevers for effective care. Discussing blood pressure levels and changes in treatment plans when blood pressure goals are not met are critical physician–patient interactions. Setting goals and creating action plans demand dedication and commitment (from the physician and the patient), but the long-term benefits are improved quality of patient care and satisfaction [77].

### **Targeted screening**

Screening is an integral component of the secondary level of diabetes prevention; however, the focus should be on screening aptly rather than on screening every individual or screening for every indication. The frequency and extent of screening should be considered [78]. Quaternary and quinary prevention methods must also be practiced at this stage.

### **Tertiary prevention—Diabetes with microvascular and macrovascular complications**

The focus of tertiary prevention is to limit disability and rehabilitate patients affected by disease. In T2DM, the main focus of tertiary prevention is to prevent microvascular and macrovascular complications with associated risk factors such as smoking, obesity, physical inactivity, poor glycemic control, hypertension, and high cholesterol levels.

### **Preventive strategies**

Compared to conventional therapy, intensive therapy for T2DM led to a 25% decrease in adverse microvascular outcomes. Furthermore, macrovascular outcomes in terms of diabetes-related deaths and all-cause mortality showed a reduction of 10% and 6%, respectively, thus emphasizing the role of intensive therapy in the prevention of microvascular and macrovascular complications [71].

Furthermore, studies have reported an association of strict blood glucose control with a decrease in microvascular complications related to photocoagulation, incidence or progression of macular edema, diabetic retinopathy progression, and risk of macroalbuminuria, microalbuminuria, or proteinuria [79,80]. However, data on the role of improved glycemic control in T2DM and its impact on decreased macrovascular disease events are limited [81].

Preventive approaches for severe complications such as diabetic ulcers should include health education directed at healthcare

professionals to raise awareness among patients and caregivers. Foot care, appropriate footwear use, and annual foot screenings for patients with diabetes play an important role in the prevention of complications [82]. Additionally, other measures such as a focus on nutrition, physical activity, cessation of tobacco usage, and pharmacotherapy with ACE inhibitors and statins should be prescribed [80].

### The economic dimension

Globally, diabetes-related healthcare expenditures are significant, with an estimated USD 966 billion spent on diabetes care in 2021, a figure projected to rise to USD 1,054 billion by 2045 [83]. In developing countries, a large share of both direct and indirect diabetes-related costs is borne out-of-pocket, often leading to considerable financial hardship for affected individuals [84]. These economic realities reinforce the importance of preventive diabetology as a public health and policy priority.

A systematic review evaluating the cost-effectiveness of preventive interventions found that primary prevention, such as lifestyle interventions for at-risk individuals, was approximately USD 5,000 less expensive than standard care. Secondary prevention strategies, like targeted screening for individuals aged >55 years, cost USD 34,375 per quality-adjusted life year (QALY), making them considerably more cost-effective than universal screening approaches. Education-based interventions reduced diabetes-related medical costs by 2,583 Swedish francs, while diet and exercise, when added to standard care, yielded cost savings of USD 16,000 per QALY. Pharmacologic interventions, particularly when combined with hypocaloric diets or as part of combination therapies, also demonstrated favorable cost-effectiveness.

Notably, the review underscored the high burden of macrovascular complications in diabetes and strongly advocated for global investment in preventive measures to offset future clinical and economic consequences [85]. Therefore, T2DM should be addressed from a prevention-first perspective at every stage to meaningfully reduce its health, social, and economic toll, particularly in resource-constrained settings.

### Conclusion

Despite substantial advancements in diabetes management practices, its incidence continues to rise relentlessly. A shift in the attitudes of healthcare professionals towards prioritizing preventative management over a predominantly curative approach is crucial for effectively addressing this growing health challenge. The upstream endeavor in diabetes care can begin at an individual level when preventive diabetology is practiced as an approach to managing diabetes. This proactive approach promises a consistent, preventive, and promotive outlook to providing care to patients at various stages of living with diabetes. Translating this philosophy

into daily clinical practice is crucial for a paradigm shift in how diabetes is handled, and therefore managing the burden of diabetes.

However, the larger picture in diabetes care should also involve policy development and be based on individual and population-level strategies. The role of policymakers, key stakeholders, and governments in this endeavor is enormous. Therefore, the strong interplay of social determinants of health in diabetes care cannot be ignored.

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