Medical Nutrition Therapy for the Treatment of Diabetes: Prioritizing Recommendations Based on Evidence

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Roeland J. W. Middelbeek, Samar Hafida, and Cara Schrager

Keywords

Type 1 diabetes · Type 2 diabetes · Nutrition therapy · Glycemic index

Key Points

- Medical nutrition therapy is recognized as an essential component of diabetes self-management and education, which are crucial to the comprehensive care of people with diabetes [1].
- Medical nutrition therapy plans should be individualized, flexible, and involve principles of shared decision-making between persons with diabetes and their healthcare teams.
- Medical nutrition therapy involves delivering tools and support for adopting and maintaining healthy eating patterns focused on goal-specific outcomes with attention to promoting sustained behavioral changes over time.
- Medical nutrition therapy has been shown to be an effective method to manage weight loss, diabetes, high blood pressure, and high cholesterol levels [2, 3].

Introduction

The incidence and prevalence of diabetes has skyrocketed in the past decades, posing a significant threat to communities worldwide, with nearly half a billion people currently living with diabetes [4]. The International Diabetes Federation estimates that the prevalence will reach staggering numbers by 2045, affecting 700 million individuals globally. In the United States, the estimated prevalence of diabetes is 10.5%, affecting over 34 million people, with 7.3 million who are unaware of their diagnosis [5]. Diabetes care is complex and requires an approach that spans multiple disciplines and involves a myriad of professional services. Medical nutrition therapy is a fundamental pillar in the treatment of people with diabetes, and has the potential to prevent progression and alleviate its burden.

R. J. W. Middelbeek (✉) · S. Hafida
Joslin Diabetes Center, Boston, MA, USA

Harvard Medical School, Boston, MA, USA
e-mail: roeland.middelbeek@joslin.harvard.edu

C. Schrager
Joslin Diabetes Center, Boston, MA, USA

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Medical Nutrition Therapy (MNT) for Diabetes

Definition of MNT

The Academy of Nutrition and Dietetics defines MNT as a "specific application of the nutrition care process in clinical settings that is focused on the management of diseases," a definition distinct from nutrition counseling which is the process of supporting individuals to establish unique goals based on their priorities, in order to foster a routine of self-care, centered around healthful eating [3]. The legal definition of MNT is the evidence-based application of nutrition care delivered by registered dietitian nutritionists (RDN), where a face-to-face assessment of an intervention is conducted in accordance with nationally accepted protocols. In order to fulfill the components of MNT, an assessment, nutrition-based diagnosis, intervention, and plan for monitoring must be conducted (Fig. 10.1).

Goals of MNT

The American Diabetes Association (ADA) outlines four main goals of MNT (Table 10.1). These include encouraging healthful eating, personalizing nutrition needs, providing evidence-based food-related messaging, and offering practical tools to help with meal planning.

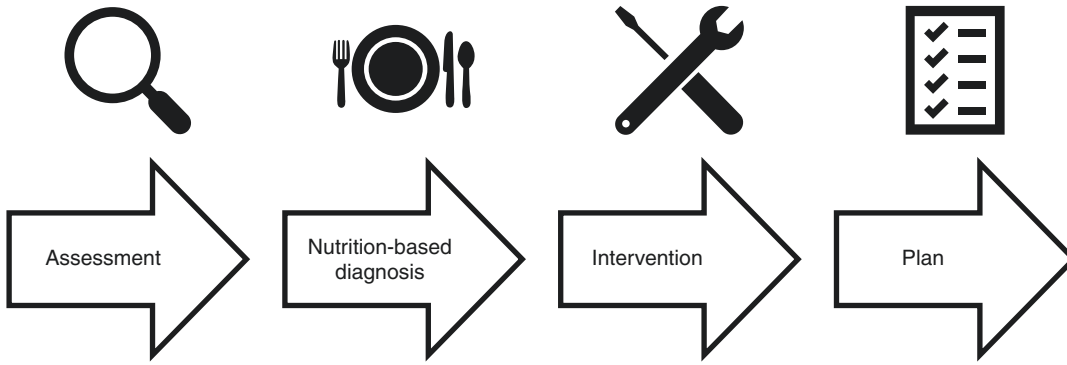

Fig. 10.1 Process of medical nutrition therapy

Table 10.1 Goals of MNT

Encourage healthful eating	**Personalize nutrition needs**
Adopt appropriate portions Choose foods dense in nutrients Achieve and maintain goals related to: Body weight A1C[a] Blood pressure Cholesterol Prevention of diabetes complications	To support personal and cultural food preferences Consider barriers to food access Assess readiness to embrace change
Provide evidence-based food-related messaging	**Offer practical tools**
To maintain the pleasure of eating Promote healthy relationship with food	To help with daily planning of meals

[a]*A1C* glycated hemoglobin

Adapted from Evert AB, Dennison M, Gardner CD, Garvey WT, Lau KHK, MacLeod J et al. Nutrition Therapy for Adults With Diabetes or Prediabetes: A Consensus Report. Diabetes Care. 2019;42:731–754 [6]

Table 10.2 Domains where MNT is effective in the management of diabetes

Glycemic control			**Cardiovascular risk factor mitigation**				
↓ A1C		↓ FPG mg/dL	↓ Total Chol Mg/dL	↓ LDL Mg/dL	↑ HDL Mg/dL	↓ TG Mg/dL	↓ SBP/DBP mmHg
T2DM	0.3–2%	18–61	8–28	8–22	2.4–6	15–153	3.2–9/2.5–5.3
T1DM	1–1.9%						
Medication use			**Weight management**				
↓ Total daily dose of insulin, medication dosages, and number of medications taken for diabetes management			↓ Weight (kg)	↓ BMI kg/m^2	↓ Waist circumference (cm)		
			2.4–6.2	0.3–2.1	1.0–5.5		

↓, reduction; ↑, increase; *A1C* glycated hemoglobin; *FPG* fasting plasma glucose; *T2D* type 2 diabetes; *T1D* type 1 diabetes; *Total Chol* total cholesterol; *LDL* low-density lipoprotein; *HDL* high-density lipoprotein; *TG* triglycerides; *SBP* systolic blood pressure; *DBP* diastolic blood pressure; *BMI* body mass index

Effectiveness of MNT in the Management of Diabetes

The Academy of Nutrition and Dietetics published evidence-based guidelines endorsed by the ADA for the management of adults with type 1 and type 2 diabetes [2, 3]. The review of the literature identified 30 diabetes-targeted nutrition practice guidelines, which demonstrated effectiveness in the following domains: glycemic control, cardiovascular risk factor mitigation, medication use, weight management, diabetes prevention, and quality of life (Table 10.2).

MNT and Glycemic Control

Intervention studies involving MNT delivered by RDNs in a series of encounters to subjects with type 2 diabetes have shown significant improvements in hemoglobin A1c (a marker of glucose control over a 3-month period), with change in A1c from −0.3% to −2% [7–9]. A1c reductions were more pronounced in those who were newly diagnosed with type 2 diabetes, and with higher baseline A1c of >8%. Similar A1c reductions were also seen in people with type 1 diabetes, who received MNT using carbohydrate counting to calculate mealtime insulin doses, resulting in A1C reductions of −1% to −1.9%. MNT intervention was delivered by a series of visits conducted by RDNs over a period of 6 months [10, 11]. In addition to hemoglobin A1C improvement, fasting blood glucose levels also showed improvements ranging between 18 and 61 mg/dL with regularly delivered MNT sessions in people with type 1 as well as type 2 diabetes [3, 10].

Cardiovascular Risk Factor Mitigation

Several studies assessing total cholesterol, low-density lipoprotein (LDL), high-density lipoprotein (HDL), and triglyceride (TG) levels in adults with type 2 diabetes who received MNT reported mixed effects at the end of the study period. This was likely due to the prevalence of lipid-lowering agents already used by the participants during the study period. However, a number of other studies did result in improvements in LDL cholesterol, HDL, and TG levels [6]. For blood pressure control, mixed results were also reported in several randomized controlled studies and cohort studies of adults with type 1 and 2 diabetes where MNT was a component of the intervention. Some studies showed no change in blood pressure levels, and six studies demonstrated a significant lowering of systolic and

diastolic blood pressure. It is worth noting that 50–70% of the subjects were taking medications to lower blood pressure, and most had near-normal levels at the time of study entry [3, 8, 12].

Medication Use

MNT delivered by RDNs in regular intervals was associated with significant decreases in doses and number of medications required to improve glucose in people with type 2 diabetes. The favorable effect of MNT persisted for 2 years in the United Kingdom Prospective Diabetes Study (UKPDS), after which participants required escalation of therapy due to the natural progression of type 2 diabetes. MNT in the form of carbohydrate counting resulted in the improvement of A1C in adults with type 1 diabetes, without an increase in the total daily dose of insulin. Furthermore, MNT alleviated or prevented weight gain associated with initiation of basal insulin in people with type 2 diabetes [13] and insulin pump therapy in people with type 1 diabetes [14].

Weight Management

Intervention with MNT in several studies involving both participants with type 1 and type 2 diabetes demonstrated mixed results with regard to changes in body weight, body mass index (BMI), and waist circumference. Some outcomes showed no change, while others reported 2.4 to 6.2 kg weight loss and decrease in waist circumference by 1 cm to 5.5 cm [3, 14].

Diabetes Prevention

Reducing the risk for type 2 diabetes involves maintaining a healthy weight, as overweight and obesity are key risk factors for the development of type 2 diabetes. Cereal fiber and magnesium, both components of whole grains, and fruit and green leafy vegetable intake are consistently associated with lower risk of developing type 2 diabetes [15–17] with a possible protective role for low-fat dairy foods [18]. Remaining physically active is important as sedentary time is associated with an increased risk of developing type 2 diabetes [19]. A number of risk factors, both non-modifiable (genetics and aging) and modifiable (central obesity, sedentary lifestyle, and diet), have been identified as contributing to insulin resistance, a common factor in the development of diabetes and cardiovascular disease. Large clinical trials have demonstrated the role of nutrition therapy, leading to modest weight loss, combined with increased physical activity in the prevention or delay of type 2 diabetes. Examples of larger and well-designed trials include the Finnish Diabetes Prevention Study [20] and the Diabetes Prevention Program (DPP) [21].

Quality of Life

In a total of six studies where MNT was incorporated, adults with both type 1 and type 2 diabetes reported an improved quality of life. These studies included a number of RDN encounters followed by long-term follow-up with RDN visits. The improvements in the quality of life included self-perception of health status, knowledge and motivation, treatment satisfaction, and psychological well-being [3].

Recommendations for MNT Referrals and Encounters

Who Should Be Referred?

MNT is effective in improving medical outcomes and the quality of life and is cost-effective [22, 23]. Anyone who is newly diagnosed with prediabetes and/or diabetes should be referred to a RDN for MNT. Anyone with comorbidities, such as overweight or obesity, a history of disordered eating, hypertension, hyperlipidemia, and diabetic nephropathy, should also be referred to a RDN for MNT. There are four critical times in which a person with diabetes should be referred to a RDN for nutrition: (1) at diagnosis, (2) annually, (3) when a new diabetes complication occurs, or (4) when a transition in care occurs [1].

Frequency of Encounters

It is recommended there be a series of three to four encounters with an RDN, lasting from 45 to 90 minutes, starting at diagnosis of diabetes. The referral should be completed within 3 to 6 months after a diagnosis of diabetes. Follow-up appointments are recommended at least annually for ongoing monitoring and evaluation [22].

Assessment During Encounters

The RDN will assess usual food intake, the level of physical activity, current medications, current laboratory values, and anthropometric measurements, in addition to glycemic control. The goal of nutrition therapy is to promote healthy eating patterns that emphasize a variety of nutrient-dense foods and appropriate portion sizes rather than the individual micro−/macronutrients or single foods. Teaching individuals how to make appropriate food choices (including by means of carbohydrate counting) and using data from glucose monitoring to evaluate short-term effectiveness are important components of successful MNT for type 2 diabetes.

The plate method is a general guideline for healthy food distribution and emphasizes healthy portions and food choices. Persons with diabetes can benefit from basic information about carbohydrates – what foods contain carbohydrates and how many servings to select for meals (and snacks if desired). They should learn what types of carbohydrate foods have the biggest impact on glucose levels. The carbohydrate list is composed of starches, fruits, milk, and sweets; one serving or carbohydrate exchange is the amount of food that contains 15 g of carbohydrate. During the initial assessment, the RDN will guide the person with diabetes in choosing the appropriate amounts of carbohydrate servings per meal and snack. In addition, the RDN will help clarify how other macronutrients (proteins and fats) play a role in health and diabetes management.

Follow-Up

Successful self-management of diabetes is an ongoing process of problem-solving, adjustment, and support. Individuals must be able to anticipate and cope with the wide variety of decisions they face on a daily basis. Support from family and friends is important, in addition to continuing education and support from professionals. Structured programs with consistent follow-up contact assist individuals to achieve lifestyle goals and to maintain what are often challenging lifestyle changes. Technology is a helpful tool for education and diabetes management. Some apps provide data logging functions and

food databases. These help validate the successful achievement of someone's nutrition and physical activity goals. There are hundreds of mobile apps available for download, some free and some requiring a small fee.

MNT Intervention

Macronutrients

Carbohydrate

Carbohydrates are addressed first as it is the balance between carbohydrate intake and available insulin in the body that determines the postprandial glucose response and because carbohydrate is the major determinant of mealtime insulin doses. Foods containing carbohydrates – grains, fruits, vegetables, legumes, milk, and yogurt – are important components of a healthy diet and should be included in the food/meal plan of persons with diabetes. A number of studies have reported that when subjects are allowed to choose from a variety of starches and sugars, the glycemic response is similar, as long as the total amount of carbohydrate is the same. Consistency in carbohydrate intake is also associated with good glycemic control [6].

Research does not support any ideal percentage of energy from macronutrients for persons with diabetes [6], and it is unlikely that one such combination of macronutrients exists [3]. Macronutrient intake should be based on the Dietary Reference Intakes (DRI) for healthy adults. It is important to tailor carbohydrate recommendations based on the person's individual needs, preferences, and impact on glucose levels.

The ideal amount of carbohydrates recommended for healthy adults to maintain well-being is unknown. This also applies to people with diabetes, where the quality of carbohydrates outweighs the significance of how many are consumed. High-quality carbohydrates include those dense in fiber, vitamins, and minerals. Processed carbohydrates should ideally be low in sodium and added sugars.

Although different carbohydrates produce different glycemic responses (GI), there is limited evidence to show long-term glycemic benefit when low-GI diets versus high-GI diets are implemented. The benefits of a low-GI diet are complicated by differing definitions of "high-GI" or "low-GI" foods or diets. Systemic reviews related to glycemic index in people with diabetes have shown no effect of HbA1c and limited effects on fasting glucose [6].

Protein

There is no evidence to suggest that usual intake of protein (15–20% of energy intake) be changed in people who do not have renal disease [6, 22]. Although protein has an acute effect on insulin secretion, usual protein intake in long-term studies has minimal effects on glucose, lipids, and insulin concentrations.

Protein is probably the most misunderstood nutrient with inaccurate advice frequently given to persons with diabetes. Although people with diabetes are often told that 50–60% of protein becomes glucose and enters the bloodstream 3–4 h after it is eaten, research documents the inaccuracy of this statement. Although nonessential amino acids undergo gluconeogenesis in subjects with controlled diabetes, the glucose produced does not enter the general circulation [24]. If differing amounts of protein are added to meals or snacks, the peak glucose response may be affected by the addition of protein, as there may be delayed glycemic excursions [25]. However, including protein with meals and snacks can help the individual feel more satiated, thereby potentially eating less overall. Protein intake may increase the insulin response to carbohydrates, and thus carbohydrate sources with high-protein content (i.e., nuts or milk) are generally not recommended to treat hypoglycemia [6, 25].

Dietary Fat

Cardioprotective nutrition interventions recommended by the "Standards of Medical Care in Diabetes" for people with diabetes include reduction in saturated and trans fatty acids, as well as increase in plant sterols/stanols and *n*-3 fatty acids [24, 25]. It is still important to be aware that foods high in cholesterol tend to have a higher saturated fat content [26].

Nutrition goals for persons with diabetes are the same as for persons with preexisting cardiovascular disease. Thus, saturated fats <7% of total energy, minimal intake of trans fatty acids, and cholesterol intake <200 mg/day are recommended [3]. Two or more servings of fish (with the exception of commercially fried fish fillets) are recommended. In persons with type 2 diabetes, an intake of ~2 g/day of plant sterols and stanols has been shown to lower total and LDL cholesterol. If products containing plant sterols are used, they should displace, rather than be added to the diet, to avoid weight gain.

Micronutrients

There is no evidence of benefit from vitamin or mineral supplementation in persons with diabetes who do not have underlying deficiencies [3, 6]. It is recommended that health professionals focus on nutrition counseling for acquiring daily vitamin and mineral requirements from natural foods and a balanced diet rather than micronutrient supplementation. Research including long-term trials is needed to assess the safety and potentially beneficial role of chromium, magnesium, and antioxidant supplements and other complementary therapies in the management of diabetes. In select groups such as the elderly, pregnant or lactating women, strict vegetarians, or those on calorie-restricted diets, a multivitamin supplement may be needed. Routine supplementation with antioxidants, such as vitamins E and C and carotene, has not proven beneficial and is not advised because of concerns related to long-term safety [6].

Other Nutritional Considerations

Nonnutritive Sweeteners

Nonnutritive sweeteners can be used as an alternative for products sweetened by sugar. However, it is preferred to replace sugar-sweetened beverages (SSBs) with water. The use of SSB as a replacement of sugar and without compensation for reduced caloric intake may help reduce weight [27, 28]. People should be recommended to abstain from consuming additional calories from other foods when sugar substitutes are used with the goal of reducing caloric intake. SSB may have putative negative effects, including negatively modifying hunger sensation [27].

Fiber

Recommendations for fiber intake for people with diabetes are similar to the recommendations for the general public (DRI: 14 g/1000 kcal). Diets containing 44–50 g fiber daily are reported to improve glycemia, but more usual fiber intakes (up to 24 g/day) have not shown beneficial effects on glycemia. It is unknown whether free-living individuals can sustain daily consumption of the amount of fiber needed to improve glycemia. However, some research suggests that soluble fiber can decrease postprandial glucose and A1C [29]. In addition, diets high in total and soluble fiber, as part of cardioprotective nutrition therapy, have been shown to reduce total cholesterol by 2–3% and LDL cholesterol up to 7% [3]. Therefore, foods containing 25–30 g/day of fiber, with special emphasis on soluble fiber sources (7–13 g), are to be encouraged.

Alcohol

Recommendations for alcohol intake are similar to those for the general public. If individuals with diabetes choose to use alcohol, daily intake should be limited to one drink per day or less for women and two drinks per day or less for men [25]. One drink is defined as a 12 oz. beer, 5 oz. wine, or 1.5 oz. of distilled spirits, each of which contains about ~14 g alcohol. Moderate amounts of alcohol when ingested with food have minimal, if any, effect on blood glucose and insulin concentrations, and the type of beverage consumed does not appear to make a difference. However, the effect of alcohol on persons with diabetes is individualized. For individuals using insulin or insulin secretagogues, if alcohol is consumed, it should be consumed with food to prevent hypoglycemia. Moderate alcohol consumption is associated with a decreased incidence of heart disease in persons with diabetes [30]. However, chronic excessive ingestion of alcohol (>3 drinks/day) can cause deterioration of glucose control with the effects from excess alcohol being reversed after abstinence for 3 days. In epidemiological studies, moderate alcohol intake is associated with favorable changes in lipids, including triglycerides. Because the available evidence is primarily observational, it does not support recommending alcohol consumption to persons who do not currently drink. Occasional use of alcoholic beverages can be considered an addition to the regular meal plan, and no food should be omitted.

Diabetes-Related Comorbidities

Diabetic Kidney Disease

The recommendations for nutrition, in particular protein intake, in patients with diabetic kidney disease have changed over time. While previously low-protein diets were advised with the goal of reducing albuminuria and reducing the progression of kidney disease, it was found that reducing protein intake did not significantly alter the progression of diabetic kidney disease [6]. Moreover, there may be increased risk of malnutrition if protein is restricted; therefore, currently there is no recommendation to restrict protein intake in persons with diabetes and kidney disease. In persons with diabetic nephropathy, a protein intake of 1 g or less per kg body weight per day is recommended.

Gastroparesis

It is advisable to refer patients with gastroparesis for consultation to a RDN with experience in gastroparesis. An important aspect will be the selection of foods of smaller particle sizes and/or consumer smaller, more frequent meals, as this can help facilitate the transfer of food through the digestive tract [31]. In addition, foods that do not delay gastric emptying such as lower fiber and lower fat foods can be beneficial. Liquid foods may be preferred over solid foods. Acute hyperglycemia could negatively affect gastric emptying and should ideally be minimized. In people with gastroparesis, timing of insulin administration can be difficult. Continuous glucose monitoring may aid in optimizing insulin administration, and some people with type 1 diabetes or insulin-treatment in type 1 diabetes may see benefit from treatment with an insulin pump [31, 32].

Cardiovascular Disease

The incidence of cardiovascular disease in people with type 1 and type 2 diabetes is high. Thus, there is particular interest in mitigating the risks of cardiovascular disease (CVD) in diabetes. Many of the nutrition recommendations for CVD reduction in the general population also apply for people with diabetes. MNT that optimizes blood glucose control, blood pressure, and lipid profiles is a cornerstone element in the management of diabetes. This has been shown to lower the risk of CVD and stroke [3, 6]. Data from clinical trials support the role of nutrition therapy for reaching glycemic targets and decreasing markers of CVD risk [3, 6]. People with diabetes are encouraged to reduce the amount of saturated fat and replace this with unsaturated fats where possible. This has been shown to

reduce total cholesterol and LDL-C and can improve cardiovascular risk factors. In a study, which included close to 50% of people with diabetes, intakes of monounsaturated and polyunsaturated fats were associated with a lower CVD risk and death, whereas intakes of saturated fat and trans fat were associated with a higher CVD risk. Replacing saturated and trans fat with monounsaturated or polyunsaturated fat in food was inversely associated with CVD [6]. In general, replacing saturated fat with unsaturated fats, especially polyunsaturated fat, significantly reduces both total cholesterol and LDL-C, and replacement with monounsaturated fat from plant sources, such as olive oil and nuts, reduces CVD risk. However, the association between saturated fat intake and the risk of cardiovascular disease remains controversial. Replacing polyunsaturated fat with saturated or refined carbohydrate has been shown to provide cardioprotective benefits. Consumption of *n*-3 fatty acids from fish or from supplements has been shown to reduce adverse cardiovascular outcomes [3, 6]. Trans fats should be avoided as they have been associated with all-cause mortality and CVD mortality [33]. Reducing sodium to the general recommendation of 2300 mg/day demonstrates beneficial effects on blood pressure [6].

Summary and Conclusions

Over the past decades, there have been major developments in the field of medical nutrition therapy for the management of diabetes. Medical nutrition therapy (MNT) is an essential pillar of diabetes management that involves an ongoing approach to deliver effective recommendations tailored to the individual needs of the person with diabetes. Monitoring of glucose, A1C, lipids, and blood pressure is crucial to assess the outcomes of nutrition therapy interventions and/or to determine if changes in medications are necessary. It is important that all healthcare providers understand the fundamentals of evidence-based nutrition therapy to safely guide recommendations that promote adoption of healthful lifestyle practices and support each individual's unique needs and wishes.

COVID-19 Addendum

In the beginning of 2020, the world was confronted with the SARS-Cov-2 global pandemic. Infection with the novel coronavirus (SARS-CoV-2) causes the respiratory illness coronavirus disease 2019 (COVID-19), which ultimately led to the COVID-19 pandemic. In the course of the COVID-19 pandemic, it became clear that, in addition to age, people with obesity and diabetes had an increased risk of severe infection and mortality from COVID-19 [34]. Although initial data showed an increased risk of mortality in people with type 2 diabetes, there was little information on whether this also extended to people with type 1 diabetes [34].

As the pandemic progressed, reports on the increased mortality in type 2 diabetes were confirmed. However, large observational studies now also determined the effects of COVID-19 on people with type 1 diabetes. A study from the United Kingdom showed increased mortality from COVID-19 in people with type 1 and type 2 diabetes, although the number of people <50 years of age and type 1 diabetes was small [35, 36]. A study from France also underscored increased morbidity in people with type 1 diabetes [37, 38].

Taken together, the epidemiological data showed that people with diabetes, along with people with obesity, are at increased risk of morbidity and mortality from COVID-19. Improving glycemic control may be a modifiable factor in mediating risk of severe illness and mortality from COVID-19 in people with diabetes. Questions remain whether different classes of pharmacological therapy in type 1 and type 2 diabetes eventually affect mortality risk. Moreover, as vaccination efforts have taken off, future studies will also determine antibody responses to vaccination against COVID-19 in people with type 1 and type 2 diabetes.

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