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Review

Decoding Diabetes Nutritional Guidelines for Physicians in Underserved American Populations

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Abstract: Medical (healthcare) deserts and food deserts, either separate or combined, exist in rural areas, globally. The physicians and other healthcare professionals who serve rural and other underserved populations, to some extent, also experience life in these areas. Dietary guidelines, from expert societies, for people with diabetes, have been helpful in guiding healthcare professionals through nutritional interventions. However, these guidelines are not designed for rural areas where healthcare resources are scarce, and access to the built environment for a healthy lifestyle and affordable healthy foods are not available. Therefore, the guidelines were reviewed, with rural physicians and healthcare professionals who work in underserved areas in mind, to assess their appropriateness. Based on the guidelines and other literature, potential solutions to guideline gaps are proposed to aid in providing nutritional therapy for the underserved. The overall goals are to improve the nutritional component of healthcare for underserved people with diabetes, and to begin the conversation around creating specific guidelines for rural physicians and other healthcare professionals, where patients are at a higher risk for diabetes.

Keywords: nutrition guidelines; underserved; rural; diabetes

Citation: Kelly, O.J.; Deya Edelen, E.; Sharma, A.; Kashyap, K.; Patel, R.; Saiprakash, S.; Shah, A.; Konduri, S. Decoding Diabetes Nutritional Guidelines for Physicians in Underserved American Populations. *Endocrines* **2024**, *5*, 1–23. https://doi.org/10.3390/endocrines5010001

Academic Editor: Maria Mirabelli

Received: 13 November 2023
Revised: 31 December 2023
Accepted: 2 January 2024
Published: 5 January 2024

1. Introduction

Nonmetropolitan is limited, compared to a urban areas (metropolitan). However, rural patients may also present unique challenges that are not addressed in current dietary guidelines for people with diabetes. To put this in perspective, consider the following case.

A 64-year-old male presents to a rural, west Texas family medicine clinic for a follow-up for chronic conditions. This patient was last seen by another physician in 2019. The patient reports no acute exacerbations of chronic conditions. The patient's pertinent medical history includes hyperlipidemia, essential hypertension, Type 2 diabetes mellitus with peripheral circulatory complications, and is obese (per BMI). Physical exam reveals an alert and oriented male that appears older than the stated age. No significant findings are obtained upon a cardiac and pulmonary exam. Abdominal exam reveals a protuberant abdomen without guarding or tenderness to palpation. The patient's social history reveals the patient is away for several weeks at a time to lead cattle drives. This occupation has led to many traumatic incidents for which he received medical attention but have not led to significant morbidity. The patient states his diet is varied and is limited by his access to fresh, nutrient-dense foods. The patient reports that when he is home, he purchases his food from the gas station or dollar store. He reports that his home, a mobile trailer, does not have electricity and he is unable to keep food cool during the summer months. The patient is not insured and is hesitant to pick up prescribed medications from the local pharmacy. The patient received standard counseling for weight management and lifestyle changes. In addition, the patient was provided a sample of a continuous glucose monitor, to help watch blood glucose levels, and was counseled on the adverse effects of hyperglycemic

states. The patient also received a sample of metformin hydrochloride 500 mg and was instructed to pick up other prescriptions from the pharmacy and to complete blood work.

Although the definition of rural is not universal [1], in the US, more people are diagnosed with diabetes in rural compared to urban counties. Of note is that more than one-third of these non-metropolitan counties reside within the southeastern region, sometimes referred to as the diabetes belt. Furthermore, the majority of nonmetropolitan counties do not have a diabetes self-management education and support (DSMES) program [2]. Therefore, diabetes is an increased concern for rural communities because of the limited access to resources that promote a healthy life [3]. This is not a new or novel finding; people in rural communities have had the same main concerns regarding healthcare as they did a decade ago [4], suggesting few positive changes have occurred. In addition, the need for more rural physicians has been known for at least two decades [5]. Moreover, dollar stores are becoming the go-to store for many rural Americans, which may be increasing their exposure to ultraprocessed food [6]. It is important to note that rural health disparities are a global issue—they are not limited to the U.S., e.g., [7,8]. There is a wealth of data related to rural–urban disparities in cardiovascular disease, mortality, and health literacy already available, e.g., [9–12], and it seems that access to specialty healthcare is an issue for both urban and rural inhabitants [13]. However, a review of this literature, while interesting and important, is beyond the scope of this paper.

The American Diabetes Association (ADA) nutritional guidelines (for people with prediabetes and diabetes) are updated regularly. These guidelines are an invaluable resource for healthcare professionals. The most positive change in recent years has been the addition of lower-carbohydrate diet options, to help control glycemia [14]. The ADA are aware of the limitation of rural areas and suggest telemedicine as a possible solution to increase healthcare access for rural populations, with a focus on DSMES and utilizing community health workers under the supervision of a physician [15]. Based on the data in these guidelines, there is no doubt that nutrition therapy for diabetes improves outcomes. This review is not a critique of the ADA, or otherguidelines; it points to gaps in nutritional guidelines for diabetes globally for underserved areas. It is important to note that other dietary guidelines for diabetes are similar, e.g., [16,17] and others have provided practical tips based on nutritional guidelines [18]. Nevertheless, a significant gap (chasm) exists in the literature related to the management of diabetes in rural areas. Therefore, the goal of this review is to create awareness of the issue where rural physicians and other rural healthcare professionals may find it difficult to apply the current dietary guidelines in their practice, and alternative strategies are necessary.

2. Nutritional Guidelines under a Rural Lens

Implementing evidence-based dietary guidelines, from expert societies, for people with diabetes, requires numerous, specific resources and an appropriate built environment. In medical (healthcare) deserts [19], this is challenging due the low number of healthcare resources, including personnel (e.g., dietitians, certified diabetes educators, and physicians) and lack of built environments (e.g., hospitals, gyms, and walking parks) [20]. Moreover, many rural areas are also food deserts (where there is limited access to fresh foods due to the lack of grocery stores or their high cost and socioeconomic status [21,22]). Furthermore, intensive lifestyle interventions, such as those based on the Look AHEAD trial [23], known to be effective at reducing weight, require a multitude of resources and are not feasible in medical and food deserts. The lack of accessibility to fresh foods and other health disparities play a prominent role in how well patients can manage their diabetes. Additionally, foods that contribute to type 2 diabetes are much more affordable and available in food deserts as compared to fresh foods [6,21]. This makes it difficult to implement a healthy diet based on guidelines and poses a significant challenge for the rural physician. All this evidence suggests that alternative strategies are required for rural physicians at the frontier of healthcare. Therefore, Table 1 highlights the potential issues with the implementation of current nutritional guidelines for diabetes in rural/underserved areas, with a focus on rural

physicians in the United States. This table presents the ADA consensus recommendations in the left column, the resources needed in the middle column, and potential implications for the rural physician in the right column.

Table 1. A rural lens on the American Diabetes Association's consensus recommendations [14] for diabetes nutrition therapy.

	Consensus Recommendation [14]	Resources Assumed	Application in Rural Areas
	Effectiveness of diabetes nutrition therapy		
1.	Refer adults living with type 1 or type 2 diabetes to individualized, diabetes-focused MNT at diagnosis and as needed throughout the life span and during times of changing health status to achieve treatment goals. Coordinate and align the MNT plan with the overall management strategy, including use of medications, physical activity, etc., on an ongoing basis.	Presence of dietitians with experience in diabetes. Clinics with multidisciplinary teams, including specialties (personnel). Local, affordable fitness studios (aerobic and resistance weights).	Absence of multidisciplinary clinics and other healthcare professionals, especially dietitians, shortage of nurses in rural areas [24]. There is a need for all types of healthcare professionals in rural areas [25]. The rural physician is at the frontline and must address MNT.
2.	Refer adults with diabetes to comprehensive diabetes self-management education and support (DSMES) services according to national standards.	DSMES services must meet national standards, and must be accredited by the ADA or ADCES. They require a sponsor organization, dedicated multidisciplinary team, staff training, access to exercise facilities, meeting rooms, technology for data reporting, etc., see https://www.cdc.gov/diabetes/dsmes-toolkit/index.html. Access date 12 December 2023.	Developing a local DSMES program requires significant resources and capital investment and is probably out of scope for a rural family medicine physician in private practice.
3.	Diabetes-focused MNT is provided by a registered dietitian nutritionist/registered dietitian (RDN), preferably one who has comprehensive knowledge and experience in diabetes care.	Presence of dietitians with experience in diabetes.	The rural physician must address MNT.
4.	Refer people with prediabetes and overweight/obesity to an intensive lifestyle intervention program that includes individualized goal-setting components, such as the Diabetes Prevention Program (DPP) and/or to individualized MNT.	Intensive lifestyle intervention programs typically require specialized foods, access to exercise facilities, and regular follow-ups with a multidisciplinary team. DPP require significant resources, at least three dedicated staff (lifestyle coach, data preparer, program coordinator), a CDC-approved curriculum (all aspects, including mental health), a multidisciplinary team to provide education, and capital investment. See https://www.cdc.gov/diabetes/prevention/index.html. Access date 12 December 2023.	Developing a local DPP requires significant resources and capital investment and is probably out of scope for a rural family medicine physician in private practice. The rural physician must address MNT.

Table 1. *Cont.*

	Consensus Recommendation [14]	Resources Assumed	Application in Rural Areas
5.	Diabetes MNT is a covered Medicare benefit and should be adequately reimbursed by insurance and other payers or bundled in evolving value-based care and payment models.	Presence of dietitians with experience in diabetes. Universal insurance coverage for MNT.	Is a rural physician able to bill Medicare for MNT or does it have to be a dietitian? Can any form of nutritional therapy be billed for by a rural physician? Opportunity for Medicare and other insurers, to also reimburse rural physicians for providing nutritional therapy. In rural areas, there is limited access to health insurance, compared to urban areas [26].
6.	DPP-modeled intensive lifestyle interventions and individualized MNT for prediabetes should be covered by third-party payers or bundled in evolving value-based care and payment models.	Local DPP. Presence of dietitians with experience in diabetes.	Is a rural physician able to bill Medicare for MNT or does it have to be a dietitian? Can any form of nutritional therapy be billed for by a rural physician? An opportunity for Medicare to also reimburse rural physicians for providing nutritional therapy. In rural areas there is limited access to health insurance, compared to urban areas [26].
	Macronutrients		
1.	Evidence suggests that there is not an ideal percentage of calories from carbohydrate, protein, and fat for all people with or at risk for diabetes; therefore, macronutrient distribution should be based on an individualized assessment of current eating patterns, preferences, and metabolic goals.	Resources to assess macronutrient distribution (software, personnel, and time). Resources to follow-up on macronutrient distribution (software, personnel, and time). Easy access to a wide variety of foods.	For a review of dietary assessment toolkits, see [27]. There are relatively inexpensive, digital options for rural physicians if they want to perform dietary assessment, e.g., using Food Processor (ESHA, Salem, OR, USA), MyFood 24 (Nexus, Leeds, UK), or Power Diary (Salt Lake City, UT, USA). However, time is required to interpret the results and formulate a plan.
2.	When counseling people with diabetes, a key strategy to achieve glycemic targets should include an assessment of current dietary intake followed by individualized guidance on self-monitoring carbohydrate intake to optimize meal timing and food choices and to guide medication and physical activity recommendations.	Resources to assess dietary intake, especially carbohydrate, how much carbohydrate at each meal, etc. (software, personnel, and time). Resources to follow-up on dietary intake (software, personnel, and time). Easy access to a wide variety of foods. Local, affordable fitness studios (aerobic and resistance weights).	For a review of dietary assessment toolkits, see [27]. There are, relatively inexpensive, digital options for rural physicians if they want to perform dietary assessment, e.g., Food Processor (ESHA, Salem, OR, USA), MyFood 24 (Nexus, Leeds, UK), Power Diary (Salt Lake City, UT, USA)—we are not endorsing these products. However, time is required to interpret the results. The rural physician can provide patient education on carbohydrate counting—may have to develop the content so it is appropriate for their patients.

Table 1. *Cont.*

	Consensus Recommendation [14]	Resources Assumed	Application in Rural Areas
3.	People with diabetes and those at risk for diabetes are encouraged to consume at least the amount of dietary fiber recommended for the general public; increasing fiber intake, preferably through food (vegetables, pulses (beans, peas, and lentils), fruits, and whole intact grains) or through dietary supplements may help in modestly lowering A1C.	Easy access to a wide variety of foods. Patient can afford to eat better.	The rural physician will have to be aware of where locals purchase foods and seek out foods with more fiber. Supplements may be the best option—must consider affordability. The rural physician can provide patient education on increasing fiber—may have to develop the content so it is appropriate for their patients.
	Eating patterns		
1.	A variety of eating patterns (combinations of different foods or food groups) are acceptable for the management of diabetes.	Easy access to a wide variety of foods, especially plant foods, which are central to all beneficial dietary patterns. Patient can afford to eat better.	Food insecurity may need to be considered. The rural physician can provide patient education on improving dietary patterns—may have to develop the content so it is based on what is available locally.
2.	Until the evidence surrounding comparative benefits of different eating patterns in specific individuals strengthens, health care providers should focus on the key factors that are common among the patterns: ○ Emphasizing nonstarchy vegetables. ○ Minimizing added sugars and refined grains. ○ Choosing whole foods over highly processed foods to the extent possible.	Easy access to a wide variety of foods, especially plant foods, which are central to all beneficial dietary patterns. Easy access to whole foods. Patient can afford to eat better.	Food insecurity may need to be considered. The rural physician can provide patient education on improving dietary patterns—may have to develop the content so it is based on what is available locally.
3.	Reducing overall carbohydrate intake for individuals with diabetes has demonstrated the most evidence for improving glycemia and may be applied in a variety of eating patterns that meet individual needs and preferences.	Easy access to a wide variety of foods, especially good-quality carbohydrate foods. Patient can afford to eat better.	This recommendation more than likely means reducing refined carbohydrate intake. The rural physician can provide patient education on reducing carbohydrate intake—may have to develop the content so it is based on what is available locally.
4.	For select adults with type 2 diabetes not meeting glycemic targets or where reducing antiglycemic medications is a priority, reducing overall carbohydrate intake with low- or very-low-carbohydrate eating plans is a viable approach.	Easy access to a wide variety of foods, appropriate for a low- or very-low-carbohydrate diet. Patient can afford this specialized diet.	Food insecurity may need to be considered. The rural physician can provide patient education on reducing carbohydrate intake—may have to develop the content so it is based on what is available locally.

Table 1. *Cont.*

	Consensus Recommendation [14]	Resources Assumed	Application in Rural Areas
	Energy balance and weight management		
1.	To support weight loss and improve A1C, CVD risk factors, and quality of life in adults with overweight/obesity and prediabetes or diabetes, MNT and DSMES services should include an individualized eating plan in a format that results in an energy deficit in combination with enhanced physical activity.	Resources to assess dietary intake, especially carbohydrate intake, how much carbohydrate consumed at each meal, etc. (software, personnel, and time). Resources to follow-up on dietary intake (software, personnel, and time). Local, convenient, DSMES program and DPP.	Developing a local DSMES program, or DPP, requires significant resources and capital investment and is probably out of scope for a rural family medicine physician in private practice.
2.	For adults with type 2 diabetes who are not taking insulin and who have limited health literacy or numeracy, or who are older and prone to hypoglycemia, a simple and effective approach to glycemia and weight management emphasizing appropriate portion sizes and healthy eating may be considered.	Resources to assess dietary intake, i.e., portion sizes (software, personnel, and time). Resources to follow-up on dietary intake (software, personnel, and time).	Food insecurity may need to be considered. The rural physician can provide patient education on portion size and reducing carbohydrate—may have to develop the content so it is based on what is available locally.
3.	In type 2 diabetes, 5% weight loss is recommended to achieve a clinical benefit, and the benefits are progressive. The goal for optimal outcomes is 15% or more when needed and can be feasibly and safely accomplished. In prediabetes, the goal is 7–10% for preventing progression to type 2 diabetes.	Presence of diabetes weight loss programs, including DSMES, DPP and intensive lifestyle intervention. Resources to assess and follow-up for dietary intake (software, personnel, and time). Local, affordable exercise facilities (aerobic and resistance weights).	Achieving consistent and sustained weight loss in patients with diabetes requires time and effort. In addition, patients need support to maintain motivation. Rural physician would need to develop a weight loss program appropriate for the area and patients. This may be out of scope for the rural physician.
4.	In select individuals with type 2 diabetes, an overall healthy eating plan that results in an energy deficit in conjunction with weight loss medications and/or metabolic surgery should be considered to help achieve weight loss and maintenance goals, lower A1C, and reduce CVD risk.	Resources to assess dietary intake and create eating plans with caloric deficits (software, personnel, and time). Clinics with multidisciplinary teams, including specialties (personnel). Local, affordable exercise facilities (aerobic and resistance weights). Health insurance that covers weight loss medications and/or metabolic surgery.	Rural physician would need to develop a weight loss program, with access to medications and/or metabolic surgery, appropriate for the area and patients. This may be out of scope for the rural physician.
5.	In conjunction with lifestyle therapy, medication-assisted weight loss can be considered for people at risk for type 2 diabetes when needed to achieve and sustain 7–10% weight loss.	Resources to assess dietary intake and create eating plans with caloric deficits (software, personnel, and time). Local, affordable exercise facilities (aerobic and resistance weights). Health insurance that covers weight loss medications.	The rural physician would need to develop a weight loss program, with access to medications, appropriate for the area and patients. This may be out of scope for the rural physician.
6.	People with prediabetes at a healthy weight should be considered for lifestyle intervention involving both aerobic and resistance exercise and a healthy eating plan such as a Mediterranean-style eating plan.	Resources to assess dietary intake and create eating plans with caloric deficits (software, personnel, and time). Clinics with multidisciplinary teams, including specialties (personnel). Local, affordable exercise facilities (aerobic and resistance weights). Easy access to a wide variety of foods.	The rural physician would need to develop a healthy eating plan to help prevent diabetes appropriate for the area and patients. This may be out of scope for the rural physician.

Table 1. *Cont.*

	Consensus Recommendation [14]	Resources Assumed	Application in Rural Areas
7.	People with diabetes and prediabetes should be screened and evaluated during DSMES and MNT encounters for disordered eating, and nutrition therapy should accommodate these disorders.	Presence of local DSMES program. Easy access to a mental health specialist/multidisciplinary clinical team. Presence of dietitians with experience in diabetes and eating disorders. Health insurance that covers eating disorder therapies.	The rural physician, if comfortable, could begin to address eating disorders; however, specialty care is needed.
	Sweeteners		
1.	Replace sugar-sweetened beverages (SSBs) with water as often as possible.	No comment.	No issue for the rural physician to educate on this topic.
2.	When sugar substitutes are used to reduce overall calorie and carbohydrate intake, people should be counseled to avoid compensating with the intake of additional calories from other food sources.	No comment.	No issue for the rural physician to educate on this topic.
	Alcohol consumption		
1.	It is recommended that adults with diabetes or prediabetes who drink alcohol do so in moderation (one drink or less per day for adult women and two drinks or less per day for adult men).	No comment.	No issue for the rural physician to educate on this topic.
2.	Educating people with diabetes about the signs, symptoms, and self-management of delayed hypoglycemia after drinking alcohol, especially when using insulin or insulin secretagogues, is recommended. The importance of glucose monitoring after drinking alcohol beverages to reduce hypoglycemia risk should be emphasized.	No comment.	No issue for the rural physician to educate on this topic.
	Micronutrients, herbal supplements, and risk of medication-associated deficiency		
1.	Without an underlying deficiency, the benefits of multivitamins or mineral supplements on glycemia for people with diabetes or prediabetes have not been supported by evidence, and therefore routine use is not recommended.	No comment.	No issue for the rural physician to educate on this topic. However, considering the poorer diets in rural areas, a daily multinutrient supplement may help prevent insufficiencies.
2.	It is recommended that MNT for people taking metformin include an annual assessment of vitamin B12 status with guidance on supplementation options if deficiency is present.	No comment.	No issue for the rural physician to educate on this topic. However, considering the poorer diets in rural areas, a daily multinutrient supplement may help prevent insufficiencies.
3.	The routine use of chromium or vitamin D micronutrient supplements or any herbal supplements, including cinnamon, curcumin, or aloe vera, for improving glycemia in people with diabetes is not supported by evidence and is therefore not recommended.	No comment.	No issue for the rural physician to educate on this topic.

Table 1. *Cont.*

	Consensus Recommendation [14]	Resources Assumed	Application in Rural Areas
	MNT and antihyperglycemic medications (including insulin)		
1.	All RDNs providing MNT in diabetes care should assess and monitor medication changes in relation to the nutrition care plan.	Presence of dietitians with experience in diabetes.	The rural physician has to address MNT.
2.	For individuals with type 1 diabetes, intensive insulin therapy using the carbohydrate counting approach can result in improved glycemia and is recommended.	No comment.	No issue for the rural physician to educate on this topic.
3.	For adults using fixed daily insulin doses, consistent carbohydrate intake with respect to time and amount, while considering the insulin action time, can result in improved glycemia and reduce the risk for hypoglycemia.	Resources to assess dietary intake, i.e., carbohydrate intakes at meals and snack time (software, personnel, and time).	The rural physician would need to develop an individualized eating plan to help keep carbohydrate intake consistent throughout the day, that is appropriate for the area. This may be out of scope for the rural physician.
4.	When consuming a mixed meal that contains carbohydrate and is high in fat and/or protein, insulin dosing should not be based solely on carbohydrate counting. A cautious approach to increasing mealtime insulin doses is suggested; continuous glucose monitoring (CGM) or self-monitoring of blood glucose (SMBG) should guide decision-making for the administration of additional insulin.	Health insurance that covers CGM or SMBG.	No issue for the rural physician to educate on this topic.
	Role of nutrition therapy in the prevention and management of diabetes complications (CVD, diabetic kidney disease, and gastroparesis)		
1.	In general, replacing saturated fat with unsaturated fats reduces both total cholesterol and LDL-C and also benefits CVD risk.	No comment.	No issue for the rural physician to educate on this topic.
2.	In type 2 diabetes, counseling people on eating patterns that replace foods high in carbohydrate with foods lower in carbohydrate and higher in fat may improve glycemia, triglycerides, and HDL-C; emphasizing foods higher in unsaturated fat instead of saturated fat may additionally improve LDL-C.	No comment.	No issue for the rural physician to educate on this topic.
3.	People with diabetes and prediabetes are encouraged to consume less than 2300 mg/day of sodium, the same amount that is recommended for the general population.	No comment.	No issue for the rural physician to educate on this topic.
4.	The recommendation for the general public to eat a serving of fish (particularly fatty fish) at least two times per week is also appropriate for people with diabetes.	Easy access to a wide variety of foods.	No issue for the rural physician to educate on this topic, possibly offer supplements as an alternative.

Table 1. *Cont.*

	Consensus Recommendation [14]	Resources Assumed	Application in Rural Areas
5.	In individuals with diabetes and non–dialysis-dependent diabetic kidney disease (DKD), reducing the amount of dietary protein below the recommended daily allowance (0.8 g/kg body weight/day) does not meaningfully alter glycemic measures, cardiovascular risk measures, or the course of glomerular filtration rateO decline, and may increase the risk for malnutrition.	Resources to assess dietary intake, i.e., protein intake (software, personnel, and time). Presence of dietitians with experience in diabetes and DKD.	This can be a challenge for rural physicians, as other guidelines and data exist. The National Kidney Foundations nutritional guidelines suggest 0.6–0.8 g/kg/d, but with higher caloric intake, and more medical supervision to mitigate any potential risk for malnutrition [28]. Two-year data from Virta Health (poster) show that sustained nutritional ketosis may help preserve kidney function [29]. A meta-analysis supports that lower-carbohydrate diets maintain eGFR better (albeit by a small number) than standard diets do [30].
6.	Selection of small-particle-size foods may improve symptoms of diabetes-related gastroparesis.	Easy access to the appropriate foods.	Appropriate foods, including medical foods, may not be readily available.
7.	Correcting hyperglycemia is one strategy for the management of gastroparesis, as acute hyperglycemia delays gastric emptying.	Resources to assess dietary intake, i.e., carbohydrate intakes (software, personnel, and time). Coupling with CGM or SMBG to make the patient more aware of what foods contribute to hyperglycemia. Health insurance that covers CGM devices or SMBG.	The rural physician can educate on carbohydrate counting and carbohydrate quality. The rural physician would need to develop a program appropriate for the area and patients.
8.	Use of CGM and/or insulin pump therapy may aid the dosing and timing of insulin administration in people with type 1 or type 2 diabetes with gastroparesis.	Health insurance that covers CGM and/or insulin pump therapy.	The rural physician can educate on carbohydrate counting and carbohydrate quality. The rural physician would need to develop a food list appropriate for the area and patients.
	Personalized nutrition		
1.	Studies using personalized nutrition approaches to examine genetic, metabolomic, and microbiome variations have not yet identified specific factors that consistently improve outcomes in type 1 diabetes, type 2 diabetes, or prediabetes.	Resources to assess and follow-up for dietary intake, (software, personnel, and time). Easy access to specialist/multidisciplinary clinical team. Presence of dietitians with experience in diabetes.	The field of personalized nutrition is still in its infancy [31]; however, the rural population requires some form of personalized nutrition, distinct from those in urban areas. Currently, this does not seem applicable to rural physicians.

Telemedicine is a good adjunct to conventional healthcare; however, it may be cost-prohibitive for rural physicians [32]. Telemedicine also requires a built environment that supports high-speed internet for patients and physicians, access to smart technology, end-to-end encryption services to maintain secure health data, and possibly large capital investment from the rural physician, as well as staff training and maintenance fees. A common and justified recommendation is that people with diabetes should see a dietitian for Medical Nutrition Therapy (MNT); however, dietitians are either not locally available or may be cost-prohibitive (with a lack of health insurance, or low socioeconomic status). This is complicated by the fact that reimbursement for MNT from Medicare possibly requires it to be performed by a dietitian, per the legal definition of MNT [14]. Creating some form of reimbursement for rural healthcare professionals who provide nutritional support may

help the current situation. Another advantage for urban area is the availability, or potential for the creation of, DSMES and Diabetes Prevention Program (DPP) services for people with diabetes. These would include some form of intensive lifestyle intervention for weight loss. These services are well suited to an area with multidisciplinary healthcare teams available, and the capital and human resources needed to develop and maintain these services.

Dietary assessment is a necessary part of MNT; however, the most important resource required is time. All types of dietary assessment (see review in [27]) require specialized software (e.g., Food Processor (ESHA, Salem, OR, USA), MyFood 24 (Nexus, Leeds, UK), and Power Diary (Salt Lake City, UT, USA). All these can perform dietary assessments fully online, where the patient would complete a food diary via an app, and the software would directly provide the results to the physician. Food Processor can have data manually inputted from 24 h recall, or food diaries. Overall, dietary assessment tools are relatively inexpensive; however, time is required to interpret the results and create meal plans or other dietary interventions. With all this in mind, the following sections will provide some preliminary resources for rural physicians to aid in, or begin, nutritional interventions.

3. Dietary Intakes of People with Diabetes

Before providing some practical nutritional considerations for people with diabetes, it is best to have some idea of what they are consuming. The National Health and Nutrition Examination Survey (NHANES) has dietary intake estimates, based on 24 h dietary recall, for people with diabetes. The limitations and strengths of dietary recall are widely publicized [33,34]; however, NHANES data are used to develop the Dietary Guidelines for Americans. While these are estimates based off one day's food intake, and are mostly based on an urban population, they could act as a reference point for people in rural areas. Overall, people with diabetes were observed as not achieving a good diet quality score (based on the United States Department of Agriculture's Healthy Eating Index (HEI) score. In addition, compared to individuals without diabetes, people with prediabetes or diabetes, seem to have lower caloric (up to 264 kcal), protein, carbohydrate and fat intakes, of up to approximately 264 kcal. Furthermore, dinner was the largest meal and contained the highest amount of carbohydrate, while snacks contained the most added sugars [35]. For people with diabetes, mean intakes of thiamin, niacin, vitamin B6, vitamin C, magnesium, and potassium were significantly lower compared to those in people without diabetes [36]. Snacks contributed approximately 20% of the daily energy intake for people with prediabetes or diabetes, which was significantly less than that for those without diabetes [33]. People with diabetes who skipped breakfast compensated with snacks, and actually consumed more energy, carbohydrate, and added sugars from snacks compared to those who ate breakfast [37]. Interestingly, the people with prediabetes or diabetes who consumed less than the recommended intake of protein (0.8 g/kg/d; the Recommended Dietary Allowance (RDA)) had a lower HEI, consumed more carbohydrate, and were insufficient for numerous micronutrients, compared to those who consumed, or exceeded, the recommended intake of protein [34]. On a more general level, those with more chronic conditions, including prediabetes and diabetes (overweight or obesity (body mass index > 25 kg/m^2), hyperglycemia (HbA1c > 5.7%), hypercholesterolemia (>200 mg/dL), and high blood pressure (>120/80 mm Hg), had a significantly lower diet quality compared to those with one chronic condition [38]. These data suggest that improving diet quality, maintaining the recommended intake of protein, and reducing snacking may be three strategies that can be targeted by the rural physician.

4. Initiating Nutritional Therapy in Rural Environments

4.1. Estimating Energy Intake

Estimating energy intake is most important when the objective is weight loss. New estimated energy requirement (EER) equations from the National Academies of Sciences, Engineering, and Medicine are available [39]; they are based on age, sex, physical activity level, and pregnancy/lactation. EER equations can be incorporated into digital records and

can be calculated in the physician's office. The ADA guidelines recommend a target weight loss of 5% to achieve a clinical benefit, with optimal benefits seen with 15% weight loss for patients with diabetes. For people with prediabetes, weight loss should be 7–10% of the body weight to help slow the progression to diabetes [14]. Body weight optimization is fundamental to diabetes management. The '3500 kcal rule' is the typical method utilized to reduce body weight. It assumes 3500 kcal = 1 lb (0.454 kg) of body weight, so a deficit of 3500 kcal over one week (500 kcal/d) should result in a loss of 1 lb of body weight. The 3500 kcal rule has its limitations [40,41] because weight loss is not linear, and it probably overestimates the rate of weight loss due to the complex physiological and metabolic factors associated with energy homeostasis. Nevertheless, it does provide a starting point to help facilitate weight loss and requires close monitoring.

An alternative solution is to utilize the MyPlate Plan [42] to estimate energy requirements, which can be easily performed during an office visit, with the aid of office staff. The patient could also complete this at home. This will provide two energy levels: (1) to help achieve a healthy weight and, (2) to maintain body weight. It must be noted that these numbers are estimates and will need to be modified over time, based on the rate of weight gain or loss, and patient perceptions. The key point is that weight management is a journey that requires considerable commitment from both the physician and the patient. Overall, free tools are available to support the rural physician in determining EER for patients, and these tools can also be utilized by patients; all that is required is access to the internet. If rural patients do not have internet access, the EER equations can easily be incorporated into the patient encounter.

Before leaving the topic of energy intake, malnutrition must be addressed. For older adults, malnutrition (undernutrition) is more prevalent in rural areas [43], which can complicate nutritional therapy. Malnutrition can easily be screened for and assessed using various tools. Nutritional assessment is more involved and leads to a medical diagnosis of malnutrition. It is more common to utilize malnutrition screening and assessment in hospitals and long-term care facilities; however, for the rural physician, regular malnutrition screening could improve patient health outcomes. Malnutrition can have profound effects on homeostasis, organ function, and mood [44]. Screening for malnutrition is rapid, inexpensive and is predominately based on recent unintentional weight loss. Two options for screening are the Malnutrition Universal Screening Tool (MUST) for adults, and the Malnutrition Screening Tool (MST). These instruments are readily available online and consist of three questions each. Answers to these questions are scored, determining if the individual is at risk of malnutrition or not. Those at risk should be then assessed to make a medical diagnosis. Assessments can be subjective and require practice. The two widely utilized recommended instruments for assessment are the Mini Nutrition Assessment®(MNA; Nestlé Nutrition Institute) and the Subjective Global Assessment (SGA). The MNA has more questions compared to the SGA (18 versus 7); however, both should take less than 15 min to complete. These are readily available online and can be utilized in rural settings.

4.2. Macronutrient Distribution

While "there is no ideal macronutrient pattern for people with diabetes" [45], NHANES data show that people with prediabetes and diabetes have approximately the same macronutrient distribution as that of people with a healthy A1C; 15% of total energy is from protein, 50% of total energy is from carbohydrates; and 35% of total energy is from fat (12% is from saturated fat) [35]. This distribution pattern is relatively close to the U.S. Acceptable Macronutrient Distribution Ranges (AMDR) [46]. Although AMDRs are technically designed for healthy people, they provide a useful frame of reference (for the most part, most patients, with or without diabetes, will be within the AMDR). Some expert bodies have determined evidence-based macronutrient distribution ranges for people with diabetes. The Asociación Latinoamericana de Diabetes (ALAD; Latin American Diabetes Association) brought together medical associations from 17 countries to produce a consensus statement

regarding the treatment of type 2 diabetes [47]. The Diabetes and Nutrition Study Group of the European Association for the Study of Diabetes also published macronutrient distribution ranges for diabetes [48], although they are from 2004, as well as guidelines for Asian Indians [49]. Any of these ranges are acceptable targets, as all ultimately fit into the AMDR. However, the larger question is if assessing and modifying macronutrient distribution is worth the resources and effort it requires for the rural physician, unless the patient is appropriate for a low- or very-low-carbohydrate diet. People with diabetes are recommended to use the diabetes plate (one half of the plate should be non-starchy vegetables, one quarter should be whole grains, and one quarter should be protein [50]; see Figure 1). Non starchy vegetables will reduce postprandial spikes, which contribute to A1C [51]; this is why they should make up the majority of the plate. In fact, three quarters of the plate will help increase fiber intake. However, the reality of food deserts is the availability of the foods for this plan.

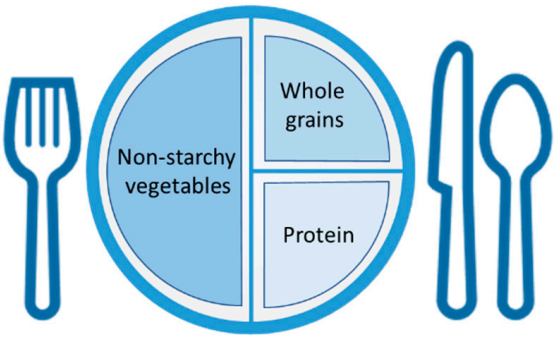

Figure 1. The diabetes plate plan.

4.3. Protein and Fat

When considering protein for rural patients, achieving the RDA could be the minimum goal [34]. Per ADA guidelines [14], lean fresh meats (the fat in red meat is high in stearic acid, an 18-carbon saturated fatty acid, which is associated with cardiovascular disease [52]), and a mixture of protein sources—plants and animal proteins are recommended. Soy protein and animal proteins, including dairy, seafood and eggs, are all of high biological value. Eggs may be more readily available in rural areas; however, overconsuming eggs should be limited for those with diabetes [53]. Consuming more egg whites, than whole eggs, could be encouraged, to increase good-quality protein intake, as the cholesterol is in the yolk.

Fat has the highest energy density [54], which helps explain the weight loss benefits of the low-fat diet [14]. However, attitudes are changing in relation to the role of dietary saturated fats and cholesterol in human health [52,55], with some suggesting that saturated fat in the context of the whole diet is more important than setting a target intake [56]. Considering rural areas are food deserts, maintaining saturated fat at 10% of total calories is a good starting point. This would help to direct the patient to healthier food options. Reducing the consumption of saturated fat slowly over time may be the best approach; however, resources to assess dietary intake and meal options appropriate for the area are needed.

4.4. Carbohydrate

The most important macronutrient in relation to diabetes is carbohydrate, with and emphasis on carbohydrate quality [34]. This includes making more whole grain choices and limiting refined carbohydrates, especially from ultraprocessed foods and snacks. Nutritional intervention is a key component of diabetes management, along with medications and other lifestyle changes. One key point is that people with diabetes need reminding that glycemic medications perform specific functions to address hyperglycemia. However, poor-quality dietary carbohydrate will still raise blood sugar, independent of most medications.

The primary exception are α-glucosidase inhibitors, which can reduce the amount of carbohydrate digested (not 100% effectively), although simple sugars (i.e., monosaccharides such as glucose and fructose) will still become absorbed; [57], see Figure 2. In rural areas with limited access to a variety of foods, snacks (number and amount) may be the best food type to target to help reduce refined carbohydrate and added sugars intakes [33].

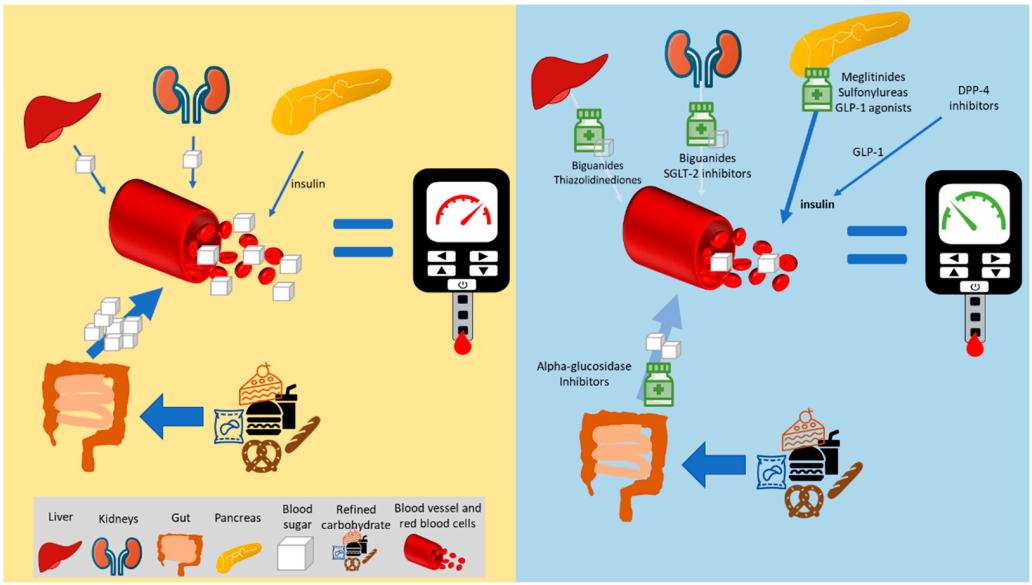

Figure 2. Foods, especially refined carbohydrates, have the greatest effect on blood glucose. This figure is adapted from [58] and summarizes the primary actions of common diabetes medications; however, not all known actions are depicted. Medications target specific actions to manage blood glucose; however, regardless of the medication used, the wrong foods will raise blood glucose. This results in postprandial glucose spikes, which contribute to a higher A1C [51]. The yellow box depicts what contributes to blood glucose and the blue box shows how medications manage physiological mechanisms; however, food still greatly contributes to blood glucose. DPP-4 = dipeptidyl peptidase 4 (gliptins); GLP-1 = glucagon-like peptide-1; SGLT-2 = sodium glucose cotransporter 2.

4.5. Water

Water is the other, often overlooked, macronutrient [59]. A recent meta-analysis associates higher water intake with a reduced risk of type 2 diabetes [60]. However, hydration is not reviewed in the ADA guidelines [14]. Maintaining good hydration status in people with diabetes has many metabolic benefits [61]. People with diabetes may be at higher risk of dehydration due to hyperglycemia and its associated increased urinary output. In addition, underhydration may increase hyperglycemia [62] and contribute to diabetic ketoacidosis in children and adolescents [63], and adults with type 1 diabetes [64]. Water intake recommendations for healthy people (Adequate Intakes) are 3.7 L and 2.7 L per day for men and women, respectively [65], with adjustments made for activity level and age (older people tend to drink less so are at a higher risk for dehydration [66]). Considering rural physicians, and other rural healthcare professionals, the most practical and reasonably accurate method is to use urine color [67,68]. With this in mind, a nine-color urine chart was included for use in rural areas; see Figure 3. This can also be utilized by patients to self-monitor their hydration status. This nine-color chart is based on the original data from Armstrong et al. [69], which were converted to Color Hex Codes by Wardenaar et al. [70]. This color chart will need to be printed using a good-quality printer as color can vary. Another option is to use the lavatory urine color (LUC) chart method, based on urine voiding time [71] (the chart is available as a supplemental file in pdf format on the journal's website). When using urine color and color charts, one consideration is that vitamins B_2 and B_{12} in excess will cause a bright yellow color, and some medications will affect urine color (see MedlinePlus [72]).

Urine color	Description (Hex code)
	Clear - may be overhydrated (#F4FAFC)
	Hydrated – maintain this off-clear color (#FFFDD8)
	Hydrated (#FFFBA8)
	Possible mild dehydration – drink some water (#FCE974)
	Dehydrated – drink water (#FFBA00)
	Dehydrated – dehydration symptoms may start to show – drink water (#FFCE79)
	More dehydrated – drink water (#EAC853)
	Risk of severe dehydration – drink water immediately (#E1C161)
	Severe dehydration – drink water and seek medical aid (#898253)

Figure 3. Urine color chart for use in clinic or to provide to patients to improve hydration status.

4.6. Micronutrients

The ADA guidelines do not support the use of supplementary vitamins and minerals, specifically to help control blood glucose or improve CVD risk factors [14]. The default target intakes for the micronutrients are the Dietary Reference Intakes; all the tables are freely available here [73]. Patients with diabetes on metformin should be monitored for B_{12} deficiency at least annually [14]. Epidemiological studies suggest that lower potassium, magnesium, and zinc status are associated with uncontrolled diabetes [74], and may be worth monitoring. Chromium may not help with blood sugar management [14], although some studies do support it use [74]. However, it is important to know what supplements the patient is taking. Maintaining a non-judgmental approach to micronutrient supplements and herbals will help gain patient trust and facilitate the open sharing of information. The major reason to ask a patient to stop taking a supplement is if it contraindicated for any aspect of their medical treatment (e.g., nutrient–drug interactions). Overall, as there is not strong evidence to support the use of certain micronutrients and herbs/spices specifically for glycemic control, the patient's money may be best spent on other means to control glycemia. However, as the rural community resides in food deserts, a one-a-day multinutrient supplement may help reduce micronutrient insufficiencies. In addition, other supplements, e.g., calcium and omega-3 (fish oil), may be needed based on patient needs.

4.7. Non-Nutritive Sweeteners

The original goal of non-nutritive sweeteners was to reduce calories and avoid blood sugar spikes. Regardless, it is logical to assume that the use of non-nutritive sweeteners does not break the sweet habit [75]. While low-/non-caloric sweeteners do reduce the overall energy intake of a patient, they may not improve glycemic outcomes [76,77] as they may disrupt the patient's insulin sensitivity [78]. Diet sodas that contain aspartame have been associated with higher A1C levels and higher risks of metabolic syndrome [79]. This could be that individual's pair higher-calorie and carbohydrate foods with low-calorie/zero-calorie beverages. However, sugar-sweetened beverages (which include added sugars as the form of sweetener), including soda, fruit juice, and energy drinks [80] should still be limited. Ideally, they should be replaced with plain water, sparkling water, or flavored water as much as possible. Therefore, as access to a wide variety of foods and beverages

is limited in rural areas, the most important consideration may to limit sugar-sweetened beverages as they will directly increase blood glucose.

4.8. Alcohol

Moderate alcohol consumption is recommended for people with diabetes, and equates to approximately one drink per day. One drink is defined as a 12 oz of beer, a 5 oz glass of wine, or 1.5 oz of distilled spirits (approx. 15 g alcohol) [14]. However, one additional consideration is the carbohydrate/sugar content of different alcoholic drinks; that of beers is the highest and that of distilled spirits is the lowest; low-carb beers are available. It is also important to educate people with diabetes about the signs, symptoms, and self-management of delayed hypoglycemia after drinking alcohol, especially when using insulin or insulin secretagogues. In this case, wearing a medical ID bracelet or identification to identify oneself as a person with diabetes is recommended. The signs and symptoms of delayed hypoglycemia can range from hypertension, worsening neuropathy, dehydration, and cardiovascular diseases, to even certain cancers; however, with moderate and sensible alcohol consumption, adverse risks are minimized [81].

4.9. Dietary Patterns/Quality

The ADA guidelines state that a variety of eating patterns are suitable for people with diabetes [14]. Improving diet quality means increasing the consumption of plant foods and whole foods, in addition to reducing processed food intake. There is considerable flexibility for the rural physician within the ADA guidelines to modify patients' dietary patterns. The core concept is to improve carbohydrate quality (more whole grains and less refined grains) to help improve glycemia. Rural physicians must assess what foods the patient has access to and suggest an eating pattern that works best with their situation [21]. A simpler approach may be to utilize the ADA Diabetes Plate Method; resources available in [82]. Briefly, this method assumes a nine-inch plate, where half should be non-starchy vegetables, one quarter should be protein foods (lean), and the other quarter can be carbohydrate foods (grains, starchy vegetables, beans, fruits, or dairy), and water or a zero-calorie drink; see Figure 1.

Most people are aware of the Mediterranean diet and a low-fat diet; however, one dietary pattern that is receiving more attention is the very-low-carbohydrate diet. This is typically referred to as the ketogenic diet, and it is defined as maintaining a state of nutritional ketogenesis (a blood ketone level between 0.5 and 4.0 mM), by limiting the daily intake of carbohydrates to 20–50 g/d and that of protein to 1.5 g/kg of body weight, with the remainder of energy coming from fats [83]. While this diet is appropriate for some patients with diabetes (uncontrolled diabetes or requiring medication reduction), it requires time and resources to remain compliant, including monitoring blood and/or urinary ketones. Therefore, the very-low-carbohydrate diet may be impractical from a rural physician perspective (time and effort) as well as the rural patient perspective (cost and access to the right foods). Ultimately, it is best if the patient with diabetes is recommended to try a very-low-carbohydrate diet by the rural physician with full physician support.

5. Cultural Preferences

Cultural preferences are a vital component when providing dietary advice. Cultural preferences are not directly addressed in the ADA guidelines [14]; however, they come into play when creating an individualized diet. For example, African American diets often have starchy vegetables (white and sweet potatoes) as a staple food [84]. Starchy vegetables should be limited as they contribute to higher postprandial blood glucose [14]. In this case, a good starting point may be to reduce the serving size. Substitutes include pinto, kidney, or navy beans. Patients could also be encouraged to embrace the diversity of traditional vegetables in their diets, such as green leafy vegetables such as collard, mustard, or spinach greens [84], if available. Understanding the value of traditional foods in an individual's life is a core component of culturally competent nutritional recommendations, which can play a

huge role in patient compliance and overall improved health. Recommending foods outside of the patients' cultural preferences has been shown to lead to cultural disconnection, which in turn can lead to decreased adherence to recommended diet plans, and the possible loss of social support [85].

As a population, African Americans have the second highest incidence of diagnosed diabetes at 12.1%, in contrast to white Americans with a lower incidence of 7.4% [86]. Studies have attributed this difference to a variety of genetic and environmental factors, including the increased incidence of obesity, higher rate of insulin resistance (beginning in childhood and continuing into adulthood), and lower average physical activity. Furthermore, racial disparities in health care have contributed to Black Americans having disproportionately higher rates of diabetes complications (end-stage renal disease, lower-extremity amputations, retinopathies, and microalbuminuria) and mortality than white Americans [87]. For many African American patients, the purchasing, preparation, and consumption of food are important ways to preserve their cultural traditions and connect with their communities, especially during semi-regular, inter-generational gatherings [88]. A focus group study of Black communities in north central Florida, for instance, found that many participants perceived dietary changes as disrespectful to elders, "giving up part of their cultural heritage," and "trying to conform to the dominant culture" [89]. On the other hand, culturally competent dietary self-management interventions, such as helping patients modify existing recipes, has been shown to increase patient compliance and improve health outcomes (lower weight and A1C levels) [90].

Native Americans, also referred to as American Indians and Alaskan Natives (AI/ANs), have the highest rate of diabetes in the U.S. According to the National Diabetes Statistics Report, 14.7% of AI/AN's have been diagnosed with diabetes, which is approximately double the value for non-Hispanic whites at 7.5% [86]. However, it is important to note that diabetes prevalence in AI/AN's varies between regional populations, with those in the IHS Southwest Subregion 2 (Nevada, Arizona, and Utah) having the highest prevalence at 21.1% [91]. Age-adjusted diabetes mortality rates in AI/AN communities have been shown to be more than three times higher than the US average [92]. Furthermore, AI/AN individuals are more likely to experience the burdens of poverty, such as a limited ability to purchase more nutritious whole foods or reduced access to registered dieticians, especially in rural areas [93]. Native American patients are also more likely to have exacerbating comorbidities, with higher obesity and CVD mortality rates than the overall population [91]. Traditional Native American diets vary widely depending on their region and tribal group. The Special Diabetes Program for Indians (SDPI) has operated since 1997 and provides diabetes interventions (nutrition services, weight management programs, etc.), which address individual- and community-level factors in 80 tribes. SDPI programs use the CDC PreventT2 curriculum, which promotes moderate weight loss (5–7%) through increased physical exercise and dietary changes [94]. These nutritional modifications include increasing fiber, protein, and water intake, and reducing the consumption of foods high in carbohydrates and fat. According to the 2020 United States Census, however, 87% of those who identify as AI/AN live outside of tribal areas, and therefore may not have access to the SDPI and other Indian Health Service (IHS) resources [95]. Resources that can help the physician include the My Native Plate, which recommends a plate comprising 50% non-starchy vegetables, 25% grains and/or starchy vegetables, and 25% protein, and a side of fruit [96], as well as the Food Insecurity Assessment Tool and Resource List [97].

Apart from food preferences, factors such as non-citizenship status, lack of health insurance, migration stress, and certain acculturation patterns have been associated with increased risk for diabetes in immigrant populations [98]. Once diagnosed, immigrant populations face unique challenges in their disease management, including health insurance access, linguistic challenges, a lack of culturally sensitive care, variable health knowledge, and racial and ethnic discrimination [99]. These increased risk factors and challenges with disease management often compound in ways that can escape the understanding of physicians and medical professionals in the healthcare system. Yet, to effectively treat

these populations and encourage adherence to dietary treatment regimens, these additional factors and considerations are vital to understand. Cultural foods often serve as a vital component of an individual's cultural heritage, and for many immigrants serve to maintain connection to that heritage. Therefore, there is value and an increased likelihood of adherence to a diet, if the dietary plans are considerate and inclusive of an individual's ethnic diet. Culturally sensitive health education targeted towards ethnic minority groups have been found to improve glycemic control and increased adherence to diabetic treatment and lifestyle regimens [100]. When creating a diet plan with a patient, important considerations would include asking the patient about their current eating habits, how food might play a role in their heritage or lifestyle, and if food has social value to them. It may be more successful to work with patients to find dishes within their ethnic diet or encourage modifications of ethnic foods to meet diabetic requirements as opposed to encouraging them to switch to other diets. Social support has long been considered essential in helping individuals with diabetes management, but for immigrants and cultural minorities, social gatherings, especially those centered around ethnic foods that they can no longer have due to prescribed dietary restrictions, can serve as stressors [101]. Among populations with collectivist cultures, social harmony is highly valued. In these populations, strict diet regimens can serve as a disruption to social harmony, leading to increased social stress [102]. This, in turn, can lead to cultural disconnection and can contribute to immigrants and cultural minorities struggling to adhere to their treatment plans.

6. Summary and Conclusions

Nutritional guidelines for prediabetes and diabetes from expert societies are excellent resources; however, their utility may diminish in medical/food deserts. This represents a large gap in rural patient management as well as the gap in the literature related to dietary habits, dietary behaviors, and cultural preferences of people with diabetes in rural America. Table 1 summarizes the barriers to fully implementing nutritional guidelines, including DSMES, DPP, and intensive lifestyle interventions that have been shown to be effective. In rural areas, these programs are either not available or are cost-prohibitive to create locally. However, because of the complexity of the nutritional therapy required, certain groups are at a higher risk for complications in rural areas due to food and/or healthcare insecurity; these are those with eating disorders and other conditions (diabetes-related gastroparesis and chronic kidney disease). To encourage rural physicians and other rural healthcare professionals to utilize dietary management in diabetes, some form of Medicare/Medicaid reimbursement for nutritional therapy could be developed (as an alternative to MNT, which is legally defined). In addition, less expensive software licenses for dietary assessment solutions may alleviate the cost barrier. There is a great opportunity to create specific DSMES and DPP toolkits for rural physicians, which could be easier to implement (e.g., online modules and patient workbooks). Telemedicine remains an option for rural areas; however, it may need to be modified from its current form to fit the rural environment. A crucial aspect of successful dietary intervention is meeting the patient where they are. Cultural preferences must be included, as well as knowledge of the local foods available. For rural physicians initiating dietary therapy, this may be more important than any other factors.

The following bullet points and figure (Figure 4) summarize the information provided here to help supplement the ADA guidelines:

1. The process must be supportive and positive, and include cultural preferences.
2. Screen for malnutrition;
3. For weight loss, the 3500 kcal rule is a good starting point but has limitations.
4. Focus on improving diet quality, especially carbohydrate quality, to reduce micronutrient insufficiencies;
5. Limit sugar-sweetened beverages;
6. Focus on modifying snacks to help reduce energy intake, refined carbohydrates, and added sugars;

7. Increase plant foods and whole foods in the diet;
8. Decrease processed meat consumption, and reduce processed food where possible to reduce sodium;
9. Maintain good hydration;
10. Assess B_{12} status at least annually for those on metformin.

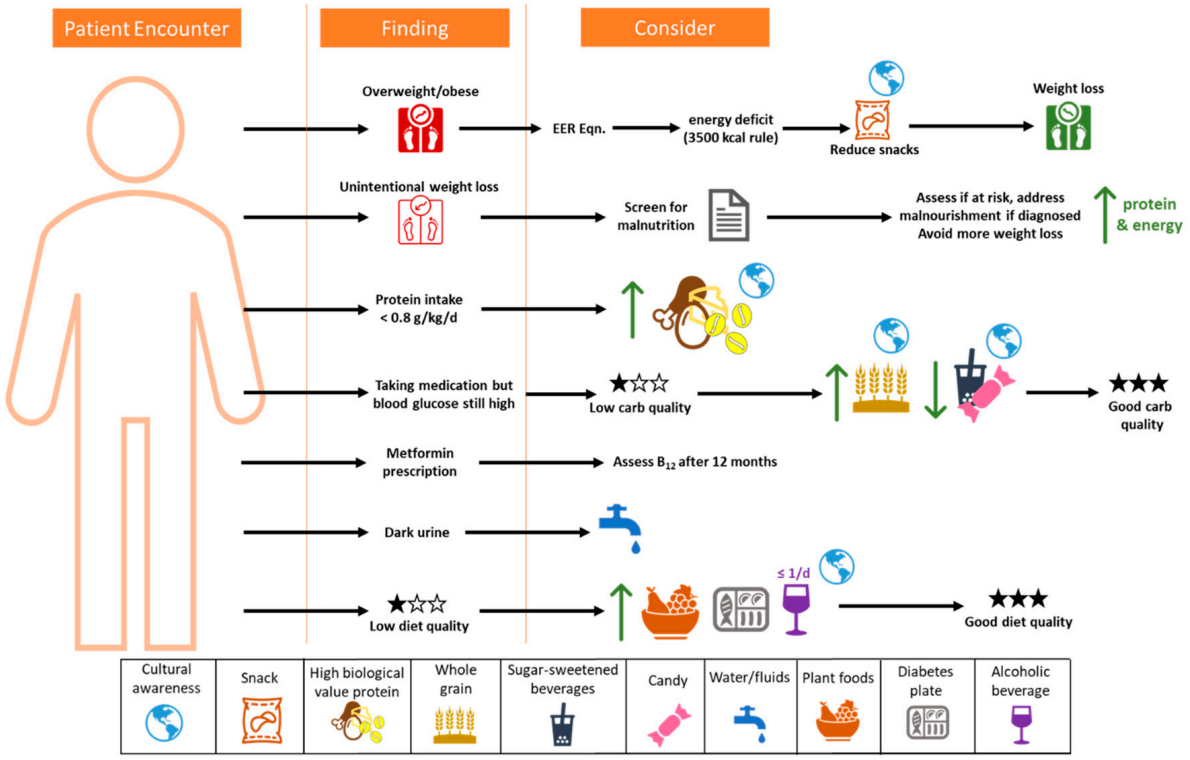

Figure 4. Supplemental information to help implement dietary guidelines for people with diabetes in rural areas. In this figure, the supplementary information is summarized in a schematic form. At patient encounters, one or more nutrition-related findings could be present and the considerations for follow up are included. The globe is placed where cultural preferences would be a vital consideration for successful outcomes.

The main limitation of this review is that due to the lack of nutritional data related to rural and underserved communities, the Supplementary Information included was not based on a series of systematic reviews and meta-analyses, though the information is generally accepted as useful in nutritional therapy. In addition, the information provided should not supersede good clinical judgement and experience. However, in some regards, this limitation forms the basis for the review—to highlight gaps in the current dietary guidelines for diabetes.

Creating new nutritional guidelines and lifestyle intervention programs for rural and underserved communities first requires that the knowledge gaps be filled. A good beginning is to assess the scale of the problem. Ideally, a NHANES type of study could be performed in rural areas across the country; this could be separate from, or integrated into, the current NHANES program. Rural physicians could be interviewed to learn their perceptions of, and approaches to, nutritional care in rural communities. In addition, an assessment of the available foods from local stores is required to obtain a picture of the rural nutritional landscape.

Apart from the evidence-based DSMES, DPP, and intensive lifestyle interventions, there are few major advancements in managing diabetes with healthy nutrition and lifestyle changes, with sufficient evidence to be included in nutritional guidelines. However, Virta Health have had success with a remote care model to reduce progression from prediabetes to diabetes, over two years [103]. This model could be modified and assessed for use in

rural areas. Ultimately it seems that lower-carbohydrate-type diets may become more mainstream in diabetes management. Glucagon-like peptide-1 (GLP-1) production can be increased and gut microbiota species can be improved using a food-based approach (low-carbohydrate diet, high in almonds) [104]. This suggests that modulating the gut microbiota with fibers may play a future role in the management of diabetes; see recent reviews [105,106]. Given the potential for micronutrient insufficiencies, as well as low intakes of phytonutrients, in rural areas, affordable dietary supplements that complement the rural diet may be an opportunity for future diabetes management. While the ADA does not recommend any supplements for a specific reduction in blood glucose [14], there must be some phytonutrients that can modulate blood glucose; after all, metformin is derived from a plant compound [107]. The leading candidates for future diabetes supplements have been reviewed previously [108]. One fascinating area as it relates to the future of diabetes management in rural areas is the utilization of n-of-1 clinical trials to develop personalized nutrition for rural and underserved areas, due to their unique circumstances. N-of-1 clinical trials were originally conceived for use in medicine, and they particularly suit the field of nutrition [109]. However, they are complex due to the repeated crossover of treatments and may not suit current outcomes of interest, e.g., A1C. The Westlake N-of-1 Trials for Macronutrient Intake (WE-MACNUTR) tested inter-individual variations in postprandial glycemic response and provided evidence that this type of trial is feasible [110,111]; however, its application in rural areas may require further modifications.

This review serves as a call to action for the nutritional health of rural America. The intention is to be a catalyst for the creation of diabetes nutrition guidelines for rural healthcare professionals, by rural healthcare professionals. The gap in knowledge provides endless opportunities for research in rural areas, especially in nutritional therapy. The authors are currently seeking collaborations to begin to gather nutritional information from rural communities. Learnings from rural communities may help improve current nutritional guidelines and diabetes prevention and care for all.

In conclusion, the key findings of this review are that (1) the current dietary guidelines for diabetes have significant gaps in relation to nutritional therapy in rural and underserved areas, (2) people with diabetes in rural areas are estimated to have a macronutrient distribution similar to that of those without diabetes, and be within the AMDR, (3) people with diabetes are estimated to consume a diet of poor quality and that may be insufficient in micronutrients, (4) supplemental resources to assist the rural physician initiate nutritional therapy were discussed and summarized, (5) cultural preferences must be part of the nutritional therapy approach for rural communities, and (6) there is an urgent need to investigate the nutritional environment of rural communities. The health of rural communities must be addressed, and rural physicians and other rural healthcare professionals must be supported with relevant guidelines and resources.

Author Contributions: Original concept, O.J.K.; writing first draft, E.D.E., K.K., A.S. (Anika Sharma), R.P., S.S., S.K., A.S. (Ali Shah) and O.J.K.; writing, reviewing and editing, all authors; All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Acknowledgments: The authors want to thank our Medical Librarian, Christina Seeger, for her help.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Bennett, K.J.; Borders, T.F.; Holmes, G.M.; Kozhimannil, K.B.; Ziller, E. What Is Rural? Challenges and Implications of Definitions that Inadequately Encompass Rural People and Places. *Health Aff.* **2019**, *38*, 1985–1992. [CrossRef]
2. Rutledge, S.A.; Masalovich, S.; Blacher, R.J.; Saunders, M.M. Diabetes Self-Management Education Programs in Nonmetropolitan Counties—United States, 2016. *Surveill. Summ.* **2017**, *66*, 1–6. [CrossRef]

3. O'Connor, A.; Wellenius, G. Rural–urban disparities in the prevalence of diabetes and coronary heart disease. *Public Health* **2012**, *126*, 813–820. [CrossRef]
4. Bolin, J.N.; Bellamy, G.R.; Ferdinand, A.O.; Vuong, A.M.; Kash, B.A.; Schulze, A.; Helduser, J.W. Rural Healthy People 2020: New Decade, Same Challenges. *J. Rural Health* **2015**, *31*, 326–333. [CrossRef]
5. Rosenblatt, R.A.; Hart, L.G. Physicians and rural America. *West. J. Med.* **2000**, *173*, 348–351. [CrossRef]
6. Feng, W.; Page, E.T.; Cash, S.B. Dollar Stores and Food Access for Rural Households in the United States, 2008–2020. *Am. J. Public Health* **2023**, *113*, 331–336. [CrossRef]
7. Li, Y.; Kou, C.; Bai, W.; Hua, W.; Yu, W.; Song, Y.; Liu, X.; Li, W. Trends in Diabetes Mortality by Gender in Urban and Rural Areas in China From 2003 to 2012: An Age-Period-Cohort Analysis. *Asia Pac. J. Public Health* **2019**, *31*, 238–245. [CrossRef]
8. Ranasinghe, P.; Jayawardena, R.; Gamage, N.; Sivanandam, N.; Misra, A. Prevalence and trends of the diabetes epidemic in urban and rural India: A pooled systematic review and meta-analysis of 1.7 million adults. *Ann. Epidemiol.* **2021**, *58*, 128–148. [CrossRef]
9. Loccoh, E.C.; Maddox, K.E.J.; Wang, Y.; Kazi, D.S.; Yeh, R.W.; Wadhera, R.K. Rural-Urban Disparities in Outcomes of Myocardial Infarction, Heart Failure, and Stroke in the United States. *J. Am. Coll. Cardiol.* **2022**, *79*, 267–279. [CrossRef]
10. Hammond, G.; Luke, A.A.; Elson, L.; Towfighi, A.; Joynt Maddox, K.E. Urban-Rural Inequities in Acute Stroke Care and In-Hospital Mortality. *Stroke* **2020**, *51*, 2131–2138. [CrossRef]
11. Chen, X.; Orom, H.; Hay, J.L.; Waters, E.A.; Schofield, E.; Li, Y.; Kiviniemi, M.T. Differences in Rural and Urban Health Information Access and Use. *J. Rural Health* **2019**, *35*, 405–417. [CrossRef]
12. Kozhimannil, K.B.; Interrante, J.D.; Henning-Smith, C.; Admon, L.K. Rural-Urban Differences In Severe Maternal Morbidity And Mortality In The US, 2007–2015. *Health Aff.* **2019**, *38*, 2077–2085. [CrossRef]
13. Cyr, M.E.; Etchin, A.G.; Guthrie, B.J.; Benneyan, J.C. Access to specialty healthcare in urban versus rural US populations: A systematic literature review. *BMC Health Serv. Res.* **2019**, *19*, 974. [CrossRef]
14. Evert, A.B.; Dennison, M.; Gardner, C.D.; Garvey, W.T.; Lau, K.H.K.; MacLeod, J.; Mitri, J.; Pereira, R.F.; Rawlings, K.; Robinson, S.; et al. Nutrition Therapy for Adults With Diabetes or Prediabetes: A Consensus Report. *Diabetes Care* **2019**, *42*, 731–754. [CrossRef]
15. ElSayed, N.A.; Aleppo, G.; Aroda, V.R.; Bannuru, R.R.; Brown, F.M.; Bruemmer, D.; Collins, B.S.; Hilliard, M.E.; Isaacs, D.; Johnson, E.L.; et al. 1. Improving Care and Promoting Health in Populations: Standards of Care in Diabetes-2023. *Diabetes Care* **2023**, *46*, S10–S18. [CrossRef]
16. Diabetes Canada Clinical Practice Guidelines Expert Committee; Sievenpiper, J.L.; Chan, C.B.; Dworatzek, P.D.; Freeze, C.; Williams, S.L. Nutrition Therapy. *Can. J. Diabetes* **2018**, *42* (Suppl. S1), S64–S79. [CrossRef]
17. Dyson, P.A.; Twenefour, D.; Breen, C.; Duncan, A.; Elvin, E.; Goff, L.; Hill, A.; Kalsi, P.; Marsland, N.; McArdle, P.; et al. Diabetes UK evidence-based nutrition guidelines for the prevention and management of diabetes. *Diabet. Med.* **2018**, *35*, 541–547. [CrossRef]
18. Gray, A.; Rebecca, J. *Nutritional Recommendations for Individuals with Diabetes*; Mdtext Com, Inc.: South Dartmouth, MA, USA, 2019.
19. Rosik, P.; Stępniak, M.; Wiśniewski, R. Delineation of health care deserts using accessibility measures: The case of Poland. *Eur. Plan. Stud.* **2020**, *29*, 1151–1173. [CrossRef]
20. Lucas-Gabrielli, V.; Chevillard, G. Medical deserts" and accessibility to care: What are we talking about? *Med. Sci.* **2018**, *34*, 599–603. [CrossRef]
21. Delk, J.A.; Singleton, B.A.; Al-Dahir, S.; Kirchain, W.; Bailey-Wheeler, J. The effect of food access on type 2 diabetes control in patients of a New Orleans, Louisiana, clinic. *J. Am. Pharm. Assoc.* **2022**, *62*, 1675–1679. [CrossRef]
22. Berkowitz, S.A.; Karter, A.J.; Corbie-Smith, G.; Seligman, H.K.; Ackroyd, S.A.; Barnard, L.S.; Atlas, S.J.; Wexler, D.J. Food Insecurity, Food "Deserts," and Glycemic Control in Patients With Diabetes: A Longitudinal Analysis. *Diabetes Care* **2018**, *41*, 1188–1195. [CrossRef] [PubMed]
23. Look, A.R.G.; Wing, R.R.; Bolin, P.; Brancati, F.L.; Bray, G.A.; Clark, J.M.; Coday, M.; Crow, R.S.; Curtis, J.M.; Egan, C.M.; et al. Cardiovascular effects of intensive lifestyle intervention in type 2 diabetes. *N. Engl. J. Med.* **2013**, *369*, 145–154. [CrossRef]
24. Smith, J.G.; Plover, C.M.; McChesney, M.C.; Lake, E.T. Isolated, small, and large hospitals have fewer nursing resources than urban hospitals: Implications for rural health policy. *Public Health Nurs.* **2019**, *36*, 469–477. [CrossRef] [PubMed]
25. Harrington, R.A.; Califf, R.M.; Balamurugan, A.; Brown, N.; Benjamin, R.M.; Braund, W.E.; Hipp, J.; Konig, M.; Sanchez, E.; Joynt Maddox, K.E. Call to Action: Rural Health: A Presidential Advisory From the American Heart Association and American Stroke Association. *Circulation* **2020**, *141*, e615–e644. [CrossRef]
26. Coughlin, S.S.; Clary, C.; Johnson, J.A.; Berman, A.; Heboyan, V.; Benevides, T.; Moore, J.; George, V. Continuing Challenges in Rural Health in the United States. *J. Environ. Health Sci.* **2019**, *5*, 90–92.
27. Dao, M.C.; Subar, A.F.; Warthon-Medina, M.; Cade, J.E.; Burrows, T.; Golley, R.K.; Forouhi, N.G.; Pearce, M.; Holmes, B.A. Dietary assessment toolkits: An overview. *Public Health Nutr.* **2019**, *22*, 404–418. [CrossRef]
28. Ikizler, T.A.; Burrowes, J.D.; Byham-Gray, L.D.; Campbell, K.L.; Carrero, J.J.; Chan, W.; Fouque, D.; Friedman, A.N.; Ghaddar, S.; Goldstein-Fuchs, D.J.; et al. KDOQI Clinical Practice Guideline for Nutrition in CKD: 2020 Update. *Am. J. Kidney Dis.* **2020**, *76*, S1–S107. [CrossRef]
29. Athinarayanan, S.J.; Roberts, C.G.P.; Adams, R.N.; Volk, B.M.; Phinney, S.D.; Volek, J.; McKenzie, A.L. 410-P: Two-Year (2y) eGFR Slope in People with Type 2 Diabetes (T2D) Receiving a Very Low Carbohydrate Diet (VLCD) Intervention. *Diabetes* **2023**, *72*, 410-P. [CrossRef]

30. Asano, M.; Fukuda, T.; Fukui, M.; Hashimoto, Y.; Oyabu, C.; Tanaka, M.; Yamazaki, M. Impact of low-carbohydrate diet on renal function: A meta-analysis of over 1000 individuals from nine randomised controlled trials. *Br. J. Nutr.* **2016**, *116*, 632–638. [CrossRef]
31. de Las Hazas, M.-C.L.; Dávalos, A. Individualization, Precision Nutrition Developments for the 21st Century. In *Advances in Precision Nutrition, Personalization and Healthy Aging*; Haslberger, A.G., Ed.; Springer International Publishing: Cham, Switzerland, 2022; pp. 25–50.
32. Haleem, A.; Javaid, M.; Singh, R.P.; Suman, R. Telemedicine for healthcare: Capabilities, features, barriers, and applications. *Sens. Int.* **2021**, *2*, 100117. [CrossRef]
33. Heitman, K.; Thomas, S.E.; Kelly, O.; Fanelli, S.M.; Krok-Schoen, J.L.; Luo, M.; Taylor, C.A. Snacks contribute considerably to total dietary intakes among adults stratified by glycemia in the United States. *PLoS Glob. Public Health* **2023**, *3*, e0000802. [CrossRef] [PubMed]
34. Fanelli, S.M.; Kelly, O.J.; Krok-Schoen, J.L.; Taylor, C.A. Low Protein Intakes and Poor Diet Quality Associate with Functional Limitations in US Adults with Diabetes: A 2005–2016 NHANES Analysis. *Nutrients* **2021**, *13*, 2582. [CrossRef] [PubMed]
35. Kelly, O.; Krok-Schoen, J.L.; Luo, M.; Taylor, C.A. Evaluation of Dietary Intakes of Macronutrients in Adults with Different A1C Levels. *Diabetes* **2018**, *67*, 763-P. [CrossRef]
36. Fanelli, S.; Kelly, O.; Luo, M.; Krok-Schoen, J.; Taylor, C. Differences in Micronutrient Intakes by Levels of Glycemic Control in US Adults. *J. Acad. Nutr. Diet.* **2018**, *118*, A133. [CrossRef]
37. Kelly, O.; Fanelli, S.M.; Krok-Schoen, J.L.; Taylor, C.A. 1577-P: Dietary Intake Trends Associated with Breakfast Skipping in U.S. Adults by Diabetes Status. *Diabetes* **2019**, *68*, 1577-P. [CrossRef]
38. Fanelli, S.M.; Jonnalagadda, S.S.; Pisegna, J.L.; Kelly, O.J.; Krok-Schoen, J.L.; Taylor, C.A. Poorer Diet Quality Observed Among US Adults With a Greater Number of Clinical Chronic Disease Risk Factors. *J. Prim. Care Community Health* **2020**, *11*, 2150132720945898. [CrossRef]
39. National Academies of Sciences, Engineering, and Medicine. *Dietary Reference Intakes for Energy*; The National Academies Press: Washington, DC, USA, 2023; p. 460.
40. Hall, K.D.; Sacks, G.; Chandramohan, D.; Chow, C.C.; Wang, Y.C.; Gortmaker, S.L.; Swinburn, B.A. Quantification of the effect of energy imbalance on bodyweight. *Lancet* **2011**, *378*, 826–837. [CrossRef]
41. Thomas, D.M.; Gonzalez, M.C.; Pereira, A.Z.; Redman, L.M.; Heymsfield, S.B. Time to correctly predict the amount of weight loss with dieting. *J. Acad. Nutr. Diet.* **2014**, *114*, 857–861. [CrossRef]
42. U.S. Department of Agriculture. MyPlate Plan. Available online: https://www.myplate.gov/myplate-plan (accessed on 1 January 2024).
43. Fleming, S.; Arensberg, M.B.; Kerr, K.; Blancato, R. The Opportunity for Quality Malnutrition Care to Improve Rural Health Outcomes and Health Equity for Older Americans. *OBM Geriatr.* **2023**, *07*, 227. [CrossRef]
44. Saunders, J.; Smith, T. Malnutrition: Causes and consequences. *Clin. Med.* **2010**, *10*, 624–627. [CrossRef]
45. ElSayed, N.A.; Aleppo, G.; Aroda, V.R.; Bannuru, R.R.; Brown, F.M.; Bruemmer, D.; Collins, B.S.; Hilliard, M.E.; Isaacs, D.; Johnson, E.L.; et al. 5. Facilitating Positive Health Behaviors and Well-being to Improve Health Outcomes: Standards of Care in Diabetes-2023. *Diabetes Care* **2023**, *46*, S68–S96. [CrossRef] [PubMed]
46. Medicine, I.O. *Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids*; The National Academies Press: Washington, DC, USA, 2005; p. 1358.
47. Guzman, J.R.; Lyra, R.; Aguilar-Salinas, C.A.; Cavalcanti, S.; Escano, F.; Tambasia, M.; Duarte, E.; Group, A.C. Treatment of type 2 diabetes in Latin America: A consensus statement by the medical associations of 17 Latin American countries. Latin American Diabetes Association. *Rev. Panam. Salud Publica* **2010**, *28*, 463–471. [CrossRef] [PubMed]
48. Mann, J.I.; De Leeuw, I.; Hermansen, K.; Karamanos, B.; Karlstrom, B.; Katsilambros, N.; Riccardi, G.; Rivellese, A.A.; Rizkalla, S.; Slama, G.; et al. Evidence-based nutritional approaches to the treatment and prevention of diabetes mellitus. *Nutr. Metab. Cardiovasc. Dis.* **2004**, *14*, 373–394. [CrossRef] [PubMed]
49. Misra, A.; Sharma, R.; Gulati, S.; Joshi, S.R.; Sharma, V.; Ghafoorunissa; Ibrahim, A.; Joshi, S.; Laxmaiah, A.; Kurpad, A.; et al. Consensus dietary guidelines for healthy living and prevention of obesity, the metabolic syndrome, diabetes, and related disorders in Asian Indians. *Diabetes Technol. Ther.* **2011**, *13*, 683–694. [CrossRef] [PubMed]
50. Sinska, B.; Kucharska, A. Dietary guidelines in diabetes—Why are they so difficult to follow? *Pediatr. Endocrinol. Diabetes Metab.* **2023**, *29*, 125–127. [CrossRef] [PubMed]
51. Hershon, K.S.; Hirsch, B.R.; Odugbesan, O. Importance of Postprandial Glucose in Relation to A1C and Cardiovascular Disease. *Clin. Diabetes* **2019**, *37*, 250–259. [CrossRef]
52. Ramsden, C.E.; Zamora, D.; Majchrzak-Hong, S.; Faurot, K.R.; Broste, S.K.; Frantz, R.P.; Davis, J.M.; Ringel, A.; Suchindran, C.M.; Hibbeln, J.R. Re-evaluation of the traditional diet-heart hypothesis: Analysis of recovered data from Minnesota Coronary Experiment (1968–73). *BMJ* **2016**, *353*, i1246. [CrossRef]
53. Carson, J.A.S.; Lichtenstein, A.H.; Anderson, C.A.M.; Appel, L.J.; Kris-Etherton, P.M.; Meyer, K.A.; Petersen, K.; Polonsky, T.; Van Horn, L.; American Heart Association Nutrition Committee of the Council; et al. Dietary Cholesterol and Cardiovascular Risk: A Science Advisory From the American Heart Association. *Circulation* **2020**, *141*, e39–e53. [CrossRef]
54. Ludwig, D.S. Lowering the Bar on the Low-Fat Diet. *JAMA* **2016**, *316*, 2087–2088. [CrossRef]
55. Harcombe, Z. US dietary guidelines: Is saturated fat a nutrient of concern? *Br. J. Sports Med.* **2019**, *53*, 1393–1396. [CrossRef]

56. Kaur, D.; Tallman, D.A.; Khosla, P. The health effects of saturated fats—The role of whole foods and dietary patterns. *Diabetes Metab. Syndr.* **2020**, *14*, 151–153. [CrossRef]
57. Derosa, G.; Maffioli, P. alpha-Glucosidase inhibitors and their use in clinical practice. *Arch. Med. Sci.* **2012**, *8*, 899–906. [CrossRef]
58. Rehani, P.R.; Iftikhar, H.; Nakajima, M.; Tanaka, T.; Jabbar, Z.; Rehani, R.N. Safety and Mode of Action of Diabetes Medications in comparison with 5-Aminolevulinic Acid (5-ALA). *J. Diabetes Res.* **2019**, *2019*, 4267357. [CrossRef]
59. Armstrong, L.E.; Barquera, S.; Duhamel, J.F.; Hardinsyah, R.; Haslam, D.; Lafontan, M. Recommendations for healthier hydration: Addressing the public health issues of obesity and type 2 diabetes. *Clin. Obes.* **2012**, *2*, 115–124. [CrossRef]
60. Janbozorgi, N.; Allipour, R.; Djafarian, K.; Shab-Bidar, S.; Badeli, M.; Safabakhsh, M. Water intake and risk of type 2 diabetes: A systematic review and meta-analysis of observational studies. *Diabetes Metab. Syndr.* **2021**, *15*, 102156. [CrossRef]
61. Vanhaecke, T.; Perrier, E.T.; Melander, O. A Journey through the Early Evidence Linking Hydration to Metabolic Health. *Ann. Nutr. Metab.* **2020**, *76* (Suppl. S1), 4–9. [CrossRef]
62. Johnson, E.C.; Bardis, C.N.; Jansen, L.T.; Adams, J.D.; Kirkland, T.W.; Kavouras, S.A. Reduced water intake deteriorates glucose regulation in patients with type 2 diabetes. *Nutr. Res.* **2017**, *43*, 25–32. [CrossRef]
63. Wolfsdorf, J.; Glaser, N.; Sperling, M.A.; American Diabetes, A. Diabetic ketoacidosis in infants, children, and adolescents: A consensus statement from the American Diabetes Association. *Diabetes Care* **2006**, *29*, 1150–1159. [CrossRef]
64. Gosmanov, A.R.; Gosmanova, E.O.; Dillard-Cannon, E. Management of adult diabetic ketoacidosis. *Diabetes Metab. Syndr. Obes.* **2014**, *7*, 255–264. [CrossRef]
65. Medicine, I.O. *Dietary Reference Intakes for Water, Potassium, Sodium, Chloride, and Sulfate*; The National Academies Press: Washington, DC, USA, 2005; p. 638.
66. Begg, D.P. Disturbances of thirst and fluid balance associated with aging. *Physiol. Behav.* **2017**, *178*, 28–34. [CrossRef]
67. Kavouras, S.A. Assessing hydration status. *Curr. Opin. Clin. Nutr. Metab. Care* **2002**, *5*, 519–524. [CrossRef] [PubMed]
68. Kostelnik, S.B.; Davy, K.P.; Hedrick, V.E.; Thomas, D.T.; Davy, B.M. The Validity of Urine Color as a Hydration Biomarker within the General Adult Population and Athletes: A Systematic Review. *J. Am. Coll. Nutr.* **2021**, *40*, 172–179. [CrossRef] [PubMed]
69. Armstrong, L.E.; Maresh, C.M.; Castellani, J.W.; Bergeron, M.F.; Kenefick, R.W.; LaGasse, K.E.; Riebe, D. Urinary indices of hydration status. *Int. J. Sport. Nutr.* **1994**, *4*, 265–279. [CrossRef] [PubMed]
70. Wardenaar, F.C.; Thompsett, D.; Vento, K.A.; Pesek, K.; Bacalzo, D. Athletes' Self-Assessment of Urine Color Using Two Color Charts to Determine Urine Concentration. *Int. J. Environ. Res. Public Health* **2021**, *18*, 4126. [CrossRef] [PubMed]
71. Wardenaar, F.C.; Thompsett, D.; Vento, K.A.; Bacalzo, D. A lavatory urine color (LUC) chart method can identify hypohydration in a physically active population. *Eur. J. Nutr.* **2021**, *60*, 2795–2805. [CrossRef]
72. MedlinePlus. Urine—Abnormal Color. Available online: https://medlineplus.gov/ency/article/003139.htm (accessed on 30 December 2023).
73. National Institutes of Health. Nutrient Recommendations and Databases. Available online: https://ods.od.nih.gov/HealthInformation/nutrientrecommendations.aspx (accessed on 30 December 2023).
74. Chehade, J.M.; Sheikh-Ali, M.; Mooradian, A.D. The Role of Micronutrients in Managing Diabetes. *Diabetes Spectr.* **2009**, *22*, 214–218. [CrossRef]
75. Shearer, J.; Swithers, S.E. Artificial sweeteners and metabolic dysregulation: Lessons learned from agriculture and the laboratory. *Rev. Endocr. Metab. Disord.* **2016**, *17*, 179–186. [CrossRef]
76. Tey, S.L.; Salleh, N.B.; Henry, J.; Forde, C.G. Effects of aspartame-, monk fruit-, stevia- and sucrose-sweetened beverages on postprandial glucose, insulin and energy intake. *Int. J. Obes.* **2017**, *41*, 450–457. [CrossRef]
77. Mejia, E.; Pearlman, M. Natural Alternative Sweeteners and Diabetes Management. *Curr. Diabetes Rep.* **2019**, *19*, 142. [CrossRef]
78. Purohit, V.; Mishra, S. The truth about artificial sweeteners—Are they good for diabetics? *Indian Heart J.* **2018**, *70*, 197–199. [CrossRef]
79. Nettleton, J.A.; Lutsey, P.L.; Wang, Y.; Lima, J.A.; Michos, E.D.; Jacobs, D.R., Jr. Diet soda intake and risk of incident metabolic syndrome and type 2 diabetes in the Multi-Ethnic Study of Atherosclerosis (MESA). *Diabetes Care* **2009**, *32*, 688–694. [CrossRef]
80. Imamura, F.; O'Connor, L.; Ye, Z.; Mursu, J.; Hayashino, Y.; Bhupathiraju, S.N.; Forouhi, N.G. Consumption of sugar sweetened beverages, artificially sweetened beverages, and fruit juice and incidence of type 2 diabetes: Systematic review, meta-analysis, and estimation of population attributable fraction. *BMJ* **2015**, *351*, h3576. [CrossRef] [PubMed]
81. van de Wiel, A. Diabetes mellitus and alcohol. *Diabetes Metab. Res. Rev.* **2004**, *20*, 263–267. [CrossRef] [PubMed]
82. American Diabetes Association. What Is the Diabetes Plate Method? Available online: https://www.diabetesfoodhub.org/articles/what-is-the-diabetes-plate-method.html (accessed on 30 December 2023).
83. Gardner, C.D.; Landry, M.J.; Perelman, D.; Petlura, C.; Durand, L.R.; Aronica, L.; Crimarco, A.; Cunanan, K.M.; Chang, A.; Dant, C.C.; et al. Effect of a ketogenic diet versus Mediterranean diet on glycated hemoglobin in individuals with prediabetes and type 2 diabetes mellitus: The interventional Keto-Med randomized crossover trial. *Am. J. Clin. Nutr.* **2022**, *116*, 640–652. [CrossRef] [PubMed]
84. Kulkarni, K.D. Food, Culture, and Diabetes in the United States. *Clin. Diabetes* **2004**, *22*, 190–192. [CrossRef]
85. Woodside, J.; Young, I.S.; McKinley, M.C. Culturally adapting the Mediterranean Diet pattern—A way of promoting more 'sustainable' dietary change? *Br. J. Nutr.* **2022**, *128*, 693–703. [CrossRef] [PubMed]
86. Centers for Disease Control and Prevention. National Diabetes Statistics Report Website. Available online: https://www.cdc.gov/diabetes/data/statistics-report/index.html (accessed on 12 December 2023).

87. Marshall, M.C., Jr. Diabetes in African Americans. *Postgrad. Med. J.* **2005**, *81*, 734–740. [CrossRef] [PubMed]
88. Kittler, P.G.; Sucher, K.P.; Nelms, M. *Food and Culture*, 7th ed.; Cengage Learning: Boston, MA, USA, 2017.
89. James, D.C. Factors influencing food choices, dietary intake, and nutrition-related attitudes among African Americans: Application of a culturally sensitive model. *Ethn. Health* **2004**, *9*, 349–367. [CrossRef]
90. Anderson-Loftin, W.; Barnett, S.; Bunn, P.; Sullivan, P.; Hussey, J.; Tavakoli, A. Soul food light: Culturally competent diabetes education. *Diabetes Educ.* **2005**, *31*, 555–563. [CrossRef]
91. Bullock, A.; Sheff, K.; Hora, I.; Burrows, N.R.; Benoit, S.R.; Saydah, S.H.; Hardin, C.L.; Gregg, E.W. Prevalence of diagnosed diabetes in American Indian and Alaska Native adults, 2006–2017. *BMJ Open Diabetes Res. Care* **2020**, *8*, e001218. [CrossRef]
92. Indian Health Service. Disparities. Available online: https://www.ihs.gov/newsroom/factsheets/disparities/ (accessed on 12 December 2023).
93. Stotz, S.; Brega, A.G.; Lockhart, S.; Hebert, L.E.; Henderson, J.N.; Roubideaux, Y.; Moore, K. An online diabetes nutrition education programme for American Indian and Alaska Native adults with type 2 diabetes: Perspectives from key stakeholders. *Public Health Nutr.* **2021**, *24*, 1449–1459. [CrossRef] [PubMed]
94. Centers for Disease Control and Prevention. National Diabetes Prevention Program. Available online: https://www.cdc.gov/diabetes/prevention/resources/curriculum.html (accessed on 30 December 2023).
95. OMH. American Indian/Alaska Native. Available online: https://minorityhealth.hhs.gov/omh/browse.aspx?lvl=3&lvlid=62 (accessed on 12 December 2023).
96. Indian Health Service. My Native Plate. Available online: https://www.ihs.gov/diabetes/education-materials-and-resources/index.cfm?module=productDetails&productID=2468 (accessed on 30 December 2023).
97. Indian Health Service. Food Insecurity Assessment Tool and Resource List. Available online: https://www.ihs.gov/diabetes/education-materials-and-resources/index.cfm?module=productDetails&productID=332 (accessed on 30 December 2023).
98. Dias, J.; Echeverria, S.; Mayer, V.; Janevic, T. Diabetes Risk and Control in Multi-ethnic US Immigrant Populations. *Curr. Diabetes Rep.* **2020**, *20*, 73. [CrossRef] [PubMed]
99. Payton, C.; Kimball, S.; Ahrenholz, N.C.; Wieland, M.L. Preventive Care and Management of Chronic Diseases in Immigrant Adults. *Prim. Care* **2021**, *48*, 83–97. [CrossRef] [PubMed]
100. Attridge, M.; Creamer, J.; Ramsden, M.; Cannings-John, R.; Hawthorne, K. Culturally appropriate health education for people in ethnic minority groups with type 2 diabetes mellitus. *Cochrane Database Syst. Rev.* **2014**, *9*, CD006424. [CrossRef] [PubMed]
101. McConatha, J.T.; Kumar, V.K.; Raymond, E.; Akwarandu, A. Cultural Dimensions of Diabetes Management: A Qualitative Study of Middle Eastern Immigrants in the U.S. *J. Cross-Cult. Gerontol.* **2020**, *35*, 85–98. [CrossRef] [PubMed]
102. Li-Geng, T.; Kilham, J.; McLeod, K.M. Cultural Influences on Dietary Self-Management of Type 2 Diabetes in East Asian Americans: A Mixed-Methods Systematic Review. *Health Equity* **2020**, *4*, 31–42. [CrossRef]
103. McKenzie, A.L.; Athinarayanan, S.J.; McCue, J.J.; Adams, R.N.; Keyes, M.; McCarter, J.P.; Volek, J.S.; Phinney, S.D.; Hallberg, S.J. Type 2 Diabetes Prevention Focused on Normalization of Glycemia: A Two-Year Pilot Study. *Nutrients* **2021**, *13*, 749. [CrossRef]
104. Ren, M.; Zhang, H.; Qi, J.; Hu, A.; Jiang, Q.; Hou, Y.; Feng, Q.; Ojo, O.; Wang, X. An Almond-Based Low Carbohydrate Diet Improves Depression and Glycometabolism in Patients with Type 2 Diabetes through Modulating Gut Microbiota and GLP-1: A Randomized Controlled Trial. *Nutrients* **2020**, *12*, 3036. [CrossRef]
105. Iatcu, C.O.; Steen, A.; Covasa, M. Gut Microbiota and Complications of Type-2 Diabetes. *Nutrients* **2021**, *14*, 166. [CrossRef]
106. Salazar, J.; Angarita, L.; Morillo, V.; Navarro, C.; Martinez, M.S.; Chacin, M.; Torres, W.; Rajotia, A.; Rojas, M.; Cano, C.; et al. Microbiota and Diabetes Mellitus: Role of Lipid Mediators. *Nutrients* **2020**, *12*, 3039. [CrossRef]
107. Bailey, C.J. Metformin: Historical overview. *Diabetologia* **2017**, *60*, 1566–1576. [CrossRef] [PubMed]
108. Petroni, M.L.; Brodosi, L.; Marchignoli, F.; Sasdelli, A.S.; Caraceni, P.; Marchesini, G.; Ravaioli, F. Nutrition in Patients with Type 2 Diabetes: Present Knowledge and Remaining Challenges. *Nutrients* **2021**, *13*, 2748. [CrossRef] [PubMed]
109. Zheng, J.S.; Ordovas, J.M. Precision nutrition for gut microbiome and diabetes research: Application of nutritional n-of-1 clinical trials. *J. Diabetes* **2021**, *13*, 1059–1061. [CrossRef] [PubMed]
110. Ma, Y.; Fu, Y.; Tian, Y.; Gou, W.; Miao, Z.; Yang, M.; Ordovas, J.M.; Zheng, J.S. Individual Postprandial Glycemic Responses to Diet in n-of-1 Trials: Westlake N-of-1 Trials for Macronutrient Intake (WE-MACNUTR). *J. Nutr.* **2021**, *151*, 3158–3167. [CrossRef]
111. Tian, Y.; Ma, Y.; Fu, Y.; Zheng, J.S. Application of n-of-1 Clinical Trials in Personalized Nutrition Research: A Trial Protocol for Westlake N-of-1 Trials for Macronutrient Intake (WE-MACNUTR). *Curr. Dev. Nutr.* **2020**, *4*, nzaa143. [CrossRef]