NCPD 2.0
ANCC CONTACT HOURS

SHUTTERSTOCK/MARILYN BARBONE

Insulin-to-carbohydrate ratios: An overview for nurses

BY LORRAINE LACCETTI MONGIELLO, DrPH, RDN, CDCES

Abstract: Carbohydrate counting is an efficacious technique to safely achieve glycemic targets and improve outcomes for patients using meal-time insulin. This article provides nurses with the knowledge and skills to assist and support their patients. It also reviews how to evaluate glycemic control and provides guidelines for referral to diabetes education programs.

Keywords: advanced carbohydrate counting, consistent carbohydrate intake, correction dose, insulin sensitivity factor, insulin-to-carbohydrate ratio, time-in-range

Each year, 1.4 million new cases of diabetes (about 5.9 per 1,000 people) are diagnosed in the US.[1] The prevalence of diabetes nationwide is projected to increase to 100 million people by 2050.[2] Diabetes has become one of the most expensive chronic diseases nationwide, costing $327 billion each year.[3] Therefore, it is an individual hardship and a substantial economic and public health burden.[4]

Effective blood glucose (BG) management is essential to reducing this burden, which can lower the risk of diabetic retinopathy, nephropathy, and neuropathy by 40%.[5] While diet modification, physical activity, and medications are the primary tools used to achieve glycemic targets, there is no one-size-fits-all approach to these modalities. In addition, BG levels vary both between and within individuals. Thus, treatments need to be specifically tailored to individual patients and self-management encouraged.

Though the registered dietitian nutritionist (RDN) is the primary provider of nutrition counseling and education, nurses and other healthcare team members must have the skills to assist patients with meal planning and address basic nutrition-related questions or concerns.[4] A multidisciplinary team that freely

Outpatient glycemic targets in nonpregnant adults

ADA[8]	AACE[9]
A1C < 7% without significant hypoglycemia(lower levels may be appropriate)	A1C ≤ 6.5% (less stringent for "less healthy")
FBS 80-130 mg/dL	FBS 70-110 mg/dL
Peak (1-2 hours) postprandial < 180 mg/dL	2 hours postprandial < 140 mg/dL

Abbreviation: FBS, fasting blood sugar

communicates with each other and the patient is essential to provide the best care and improve outcomes.

Nurses must routinely assess the patient for knowledge deficits regarding meal planning, any stress or distress associated with eating, weight change, and if the patient is reaching treatment targets. A referral for medical nutrition therapy (MNT) should be made when appropriate, ideally to a dietitian with an advanced certification, such as Certified Diabetes Care and Education Specialist or Board Certified-Advanced Diabetes Management.[6] MNT includes a comprehensive nutrition assessment, a nutrition diagnosis as well as therapeutic and counseling services, which can only be provided by an RDN.[7]

People with diabetes (PWD) should also be informed that Medicare and most private insurers cover outpatient MNT provided by RDNs for beneficiaries with diabetes, kidney disease, or a kidney transplant in the previous 36 months.[8]

Glycemic targets

Several methods can be used to determine the efficacy of treatment. A1C, which estimates mean BG concentration during the preceding 2-3 months by incorporating both pre- and postprandial glycemia, has been the principal metric to guide management. Although it does not indicate highs and lows, it is a useful indicator of overall glycemic control and a known predictor of diabetes complications.[4,5,9] A 2-hour postprandial BG is a very useful and immediate indicator of the effect of meals; its use should be encouraged.[10]

Time-in-range (TIR), or the time spent in the target BG range, has emerged as an extremely helpful gauge of BG status throughout the day for PWD who use continuous glucose monitors (CGMs). A CGM is a wearable sensor that automatically measures the amount of glucose in interstitial fluid. CGM systems provide both real-time and predictive glycemic information. The robust data garnered from a CGM can also be used to discover trends, identify asymptomatic events, and analyze glycemic variability over time. The consensus is that most PWD should aim for a TIR between 70 and 180 mg/dL at least 70% of the time (roughly 17 out of 24 hours).[11,12]

The integration of TIR data into self-management education is increasing. It received a boost when early in 2022, Medicare expanded access and removed major barriers for PWD to use CGM devices. Nurses play an important role in informing patients about the value of CGM, TIR, teaching, and supporting decision-making based on CGM data. Additionally, remote access to these metrics can be extremely useful for telemedicine.[14]

The American Diabetes Association (ADA)[14] and the American Association of Clinical Endocrinologists (AACE)[10] each provide guidelines for setting glycemic targets (see *Outpatient glycemic targets in nonpregnant adults*).[4] The ADA recommendations tend to be used by general practitioners, while the AACE guidelines, with their more aggressive targets, are more frequently followed by endocrinologists.[15] The two groups agree that it is necessary to tailor targets based on several factors, including age, social support, access to healthcare, and patient motivation.[10,14]

This review discusses advanced carbohydrate counting, a valuable and popular meal-planning technique for patients with type 1 or type 2 diabetes using bolus meal-time insulin.

Advanced carbohydrate counting

One hundred years ago, the first insulin injection was administered to a 14-year-old boy, transforming type 1 diabetes from a death decree to a chronic disease.[16] Before that, the only treatments available were austere diets with negligible amounts of carbohydrates and limited calories, as little as 450 daily.[17] Medical reports indicate that physicians prescribed a 70% fat, 8% carbohydrate diet to prevent glycosuria and acidosis, decrease coma, and delay death.[18] Obviously, these diets were not sustainable; it was not uncommon for children to perish from starvation.[17]

Today, PWD are still advised to focus on carbohydrates as they are the primary dietary influence on postprandial BG levels. While the amount of carbohydrate intake required for optimal human health has yet to be established, there is guidance on the intake of this macronutrient. The National Academy of Medicine established a minimum of 130 grams per day for adults. This is based solely on the amount of carbohydrates required to provide the brain with adequate glucose.[19] Dietary recommendations for carbohydrates are also made in the form of an acceptable macronutrient distribution

range (AMDR) based on calorie intake and designed to be used for the planning and assessment of the diets of healthy people. The AMDR for carbohydrates is 45% to 65% of total daily calories.[19] Thus, because carbohydrates have 4 calories per gram, the daily recommendation for a person whose energy needs are 2,100 calories per day is between 236 and 341 grams. The vast range of this recommendation leaves much room for individual variability. More notably, the importance of the quality of carbohydrate foods selected is known and clearly understood. Ideally, foods that are minimally processed; rich in dietary fiber, vitamins, and minerals; and low in added sugars, fats, and sodium should be emphasized.[6,21]

Reducing overall carbohydrate intake for PWD has been shown to improve glycemia and may be used in various eating patterns; but, for PWD using insulin at meal time, there is an alternative to restricting carbohydrate foods.[6] The 2023 ADA's *Standards of Care in Diabetes* states that those using meal-time insulin be offered advanced carbohydrate counting instruction and continuing education to equip them with the skills and support required to determine insulin dose based on carbohydrate intake.[22]

Two levels of carbohydrate counting have been identified: basic and advanced.[23] Learning to use either method allows PWD to make informed food choices. These methods empower patients and foster patient autonomy, enabling them to incorporate favorite, culturally meaningful and preferred foods while still reaching BG goals.[24]

Nurses can and should provide education and support to assist patients in making informed decisions, weighing the cost and benefits of various treatment options, and setting self-behavior goals.[25] Nurses may help or harm PWD depending on the words and messages used.[26] It is important not to tell PWD what to eat or what not to eat, nor label a food "good" or "bad." Instead, guide patients in determining what is best for them.[26] Practitioners who encourage autonomy increase the patient's perceived competence and the patient is significantly more likely to engage in diabetes self-management behaviors and report a higher sense of diabetes self-efficacy.[27-29]

Basic carbohydrate counting or consistent carbohydrate intake is a structured approach that emphasizes consistency in the timing of meals and the number of carbohydrates in meals.

Basic carbohydrate counting or consistent carbohydrate intake is a structured approach that emphasizes consistency in the timing of meals and the number of carbohydrates in meals. It is appropriate for PWD who are not taking insulin or those taking a fixed daily dose. Of course, the specific amount of carbohydrates needs to be determined. An important goal of MNT is that PWD be provided with guidance about a consistent pattern of carbohydrate intake regarding the time and amount consumed while also considering the insulin action time, as it can result in better glycemic control and reduce the risk of hypoglycemia.[22]

Advanced carbohydrate counting is much more flexible than the basic method. Rather than focusing on meal consistency, this method requires adjusting the insulin dose to cover the carbohydrates in each meal. This allows food choices to vary in type and amount from meal to meal and day to day. Patient instruction involves teaching PWD the relationship among meals; oral medications; insulin; physical activity; diabetes distress; emotional and physical stresses, such as sleep disturbances and illness; and BG levels. Treatment plans must be created in collaboration with patients and supported by nurses.

While advanced carbohydrate counting ultimately simplifies food decisions, it can initially be overwhelming. Food literacy, math skills, patient interest, and capability must be assessed to determine if a patient is a good candidate for advanced carbohydrate counting[12] Personalized strategies are often necessary for patients with low literacy and those with a history of or current depression, as they are likely to have a lower perceived confidence level.[30] The incorporation of advanced technologies, such as CGM, insulin pumps with bolus algorithms, and telemedicine, can help boost confidence, the accuracy of calculations, and improved outcomes.[12,31]

Two steps of advanced carbohydrate counting

Step 1: Cover the carbs

The first step is to determine the dose of rapid-acting insulin required to cover the total grams of carbohydrates in a meal. To do this, one must determine the patient's insulin-to-carbohydrate ratio (ICR). For example, this ratio may be 1:20 for someone very sensitive to insulin or only 1:8 for someone less sensitive. A ratio of 1:15 would indicate that

The 500 rule

If an individual's daily insulin dose is 13 units of basal insulin and 20 units of bolus insulin, the estimated insulin-to-carbohydrate ratio is 1:15.

13+20 = 33 units (TDD)

500/33 = 15

insulin-to-carbohydrate ratio = 1:15

for every 15 grams of carbohydrate consumed, 1 unit of rapid-acting or bolus insulin is required.[12]

A starting insulin correction ratio can be estimated in three ways. It can be based on a person's weight. For example, 101 to 120 lb would have a ratio of 1:18; 231 to 270 lb a ratio of 1:6. This approach is grounded on the general observation that as body size increases, so does insulin resistance. Thus, each unit of insulin will cover more carbohydrates in a lighter individual than in a heavier individual. A potential problem with this method is that it does not consider body composition. An individual who weighs 180 lb, but is very muscular, will be much more sensitive to insulin than a person weighing 180 lb with a higher percentage of body fat.[12]

It is also important to understand that one's sensitivity to insulin and glucose metabolism is variable throughout the day based on one's circadian rhythm, making it likely that insulin requirements will not be the same at breakfast and dinner.[32,33] Basing the insulin correction ratio on weight alone will not account for circadian variations.[12]

A second way to estimate a starting insulin correction ratio is the "500 rule," which was established on the basis that a typical diet contains about 500 grams of carbohydrates daily. To approximate the insulin correction ratio using this method, divide 500 by the patient's total daily dose (TDD) of all types of insulin (see *The 500 rule*).[12]

The 500 rule has three major flaws: it assumes that all people eat about the same amount of carbohydrates daily and that the current TDD of insulin adequately controls BG, and it does not account for the changes in insulin sensitivity throughout the day. The 500 rule and the weight method require trial and error and fine-tuning to determine accurate insulin correction ratios.[12]

Lastly, insulin correction ratios can be determined by reviewing the patient's food logs, including carbohydrate intake, insulin dose, and pre-/postmeal BG levels. This method is the most accurate, but it can be tedious and requires numerous sessions with the educator.[12]

To accurately determine an ICR, the patient must be able to judge portion size and read labels or use technology to identify the exact amount of carbohydrates in their meals. A recent study showed that subjects generally underestimated the carbohydrate content of test meals, especially in meals with higher carbohydrate content; however, repetition of estimation significantly improved accuracy.[34] Educators should adopt a learning-by-doing approach as problem-based education promotes the development of the required food-related skills.[35,36] A CGM can facilitate the process, but self-testing of BG can also be used to determine ICRs (see *Sample patient log*).

Sample patient log

	Day 1	Day 2	Day 3	Day 4
Pre-Meal BG	100 mg/dL	102 mg/dL	98 mg/dL	96 mg/dL
Rapid Insulin Dose	5 units	5 units	5 units	5 units
Carbohydrate Intake	60 grams	24 grams	84 grams	58 grams
2-h Post-Meal BG	138 mg/dL	74 mg/dL	189 mg/dL	131 mg/dL
BG Change	↑ 38 mg/dL	↓ 28 mg/dL	↑ 91 mg/dL	↑ 35 mg/dL
Target Achieved	YES	NO	NO	YES
ICR (carb/insulin)	**60/5 = 12.0**	**24/5 = 4.8**	**84/5 = 16.8**	**58/5 = 11.6**

This sample patient log reveals that the fixed premeal insulin dose of 5 units only worked half the time. This is valuable information that should be used by both the educator and the patient to adjust treatment.

On Day 1 and Day 4, 5 units adequately covered the meal, evidenced by a postprandial excursion of about 40 mg/dL or less. However, on Day 2, 5 units were more than required; on Day 3, too little insulin was taken. Using these data, the ICR used can be determined by dividing carbohydrates in the meal by 5 units of insulin. On the 2 days that postmeal targets were met, an ICR of 1:12 and 1:11.6 were used, respectively. In this case, an ICR of 1:12 could be a good starting point for the patient.

Using an ICR of 1:12, the correct dose for Day 2 would be approximately 2 units (24/12) and 7 units on Wednesday (84/12). This ratio needs to be tested and fine-tuned by analyzing the patient's logs at varying times to evaluate individual responses and guide insulin dose adjustments. Once established, the ICR can be applied to high- and low-carbohydrate meals, and less BG testing would be required.[12]

Step 2: Calculate correction dose
Administering the required amount of insulin to cover a meal is necessary; however, it will not address preexisting highs or lows. The premeal bolus dose must be adjusted if the BG is significantly above or below the patient's target range. This is achieved by applying the insulin sensitivity factor (ISF) or correction factor (a measure of the amount BG is reduced by one unit of rapid-acting insulin in about 2-4 hours). This decrease can range from 30 to 100 mg/dL, depending on individual insulin sensitivities, so individuals need to be aware of their ISF.

To estimate an ISF for those using rapid-acting insulin, the standard "1700 rule" is commonly used. This is done by dividing 1700 by the TDD of insulin (see *The 1700 rule*).

It is important to consider how much insulin is on board (IOB) prior to applying a correction dose to prevent what is known as insulin stacking.[12] This occurs when a dose of insulin is given while a previous insulin dose or the IOB is still active. Insulin stacking increases the potential for severe hypoglycemia.[12] Stacking is less likely with insulin pumps. They can calculate active insulin when determining a bolus dose by registering how much insulin was given for the carbohydrates and correction at the last meal and then using an algorithm for IOB to predict how much is still working in the body. This amount left as IOB is then deducted from the potential correction required. Several useful apps are available for those not using pumps that use an algorithm to calculate a bolus dose based on carbohydrate intake, a person's ICR, and target BG levels.[24,37]

Excessive calorie intake is a potential downside when carbohydrate counting. Since the focus is solely on carbohydrates and portions are not limited, patients may eat too many calories and overlook the amount and type of fats they consume.[12] However, a recent systematic review and meta-analysis of randomized clinical trials indicated that carbohydrate counting does not relate to any substantial change in blood lipids or body weight.[38] Nevertheless, weight change and lipid levels should be monitored and, when indicated, nutrition education and support provided to encourage eating patterns that align with the US Department of Agriculture's *2020-2025 Dietary Guidelines for Americans* and the patient's weight goals.[39]

The 1700 rule

Premeal BG: 197 mg/dL **Target premeal BG:** 110 mg/dL **Carbohydrate:** 60 grams **ISF:** 28 **ICR:** 15	The required bolus dose for this patient would be 7 units of insulin: 4 units to cover the carbohydrate (60/15 = 4), plus 3 units to lower the premeal BG, which is 87 points above the target (87/28 = 3).
Premeal BG: 80 mg/dL **Target premeal BG:** 110 mg/dL **Carbohydrate:** 60 grams **ISF:** 28 **ICR:** 15	In this case, using the ICR of 1:15, 4 units to cover the carbohydrate is required; but, since the starting BG is 30 points under target, we must use the ISF to prevent postmeal hypoglycemia. This is done by subtracting 1 unit (30/28 = 1), so the total dose would be 3 units (4-3 = 1).

Fiber and sugar alcohols

Fiber has numerous health benefits. Foods high in fiber are typically nutrient-dense, providing bulk without excess calories. PWD and those at risk for diabetes are encouraged to eat the same amount of dietary fiber suggested for all people.[6] A minimum of 14 grams of fiber per 1,000 calories consumed is currently recommended.[39]

There are two different types of fiber—soluble and insoluble. Soluble fiber found primarily in oat bran, barley, nuts, seeds, some fruits, and legumes dissolves in water and slows digestion. Some of the soluble fiber in food can be broken down by bacteria in the large intestine hours after consumption, making calories available to the body, mainly from short-chain fatty acids. Thus, energy content can vary from 0 to 2.4 kilocalories for soluble fibers compared with 4 calories per gram for other carbohydrates.[40]

Insoluble fiber is found in wheat bran, vegetables, and whole grains. It adds bulk to the stool and allows food to pass quicker through the stomach and intestines. Because these fibers are not digested and are generally not utilized by gut bacteria, insoluble fibers are estimated to provide little to no calories.[40]

Products labeled "dietetic," "sugar-free," or "no sugar added" can be sweetened with sugar alcohols, such as xylitol, erythritol, sorbitol, and maltitol. Patients need to be aware that these labels do not mean "carbohydrate-free" and that sugar alcohols contain between 0.02 and 3 calories per gram.[41] When eaten excessively, some sugar alcohols, such as mannitol and sorbitol, can cause gastrointestinal discomfort, including gas, bloating, and diarrhea. Due to these potential adverse reactions, packaged foods in the US that contain mannitol or sorbitol must include a statement about laxative effects.[41]

Glycemic response to both types of fiber and sugar alcohol is individual, variable, and based on the other foods in the meal. Thus, some PWD may need to adjust insulin

Glossary[13,54,55]

A1C: A blood test that estimates blood glucose level over the past two to three months. Also called hemoglobin A1C or glycosylated hemoglobin, the test shows the amount of glucose that sticks to the red blood cell, which is proportional to the amount of glucose in the blood.

Academy of Nutrition and Dietetics (AND): Professional organization of nutrition and dietetics practitioners.

American Association of Clinical Endocrinology (AACE): A medical organization dedicated to promoting the art and science of clinical endocrinology, diabetes, and metabolism. They publish comprehensive guidelines for the care and management of people with or at risk for *diabetes*.

American Diabetes Association (ADA): A national nonprofit that seeks to educate the public about diabetes. They publish comprehensive standards for the care and management of people with or at risk for diabetes annually.

Basal Insulin: Dose designed to stabilize blood glucose during periods of fasting, such as in between meals and during sleep.

Blood Glucose Meter: A small, portable device used to measure blood glucose levels.

Blood Glucose Monitoring: Checking blood glucose level on a regular basis in order to manage diabetes.

Board Certified in Advanced Diabetes Management (BC-ADM): Healthcare professionals who hold the BC-ADM certification manage complex patient needs and assist patients with their therapeutic problem-solving including medication adjustments.

Bolus Insulin: Dose taken to cover an expected rise in glucose, typically related to food intake.

Certified Diabetes Care and Education Specialist (CDCES): A healthcare professional with expertise in diabetes education who has met eligibility requirements and successfully completed a certification exam. (Formally CDE—Certified Diabetes Educator.)

Continuous Glucose Monitor (CGM): A sensor placed under the skin which measures blood glucose levels 24 hours a day.

Diabetes Self-Management Education and Support (DSME/S)*: Treatment that provides people with diabetes the knowledge, skills, and confidence to accept responsibility for their self-management.

Diabetes Self-Management Training (DSMT)*: Term Medicare uses for DSME.

Euglycemia: A normal level of glucose in the blood.

Fasting Blood Glucose (FBG): Blood glucose level after an 8 to 12 hours fast (usually overnight).

Hyperglycemia: Elevated blood glucose.

Hypoglycemia: Blood glucose lower than one's target, usually less than 70 mg/dL.

Insulin Resistance: The body's inability to respond to and use the insulin it produces.

Intensive Therapy: A treatment for diabetes in which blood glucose is kept as close to normal as possible.

Medical Nutrition Therapy (MNT): A key component of diabetes education and management. MNT is defined as a nutrition-based treatment provided by a registered dietitian nutritionist. It includes a nutrition diagnosis as well as therapeutic and counseling services to help manage diabetes.

Milligrams per deciliter (mg/dL): A unit of measure that shows the concentration of a substance in a specific amount of fluid. In the US, blood glucose results are reported as mg/dL.

National Standards for Diabetes Self-Management and Support (NSDSMES): Define timely, evidence-based, quality DSMES services that meet or exceed the Centers for Medicare and Medicaid Services quality standards.

Oral Hypoglycemic Agents: Medications taken by mouth by people with type 2 diabetes to manage blood glucose levels.

Postprandial Blood Glucose (PPBG): The blood glucose level 1 to 2 hours after the start of a meal.

Rapid-Acting Insulin: A type of synthetic insulin which has an onset of action of *5 to 15 minutes*, peak effect in 1 to 2 hours, and duration of action that lasts 4-6 hours.

Registered Dietitian/Registered Dietitian Nutritionist (RD/RDN): A healthcare professional who has met education requirements, successfully completed a certification exam, and received certification from the AND in order to provide MNT, nutrition education, and counseling.

Self-management: In diabetes, the ongoing process of a person managing the disease with meal planning, physical activity, insulin, and BGM. The person with diabetes designs his or her own self-management treatment plan with their diabetes care team, which may include physicians, nurses, diabetes educators, dietitians, pharmacists, and others.

Sugar Alcohols: Sweeteners that produce a smaller rise in blood glucose than other carbohydrates such as erythritol, maltitol, mannitol, sorbitol, and xylitol. Their calorie content is about 2 calories per gram.

Type 1 Diabetes (T1D): A condition characterized by hyperglycemia caused by a lack of insulin. T1D develops most often in young people but can appear in adults.

Type 2 Diabetes (T2D): A condition characterized by hyperglycemia caused by either a lack of insulin or insulin resistance. T2D diabetes develops most often in middle-aged and older adults but can appear in young people.

*The National Standards define timely, evidence-based, quality DSMES services that meet or exceed the Centers for Medicare and Medicaid Services quality standards. While the acronym DSMES is used in the literature and in current practice, it is important to note that the term diabetes self-management training (DSMT) is exclusively used when describing the Medicare benefit for diabetes self-management.

doses for fiber and sugar alcohol due to their incomplete digestion and absorption. While there is little research or consensus guidance available regarding insulin dosing for these substances, a general guideline is if a food has 5 or more grams of fiber or sugar alcohol per serving, half of the amount can be subtracted from the total amount of carbohydrates in the food.[12] For example, if a bowl of cereal contains 26 grams of total carbohydrate, which includes 8 grams of fiber, it would be calculated as containing only 22 grams of carbohydrates. Adjusting insulin for fiber and sugar alcohols may be applied individually when BG targets are not otherwise achieved.

Protein and fat

The amount of the other macronutrients, protein and fat, may also need to be considered for more precise insulin dosing in some patients.[6,22,42] Keep in mind that the current evidence suggests individual variations in the postprandial glycemic response of mixed meals and more research needs to be done to determine a useful algorithm.[38-41] The effects of protein and high-fat meals should be addressed as they occur and should be considered need-to-know guidance that can be explained to patients who are otherwise not reaching targets.[6,12]

While the evidence is still emerging regarding these macronutrients, it has been determined that:

- Protein influences postprandial BG. This effect can be delayed by approximately 1.5 hours.[47]
- High-fat meals, such as fast and fried foods, can cause delayed or prolonged hyperglycemia several hours after eating.[43]
- A measured approach to increasing bolus doses for high-fat or high-protein meals is advised to prevent hypoglycemia and delayed hyperglycemia.[6]

Various self-management skills, interests, preferences, and support are necessary for patients to choose, effectively implement, and sustain advanced carbohydrate counting.

- With insulin pumps, a split bolus feature (part of the bolus delivered immediately, the remainder over a programmed duration) may provide better insulin coverage for high-fat or high-protein mixed meals.[6]

Summary

Advanced carbohydrate counting is an effective meal-planning approach for achieving glycemic targets. Additionally, various self-management skills, interests, preferences, and support are necessary for patients to choose, effectively implement, and sustain advanced carbohydrate counting.

People using this method must be able to identify the amounts of macronutrients in their meals, calculate ICRs, correction doses, and monitor and interpret BG levels. This method also supports the pleasure of eating for PWD by providing nonjudgmental messages about food choices and increasing variety.[22]

To be successful, access to continued services and support is essential. A referral to a diabetes self-management education and support (DSMES) program best achieves this.[4] The overall objectives of DSMES programs are to support informed decision-making, self-care behaviors, problem-solving and active collaboration with the healthcare team and to improve clinical outcomes, health status, and quality of life.[48] The American Association of Nurse Practitioners and many other professional organizations recommend that providers refer PWD for DSMES.[49] Data indicate PWD who completed greater than 10 hours of DSMES over 6–12 months and those who participated on an ongoing basis had significant reductions in A1C levels and mortality.[50,51]

The 2023 *ADA Standards of Medical Care* cite four essential times for referral to and providing DSMES:

1. Upon diagnosis
2. Yearly or as needed when not meeting treatment goals
3. When complicating factors, such as health conditions, physical limitations, emotional factors, or basic living needs, impact self-management
4. When life-changing or care-changing events occur.[22]

Although DSMES services have well-documented benefits, it has been estimated that less than 5% of Medicare beneficiaries with diabetes and 6.8% of privately insured PWD in the US participate in DSMES services within the first year of diagnosis.[52] Reasons for not participating in DSMES include:

- Lack of knowledge about DSMES services
- Scarcity or unawareness of local DSMES programs
- Lack of a provider's perceived need to refer to DSMES
- Lack of provider follow-up on referrals
- Inconvenient meeting times or locations

Nurses are fundamental in linking their patients to MNT and DSMES services to help them sustain behaviors needed to self-manage their diabetes. The CDC offers a useful toolkit to promote healthcare provider referrals and provide resources to assist with the development, promotion, implementation, and sustainability of DSMES services.[53] ■

REFERENCES

1. Centers for Disease Control and Prevention. National Diabetes Statistics Report website. www.cdc.gov/diabetes/data/statistics-report/index.html. Accessed December 3, 2022.

2. Boyle JP, Thompson TJ, Gregg EW, Barker LE, Williamson DF. Projection of the year 2050 burden of diabetes in the US adult population: dynamic modeling of incidence, mortality, and prediabetes prevalence. *Popul Health Metr.* 2010;8:29. doi:10.1186/1478-7954-8-29.

3. American Diabetes Association. Economic costs of diabetes in the U.S. in 2017. *Diabetes Care*. 2018;41(5):917-928. doi:10.2337/dci18-0007.

4. Mongiello LL. Medical nutrition therapy for glycemic control. *Physician Assist Clin*. 2022;7:643-654. doi:10.1016/j.cpha.2022.05.005.

5. Nathan DM, DCCT/EDIC Research Group. The diabetes control and complications trial/epidemiology of diabetes interventions and complications study at 30 years: overview. *Diabetes Care*. 2014;37(1):9-16.

6. Evert AB, Dennison M, Gardner CD, et al. Nutrition therapy for adults with diabetes or prediabetes: a consensus report. *Diabetes Care*. 2019;42(5):731-754. doi:10.2337/dci19-0014.

7. Academy of Nutrition and Dietetics. How an RD can help with diabetes. www.eatright.org/health/health-conditions/diabetes/how-an-rdn-can-help-with-diabetes. Accessed January 14, 2023.

8. Centers for Medicare and Medicaid Services. National Coverage Determination (NCD) for Medical Nutrition Therapy. www.cms.gov/Medicare-Coverage-Database/view/ncd.aspx?ncdid=252.

9. Turner RC. The U.K. prospective diabetes study: a review. *Diabetes Care*. 1998;21(suppl 3):C35-C38. doi:10.2337/diacare.21.3.c35.

10. Garber AJ, Abrahamson MJ, Barzilay JI, et al. Consensus statement by the American Association of Clinical Endocrinologists and American College of Endocrinology on the comprehensive type 2 diabetes management algorithm - 2017 executive summary. *Endocr Pract*. 2017;23(2):207-238.

11. Battelino T, Danne T, Bergenstal RM, et al. Clinical targets for continuous glucose monitoring data interpretation: recommendations from the international consensus on time in range. *Diabetes Care*. 2019;42(8):1593-1603. doi:10.2337/dci19-0028.

12. Mongiello LL. Carbohydrate counting primer for primary care providers. *Physician Assist Clin*. 2022;7(4):655-663.

13. Centers for Medicare and Medicaid Services. Nutrition therapy services. www.medicare.gov/coverage/nutrition-therapy-services. Accessed January 14, 2023.

14. American Diabetes Association. Glycemic targets: standards of care in diabetes—2023. *Diabetes Care*. 2023;46(suppl 1):S97-S110.

15. Cornell S. Comparison of the diabetes guidelines from the ADA/EASD and the AACE/ACE. *J Am Pharm Assoc*. 2017;57(2):261-265. doi:10.1016/j.japh.2016.11.005.

16. Banting FG, Best CH, Collip JB, Campbell WR, Fletcher AA. Pancreatic extracts in the treatment of diabetes mellitus. *Can Med Assoc J*. 1922;12(3):141-146.

17. Mazur A. Why were "starvation diets" promoted for diabetes in the pre-insulin period? *Nutr J*. 2011;10:23. doi:10.1186/1475-2891-10-23.

18. Westman EC, Yancy WS Jr, Humphreys M. Dietary treatment of diabetes mellitus in the pre-insulin era (1914-1922). *Perspect Biol Med*. 2006;49(1):77-83. doi:10.1353/pbm.2006.0017.

19. Institute of Medicine. *Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids*. The National Academies Press; 2005:1358.

20. U.S. Department of Agriculture Food and Nutrition Information Center (FNIC). National Agricultural Library. www.nal.usda.gov/programs/fnic#:~:text=Carbohydrates%20provide%204%20calories%20per,view%20FNIC%20resources%20about%20Macronutrients. Accessed January 14, 2023.

21. Franz MJ, MacLeod J, Evert A, et al. Academy of Nutrition and Dietetics nutrition practice guideline for type 1 and type 2 diabetes in adults: systematic review of evidence for medical nutrition therapy effectiveness and recommendations for integration into the nutrition care process. *J Acad Nutr Diet*. 2017;117(10):1659-1679. doi:10.1016/j.jand.2017.03.022.

22. American Diabetes Association. Facilitating positive health behaviors and well-being to improve health outcomes: standards of care in diabetes—2023. *Diabetes Care*. 2023;46(suppl 1):S68-S96.

23. Gillespie SJ, Kulkarni KD, Daly AE. Using carbohydrate counting in diabetes clinical practice. *J Am Diet Assoc*. 1998;98(8):897-905. doi:10.1016/s0002-8223(98)00206-5.

24. Christensen MB, Serifovski N, Herz AMH, et al. Efficacy of bolus calculation and advanced carbohydrate counting in type 2 diabetes: a randomized clinical trial. *Diabetes Technol Ther*. 2021;23(2):95-103. doi:10.1089/dia.2020.0276.

25. Funnell MM. Patient empowerment. *Crit Care Nurs Q*. 2004;27(2):201-204. doi:10.1097/00002727-200404000-00012.

26. Dickinson JK, Funnell MM. Diabetes: changing the conversation. *Nursing*. 2019;49(6):56-60. doi:10.1097/01.NURSE.0000554614.92598.fb.

27. Yun Q, Ji Y, Liu S, et al. Can autonomy support have an effect on type 2 diabetes glycemic control? Results of a cluster randomized controlled trial. *BMJ Open Diabetes Res Care*. 2020;8(1). doi:10.1136/bmjdrc-2019-001018.

28. Robinson SA, Zocchi MS, Netherton D, et al. Secure messaging, diabetes self-management, and the importance of patient autonomy: a mixed methods study. *J Gen Intern Med*. 2020;35(10):2955-2962. doi:10.1007/s11606-020-05834-x.

29. Sallay V, Klinovszky A, Csuka SI, Buzás N, Papp-Zipernovszky O. Striving for autonomy in everyday diabetes self-management—qualitative exploration via grounded theory approach. *BMJ Open*. 2021;11(12):e058885. doi:10.1136/bmjopen-2021-058885.

30. Fortin A, Rabasa-Lhoret R, Roy-Fleming A, et al. Practices, perceptions and expectations for carbohydrate counting in patients with type 1 diabetes – results from an online survey. *Diabetes Res Clin Pract*. 2017;126:214-221. doi:10.1016/j.diabres.2017.02.022.

31. American Diabetes Association. Diabetes technology: standards of care in diabetes—2023. *Diabetes Care*. 2023;46(suppl 1):S111-S127.

32. Poggiogalle E, Jamshed H, Peterson CM. Circadian regulation of glucose, lipid, and energy metabolism in humans. *Metabolism*. 2018;84:11-27. doi:10.1016/j.metabol.2017.11.017.

33. Mason IC, Qian J, Adler GK, Scheer F. Impact of circadian disruption on glucose metabolism: implications for type 2 diabetes. *Diabetologia*. 2020;63(3):462-472. doi:10.1007/s00125-019-05059-6.

34. Buck S, Krauss C, Waldenmaier D, et al. Evaluation of meal carbohydrate counting errors in patients with type 1 diabetes. E*xp Clin Endocrinol Diabetes*. 2022;130(7):475-483. doi:10.1055/a-1493-2324.

35. McGowan L, Caraher M, Raats M, et al. Domestic cooking and food skills: a review. *Crit Rev Food Sci Nutr*. 2017;57(11):2412-2431.

36. Hill-Briggs F, Lazo M, Peyrot M, et al. Effect of problem-solving-based diabetes self-management training on diabetes control in a low income patient sample. *J Gen Intern Med*. 2011;26(9):972-978. doi:10.1007/s11606-011-1689-6.

37. Hommel E, Schmidt S, Vistisen D, et al. Effects of advanced carbohydrate counting guided by an automated bolus calculator in type 1 diabetes mellitus (StenoABC): a 12-month, randomized clinical trial. *Diabet Med*. 2017;34(5):708-715. doi:10.1111/dme.13275.

38. Builes-Montaño CE, Ortiz-Cano NA, Ramirez-Rincón A, Rojas-Henao NA. Efficacy and safety of carbohydrate counting versus other forms of dietary advice in patients with type 1 diabetes mellitus: a systematic review and meta-analysis of randomised clinical trials. *J Hum Nutr Diet*. 2022;35(6):1030-1042. doi:10.1111/jhn.13017.

39. U.S. Department of Agriculture and U.S. Department of Health and Human Services. Dietary guidelines for Americans 2020-2025. www.dietaryguidelines.gov/sites/default/files/2020-. Accessed October 10, 2022.

40. Guan Z-W, Yu E-Z, Feng Q. Soluble dietary fiber, one of the most important nutrients for the gut microbiota. *Molecules (Basel, Switzerland)*. 2021;26(22):6802. doi:10.3390/molecules26226802.

41. U.S. National Library of Medicine. Sweeteners – sugars. https://medlineplus.gov/ency/article/002444.htm. Accessed January 14, 2023.

42. Smart CEM, King BR, Lopez PE. Insulin dosing for fat and protein: is it time? *Diabetes Care*. 2020;43(1):13-15. doi:10.2337/dci19-0039.

43. Bell KJ, Fio CZ, Twigg S, et al. Amount and type of dietary fat, postprandial glycemia, and insulin requirements in type 1 diabetes: a randomized within-subject trial. *Diabetes Care*. 2020;43(1):59-66. doi:10.2337/dc19-0687.

44. Bell KJ, Smart CE, Steil GM, Brand-Miller JC, King B, Wolpert HA. Impact of fat, protein, and glycemic index on postprandial glucose control in type 1 diabetes: implications for intensive diabetes management in the continuous glucose monitoring era. *Diabetes Care*. 2015;38(6):1008-1015. doi:10.2337/dc15-0100.

45. Furthner D, Lukas A, Schneider AM, et al. The role of protein and fat intake on insulin therapy in glycaemic control of paediatric type 1 diabetes: a systematic review and research gaps. *Nutrients*. 2021;13(10):3558.

46. Krebs JD, Arahill J, Cresswell P, Weatherall M, Parry-Strong A. The effect of additional mealtime insulin bolus using an insulin-to-protein ratio compared to usual carbohydrate counting on postprandial glucose in those with type 1 diabetes who usually follow a carbohydrate-restricted diet: a randomized cross-over trial. *Diabetes Obes Metab*. 2018;20(10):2486-2489. doi:10.1111/dom.13392.

47. Paterson MA, Smart CEM, Lopez PE. Increasing the protein quantity in a meal results in dose-dependent effects on postprandial glucose levels in individuals with type 1 diabetes mellitus. *Diabet Med*. 2017;34(6):851-854.

48. Funnell MM, Brown TL, Childs BP, et al. National standards for diabetes self-management education. *Diabetes Care*. 2010;33(suppl 1):S89-S96. doi:10.2337/dc10-S089.

49. Powers MA, Bardsley JK, Cypress M, et al. Diabetes self-management education and support in adults with type 2 diabetes: a consensus report of the American Diabetes Association, the Association of Diabetes Care and Education Specialists, the Academy of Nutrition and Dietetics, the American Academy of Family Physicians, the American Academy of PAs, the American Association of Nurse Practitioners, and the American Pharmacists Association. *JAAPA*. 2020;33(7):1-20. doi:10.1097/01.JAA.0000668828.47294.2a.

50. He X, Li J, Wang B, et al. Diabetes self-management education reduces risk of all-cause mortality in type 2 diabetes patients: a systematic review and meta-analysis. *Endocrine*. 2017;55(3):712-731. doi:10.1007/s12020-016-1168-2.

51. Chrvala CA, Sherr D, Lipman RD. Diabetes self-management education for adults with type 2 diabetes mellitus: a systematic review of the effect on glycemic control. *Patient Educ Couns*. 2016;99(6):926-943. doi:10.1016/j.pec.2015.11.003.

52. Centers for Disease Control and Prevention. Overcoming barriers to referral and treatment. www.cdc.gov/diabetes/dsmes-toolkit/referrals-participation/overcoming-barriers.html. Accessed October 9, 2022.

53. Centers for Disease Control and Prevention. Diabetes self-management education and support (DSMES) toolkit. www.cdc.gov/diabetes/dsmes-toolkit/index.html. Accessed January 14, 2023.

54. Centers for Disease Control and Prevention. Terminology. www.cdc.gov/diabetes/dsmes-toolkit/background/terminology.html. Accessed January 18, 2023.

55. American Diabetes Association. Common Terms. https://diabetes.org/resources/students/common-terms. Accessed January 18, 2023.

Lorraine Mongiello is an associate professor of clinical nutrition and interdisciplinary health sciences at the New York Institute of Technology.

The author and planners have disclosed no potential conflicts of interest, financial or otherwise.

DOI-10.1097/01.NURSE.0000920448.45572.df