Blood glucose (BG) monitoring is a critical aspect of diabetes management and, for patients using insulin, the purpose is robust. A patient’s insulin dose design and adjustment are based on glycemic patterns and determining how those patterns look. Many patients will even adjust their insulin doses on a daily basis based on their glucose monitoring results. Unless the education function is outsourced, primary care staffs are responsible for educating patients about monitoring and how to self-monitor their blood glucose levels.

Providers want their care team staff and patients to understand that there is a difference between blood glucose monitoring and glucose checking. Monitoring is an integrated process. The interrelationships among the variety of factors that influence glucose control are assessed to determine whether the balance of these factors is optimal. Monitoring looks at the results of glucose checking, but also the impact of food intake (quantity, types, timing), physical activity, insulin doses, and any other factors that have been identified as influencing a person’s daily glucose patterns.

For many patients, monitoring goals should be defined in terms of their pathophysiology and the insulin program that they are using. As an example, a person who is using only one daily injection of basal insulin (with or without concurrent antidiabetes medications) needs to know the following:

- Is that program providing adequate overall control? The A1C will answer this question.
- Is the program providing adequate fasting glucose control? If fasting glucose levels do not answer this question affirmatively, increasing the basal insulin will impact the full 24 hours and it will be necessary to know the patterns later in the day.
- Is the program providing adequate prelunch and presupper control? Again, increasing a basal insulin will impact the full day, so the patterns throughout the day will need to be known.
- Are the postprandial glucose levels on target? If the A1C is slightly above normal, it is likely that the elevation causing this is postprandial (after meals). Measuring glucose levels at these times will indicate the degree of elevation, and underscore the need for a change in the insulin therapy to cover these times (perhaps prandial rapid-acting insulin would help).

Other insulin regimens would suggest the need for slightly different information. The process of determining what information is sought must occur before the patient’s monitoring regimen is designed.

**Hemoglobin A1C**

Recently, the American Diabetes Association (ADA) has recommended shortening the terminology for the HbA1c to just A1C, although the older terminology is still occasionally used. The glycosylated hemoglobin or A1C measurement reflects the average blood glucose level for the time period representing the average age of the red blood cells. We usually think of this as being 2 or maybe 3 months.

Anything that alters the lifespan of the hemoglobin, or impacts its ability to be glycosylated, can falsely raise or lower the A1C level. An alternative measure of glucose control is a measure of fructosamine, which reflects about a 2- to 3-week measure of glycemic control. This test can be used if the accuracy of the A1C test is suspect, or if you are making rapid changes to the glucose control program and want a shorter-term measure, such as with pregnancy.
There has been some discussion recently about the A1C goal. Most diabetes experts recommend targeting an A1C somewhere below either 6.5% or 7%. However, there has been some concern about this lower target in people with long-standing type 2 diabetes. For these patients a somewhat higher individualized target may be more appropriate. Suffice it to say, a safe bet is to target the lowest A1C that can safely be achieved (and the definition of safety may be adjusted by this controversy) using an insulin program that the patient or caregiver can self-manage. Many studies have correlated the A1C level with the risk of developing some of the complications of diabetes, so the imperative to achieve the best A1C always has to be balanced with safety and patient self-care issues and limitations.

Another way to express long-term glycemic control is the estimated average glucose level (eAG), which is a mathematical relationship between the A1C and average glucose levels. The objective in creating this construct was to see if the A1C could be expressed in the same units as self-monitoring results. The relationship between A1C and eAG is described by the formula: 28.7 X A1C – 46.7 = eAG.

It is important to remember that A1C (or eAG) is not a reliable measure of glycemic variability. To truly assess glucose control, the A1C measurement of the average glycemic levels over time, and an assessment of glycemic patterns obtained by glucose checking are needed. For example, a patient may obtain an A1C of 7%, which corresponds to eAG of 154 mg/dL. However, it does not reveal the range of blood glucose fluctuations that a patient has experienced within that 2- to 3-month period. The patient may have experienced wide fluctuations in blood glucose resulting in frequent episodes of hypoglycemia and/or hyperglycemia. Further, an A1C measurement of 8% does not convey whether the patient is experiencing preprandial, postprandial, or mixed hyperglycemia—information that is important for appropriate treatment.

Determining the Schedule for Blood Glucose Checking

The patient’s monitoring program should be designed to obtain data that provides answers to key questions about the quality of glycemic control and the interrelationships among the various factors that can impact glucose levels and patterns. These factors determine a patient’s glucose checking schedule.

Basic patterns for checking, which can be adapted and individualized, can be categorized as follows:

- **Sporadic checking.** Checking times should be varied among premeals, bedtime, and occasionally before and after the same meal.

- **One check per day.** Vary the check times, and perhaps, skip some days when everything is stable and utilize the extra strips to check before and after a meal.

- **Block checking.** Check once a day, with variable times. However, 1 to 2 times per month, check glucose levels in a block of 3 to 4 days where checks are done before each meal, bedtime, and then 1 to 2 hours after at least one meal to measure postprandial glycemic excursions. Typical days, rather than those that might include out-of-the-ordinary activities, should be chosen for block checking.
• **Regular preprandial checking.** Daily, before each meal and at bedtime. This schedule is used for basal bolus treatment programs for both type 1 and type 2 diabetes. Usually this schedule should be supplemented with regular checks of postprandial glucose levels. This is done to determine the effectiveness of the premeal rapid-acting insulin dose selection program and its balance with the meal plan through a carbohydrate-counting program.

**Monitoring frequency may be increased under the following circumstances:**

• The patient is pregnant. The focus on postprandial glycemic excursions is intensified in pregnant women with diabetes.

• The patient is ill or using steroids.

• Medications are being added or changed.

• The patient shows an increased incidence of hypoglycemia or hyperglycemia.

It is important to assess a patient’s ability to follow a given monitoring schedule. The following list is from the *Joslin Diabetes Deskbook*, and should be considered by providers and the diabetes care team.

1. *What information is really needed?*
   a. for the healthcare providers to design and modify the treatment program
   b. for the patient to use as feedback on his or her self-care routine
   c. to alert of potential acute problems

2. *Does the patient have any physical or mental limitations that may affect testing ability or methods?*
   a. visual limitations
   b. dexterity problems
   c. vascular or neuropathic conditions, or concerns regarding infections
   d. mental limitations affecting technique, understanding, or ability to interpret results

3. *Are there any economic, social, scheduling, or work/school-related obstacles to the monitoring recommendations?*

4. *Is the patient willing to do the testing?*

5. *If already on a testing program, how successful has the patient been at following the regimen?*

6. *Based on the above assessment, have you designed an individualized monitoring program and schedule that the patient or the patient’s significant other can self-manage, that will provide reasonable and useful information, and that can prompt appropriate action when needed?*

7. *Has or will the patient receive proper teaching?*
   a. techniques and equipment use
   b. record-keeping (for both glucose values and other key information)
   c. use and interpretation of results
8. Does the patient know his or her specific targeted values or ranges?

9. Does the patient understand what to do when values do not fall in those ranges?

10. Does the patient understand the difference between values reflecting acute concern and those reflecting longer-term control concerns?

11. Does the patient know when and how to self-manage certain off-target values, and does he or she know when values warrant a call to a medical professional for help?

12. Does the patient know how to manage sick days?

13. Does the patient need to know how to test for ketones, and if so, in what setting, using what methodology? Does he or she know how to interpret the results, and when to call for help?

**Monitoring Devices**

**Meters**

Blood glucose monitoring meters are being continually updated and modified. Most have internal memories. Some have more sophisticated capabilities to keep a glucose monitoring log.

If the meter displays an extremely high or low reading, patients should confirm this by doing another reading. Checking the meter’s calibration may be necessary. Some meters also require regular cleaning to assure accuracy. Others have an electronic alert indicating that they need to be cleaned, while others can only be cleaned by the manufacturer.

Glucose meters utilize capillary whole blood for glucose measurements, which is approximately 10% lower than glucose in plasma or serum. To compare such a value to a glucose obtained from a commercial lab one needs to multiply the result by 1.1. Many newer meters do this calculation internally and provide “plasma-like” readings directly, enabling patients to compare meter results with lab results. Before making any such comparisons one needs to confirm whether the meter result is based on capillary whole blood or has been converted to a plasma-like reading.

**The Blood Glucose Logbook**

Records MUST be kept for all monitoring schedules. This includes recording the time (often in relationship to the meal more than the actual clock time), and some indication of other factors that impact glycemic control, particularly notations about significant changes from normal patterns. Patients must be instructed to keep a daily diary or logbook. DO NOT assume that they will figure out how to do this effectively on their own. The discussion of log-keeping should be tied to the conversation about why they are checking their glucose levels and how they should be utilizing the data. The logbook is the key record that centralizes all of the important information in one place so that it can be visualized together.

The act of physically recording blood glucose levels as well as the discipline of doing so every time BG is checked reinforces the fact that monitoring is a necessary part of the person’s diabetes management and treatment regimen. It needs to be performed consistently, not occasionally, for the patient to reach and maintain glycemic targets. The logbook can also serve as a communication tool between the patient and the various members of the diabetes care team. The logbook functions as a tangible
Blood Glucose Monitoring Basics

record that can be used to illustrate and underscore the connections among food, physical activity, and glycemic control. Information in the logbook becomes a central topic of discussion and review when the patient meets with the primary care provider. Office staff should reinforce the importance of both keeping the logbook and bringing it to appointments. There is no better way of reinforcing this importance than to review it at every visit.

While internal meter memories add a significant convenience for patients, they should not substitute for a logbook. Because previous readings and meter memory are not readily visible when patients check blood sugar, they are not able to see trends or patterns the way they can when recording the result in a logbook.

Glycemic Targets

Targets should be individualized based on the patient’s checking schedule, insulin regimen and goals, and concerns about safety. Generally, ideal glycemic goals for non-pregnant adults with type 2 diabetes are as follows:

- Fasting and before a meal: 70–130 mg/dL
- 2 hours postprandial: <180 mg/dL
- Bedtime: 90–150 mg/dL

Teaching Patients Self-monitoring of Blood Glucose (SMBG)

Diabetes education is an ongoing process. Learning to manage diabetes is complex and behavioral change takes time. Newly diagnosed patients, or patients progressing to insulin therapy, are challenged to address many lifelong habits that impact their blood glucose levels. Healthcare providers need to expect that both teaching and their patients’ learning will be a process. Patience and encouragement are needed every step of the way.

The patient’s initial monitoring instruction appointment is typically scheduled for one hour. This will be led by the diabetes educator or other appropriate clinical staff person assigned by the primary care provider. It can be very helpful to include the patient’s significant family members as well. The patient will have additional weekly appointments lasting from 30 to 45 minutes for the next several weeks. It is important to assess the patient’s physical, mental, and developmental limitations that may affect ability to self-monitor blood glucose. Providers need to make certain that their office staff report and discuss any conditions impacting the patient’s ability to self-monitor blood glucose.

Self-Management Training Content and Technique

Diabetes care team staff are responsible for instructing patients about the following:

- The patient’s individual targets for A1C and blood glucose range
- Reasons for SMBG
- Monitoring technique and monitoring schedules
- How to interpret results, including:
  - Factors affecting glycemic control
  - How to identify patterns
  - When to contact the diabetes care team if results are outside of desired range
(Information about blood glucose pattern interpretation for office staff is included in the Joslin Insulin Therapy CareKit).

It is important for staff to visually assess the patient’s use of his or her blood glucose meter and look for the following common issues encountered when patients are learning SMBG:

- Not washing hands
- Not coding the meter correctly
- Difficulty putting strips into meter
- Difficulty getting blood onto strip due to visual or dexterity issues
- Not able to follow the steps that are required to use the meter properly (for example, cognition problems or unable to understand)

Assess for other common SMBG challenges, such as:

- The patient experiences or is fearful about pain and does not want to poke finger
- The patient does not want to see the results
- The patient does not have clear goals
- The patient does not think his or her doctor looks at or is told the results
- The patient feels that his or her self-care doesn't make any difference

**How the Care Team Can Help Patients Overcome Barriers to SMBG**

1. **Patient is not washing hands. Possible solution:**
   
   Explain the importance of handwashing before checking blood glucose results:
   
   - SMBG is necessary for self-care. The goal is to be effective and efficient. Blood glucose results can be dramatically affected by residual food on hands. It's okay to use alcohol wipes, but they will dry out hands over time. Handwashing is best—a quick and easy part of the SMBG process.

2. **The patient is not coding the meter. Possible solution:**
   
   First, staff should make certain that the code on the meter is correct and explain to the patient how to code the meter. If the code doesn’t match, the results are not accurate. If your staff determines that the patient is unable to remember to code the meter, prescribe a meter that doesn’t need to be coded. Your staff can check with a pharmacist about meters that do not require coding.

3. **The patient has difficulty putting the strip in the meter. Possible solution:**
   
   Preloaded discs or cylinders of strips are available on some meters. This is a great option for patients with dexterity challenges.

4. **The patient has cognition problems and cannot follow steps of the meter. Possible solution:**
   
   Simple instructions are needed. Staff should use a simply designed meter with the least amount of steps, few buttons, and preloaded strips. If the patient is unable to do SMBG him or herself, the provider should be informed, and staff should investigate whether a friend or relative is available to help.
5. The patient experiences or is fearful about pain and does not want to poke finger. Possible solutions.

Staff needs to assess how the patient is lancing his or her finger. Is the patient loading the device correctly? Does he or she know that the depth of the lancet can be adjusted? Smaller-gauge lancets are also available and some lancing devices are less irritating. Staff should investigate if the patient is changing the lancet every time and, if not, inform the patient that there is a greater experience of pain with a dull lancet. Staff can also show the patient an alternative site on the palm or forearm.*

*Staff needs to know that alternative sites for checking blood glucose should not be used if the patient has:
  o A low blood glucose level
  o A history of hypoglycemic unawareness (the patient cannot always feel when he or she is low)
  o Recently exercised
  o Recently taken mealtime insulin
  o Eaten in the past two hours

Alternative site checking should be used with caution in patients with type 1 diabetes due to the potential for rapid changes in blood glucose levels with this population.

Some studies have shown that checking on the palm is equivalent to using the fingertips.

6. The patient does not want to see the results. Possible solution:

Staff needs to reassure the patient that all information is good information. It is not uncommon for a patient to be judgmental and measure him or herself as either a success or a failure at self-care. Patients need encouragement to think in terms of high or low, rather than good or bad blood glucose levels. SMBG is not a pass or fail test, but rather checking and a necessary element of disease management.

7. The patient does not have clear goals. Possible solution:

Does the patient know what his or her blood glucose goals should be? Make sure the patient understands that insulin doses and regimens typically need to be altered. Blood glucose monitoring yields important information. Staff should let patients know that the provider needs to know if numbers are too high or too low to evaluate, and possibly adjust, the patient’s dose and/or regimen.

8. The patient doesn’t think the primary care provider looks at or is told the results. Possible solution:

Staff needs to reassure the patient about the care team approach and make sure he or she understands that the provider is managing the team and, ultimately, the patients care. The patient should be encouraged to bring his or her logbook to the next provider appointment.

9. The patient feels that his/her self-care doesn’t make any difference. Possible solution:

Staff should explain to the patient that there are many ways to treat diabetes. High or low blood glucose levels are not an inevitable part of having diabetes; stability is possible. Finding how his or her numbers can be improved is a goal that you, the patient, and the provider are working on together.
Continuous Glucose Monitoring

Continuous glucose monitoring (CGM) is state-of-the-art technology capable of measuring interstitial blood glucose levels every 5 minutes, 24 hours a day, for 3 to 7 days. CGM has a number of beneficial features including electronic record-keeping and memory downloads, graphs, averages, and event markers (medication, activity, pre/post mealtime, health status). While these features ease the burden of record-keeping, patients are still encouraged to record blood glucose levels in a daily diary or log-book, especially when beginning insulin therapy.

CGM can also facilitate the keeping of accurate glucose logs provided the patient has the correct time and date and has entered information to distinguish blood glucose as pre- or postmeal. In addition to a blood glucose number, the CGM provides results via a curve showing levels over time. Another advantage of CGM is the ability to monitor glucose excursions overnight. Continuous glucose monitors are equipped with an alarm that signals hypoglycemic or hyperglycemic excursions. This alarm, coupled with prompt treatment, may reduce the duration and severity of hypoglycemia and hyperglycemia. (More detailed information about CGM and its introduction to patients is included in the Joslin Insulin Therapy CareKit). However, CGM should be accompanied by concurrent periodic fingerstick glucose testing to verify the accuracy of these measurements.