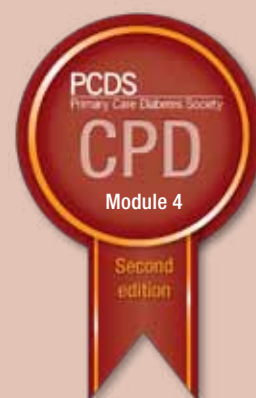


Effective self-monitoring of blood glucose



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Gwen Hall

The incidence of diabetes is on the increase. Regardless of how much time is spent with the healthcare team to care for this condition, the individual with diabetes self-manages 24 hours a day, 365 days a year. It is a huge commitment, suddenly and unexpectedly placed on a person untrained in health and diabetes at diagnosis. One tool people with diabetes may utilise is self-monitoring of blood glucose (SMBG) but it needs to be done effectively if we are not to waste valuable resources. There is some debate as to who should use SMBG. This article will explore the discussion points and provide some practical advice on how to achieve effective monitoring.

Back in 2005, Owens et al outlined a guide to the frequency of self-monitoring of blood glucose (SMBG) according to therapy use. Few published works improve on the advice therein and it remains a useful guide. NICE has provided its own, simpler, algorithm (summarised in *Figure 1*), but this does not describe frequency of testing. Another aspect of SMBG that must be considered is the recent changes to driving regulations, which will also be discussed in the article. There is little debate on the need for people with type 1 diabetes to self-monitor

their blood glucose, as the majority of them use the information to alter their insulin doses and to detect potential hypoglycaemic episodes and treat them accordingly. NICE (2009) acknowledges that, and furthermore advises that, SMBG is an essential element of self-care if backed by education.

However, NHS Diabetes (2010) points out that “there is increasing concern that health service managers and GPs are using published evidence to prevent even individuals who find blood glucose monitoring useful from checking their blood glucose whenever they feel they need to.”

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Learning objectives

After reading this article, the participant should be able to:

1. Describe how self-monitoring of blood glucose fits into updated Driver and Vehicle Licensing Agency guidance.
2. Discuss the “pros and cons” of effective self-monitoring of blood glucose.
3. Work with people with diabetes to ensure self-monitoring of blood glucose results are individualised to their lifestyle and therapy and that results are acted upon.

Key words

- Blood glucose
- Guidelines
- Self-management

Gwen Hall is a Diabetes Specialist Nurse in Primary Care in Haslemere, Surrey, and Vice Chair of the Primary Care Diabetes Society.

“Controversy exists regarding the effectiveness of self-monitoring of blood glucose in type 2 diabetes.”

The Scottish Intercollegiate Guidelines Network (SIGN; 2010) advises that the impact of SMBG on management of glycaemic control is positive but small for patients with type 2 diabetes who are not on insulin, and slightly larger, but based on poorer evidence, for those using insulin. It is difficult to use the evidence base to define those patients with type 2 diabetes who will gain most benefit from SMBG. Extrapolation from the evidence would suggest that specific subgroups of patients may benefit. These include those who are at increased risk of hypoglycaemia or its consequences, and those who are supported by health professionals in acting on glucose readings to change health behaviours including appropriate alterations in insulin dose. Further research is needed to define more clearly which subgroups are most likely to benefit (SIGN, 2010).

Effectiveness of SMBG

Controversy exists regarding the effectiveness of SMBG in type 2 diabetes. On the one hand it is seen as an expensive option with little evidence to support it; on the other it is seen as a vital tool in engaging people with diabetes

in their own care. The paragraphs that follow illustrate these differences of opinion.

Martin et al (2006) found that SMBG was associated with decreased diabetes-related morbidity and all-cause mortality in people with type 2 diabetes. The association was also observed in a subgroup of participants who were not receiving insulin. The authors’ opinion was that SMBG may be associated with a healthier lifestyle and better disease management.

Peel and Lawton (2007) found that clinical uncertainty about the efficacy and role of SMBG in people with type 2 diabetes was mirrored in individuals’ accounts. People tended not to act on their self-monitoring results, in part because of a lack of education about the appropriate response to readings – a fact well recognised by healthcare professionals working with people with diabetes. The authors stressed that healthcare professionals should be explicit about whether and when such patients should self-monitor and how they should interpret and act upon the results, especially high readings. This may be seen as

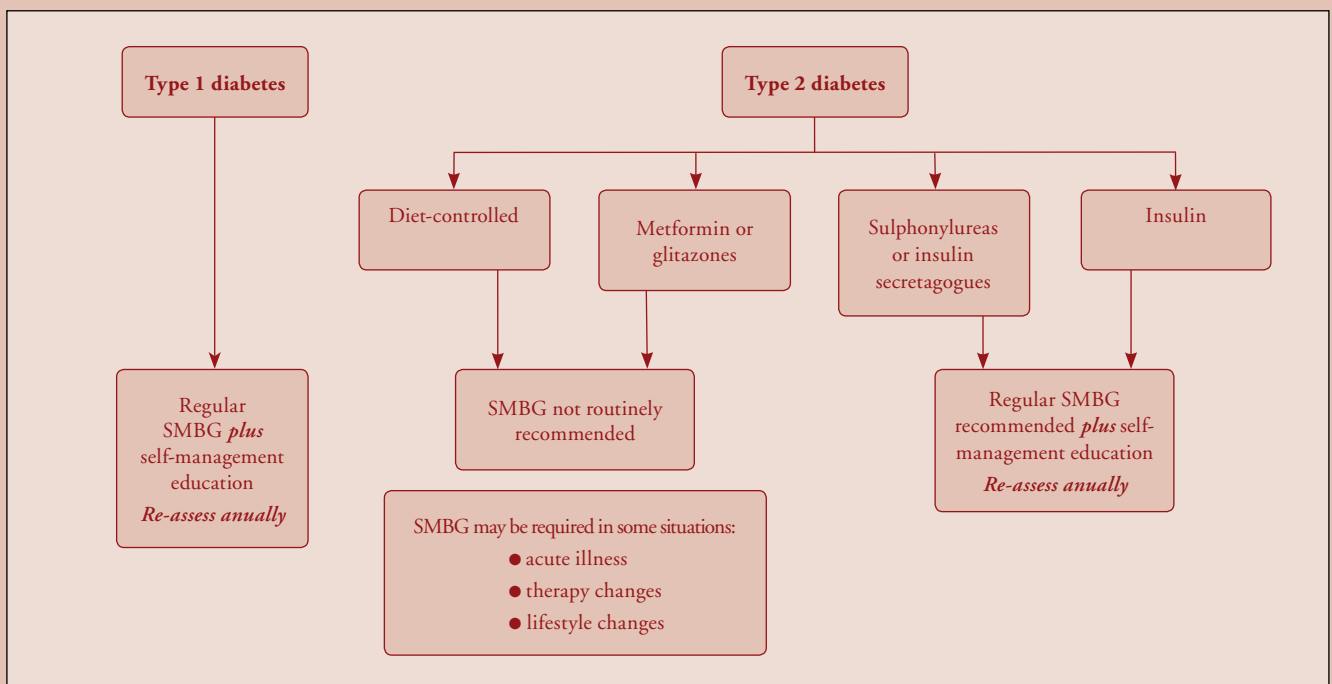


Figure 1. Summary of NICE guidance CG66 (updated) for self-monitoring of blood glucose (NICE, 2008). Reproduced with kind permission of UK Medicines Information (2011).

an argument for improved education rather than for restrictions in SMBG and is reflected in the latest guidance from NICE (*Figure 1*).

Simon et al (2008), on behalf of the DiGEM (Diabetes Glycaemic Education and Monitoring) study group, found that SMBG – with or without additional training in incorporating the results into self-care – was associated with higher costs and lower quality of life in people with non-insulin-treated type 2 diabetes. The authors felt that SMBG was unlikely to be cost-effective in addition to standardised, usual care.

Furthermore, Farmer et al (2009), again on behalf of the DiGEM study group, found no convincing evidence to recommend routine use of SMBG by reasonably well-controlled, non-insulin-treated people with type 2 diabetes. However, the authors did consider that clinical judgement is required to identify those who would benefit, including people at high risk of hypoglycaemia and those motivated to make alterations to behaviour that lead to consistent changes in blood glucose levels, and where there is strong patient preference. The authors stated that if HbA_{1c} levels remain >64 mmol/mol (8%), then self-monitoring may provide motivation for medication adherence and lifestyle measures, as insulin therapy may be required in this group.

A small study from Ireland (O’Kane et al, 2008), comprising 96 participants in the monitoring group, is frequently quoted as a reason for restricting access to SMBG testing strips. The authors concluded that people with newly diagnosed type 2 diabetes had no beneficial effects from SMBG, but that it was associated with higher scores on a depression sub-scale. The size of the study (among other things), however, leads others to argue with its validity in the larger population (see *BMJ* rapid responses; available at: <http://bit.ly/PCBVu6> [accessed 23.08.12]).

The authors of the STeP (Structured TEsting Protocol) study recognise that while some studies have questioned the value and utility of SMBG, specifically in non-insulin-treated patients, more recent studies have shown

that appropriate use of structured SMBG, combined with education and goal-setting, facilitates and reinforces adoption of healthy behaviours and promotes timely and persistent therapy adjustments, resulting in improved clinical and behavioural outcomes (Parkin, 2011). Further details on the STeP study tools and resources are available at <http://bit.ly/SIJMIJ> (accessed 23.08.12).

Hypoglycaemia

People with type 2 diabetes treated with sulphonylureas or insulin may also be subject to hypoglycaemia, and SMBG may be seen as a key component of self-management in this population. This has become even more relevant in view of the updated guidance from the Driver and Vehicle Licensing Agency (DVLA; 2012).

In its guidance, the DVLA states that those treated with insulin must:

- Have awareness of hypoglycaemia.
- Not have had more than one episode of hypoglycaemia requiring the assistance of another person in the preceding 12 months.
- Have appropriate blood glucose monitoring.

Driving

Drivers with insulin-treated diabetes are advised by the DVLA to take the following precautions:

- You must always carry your glucose meter and blood glucose strips with you. You must check your blood glucose before the first journey and every 2 hours whilst you are driving.
- In each case if your blood glucose is 5.0 mmol/L or less, take a snack. If it is <4.0 mmol/L or you feel hypoglycaemic, do not drive.
- If hypoglycaemia develops while driving, stop the vehicle as soon as possible.
- You must switch off the engine, remove the keys from the ignition and move from the driver’s seat.
- You must not start driving until 45 minutes after blood glucose has returned to normal. It takes up to 45 minutes for the brain to recover fully.

Page points

1. Self-monitoring of blood glucose may be seen as a key component of self-management in people with type 2 diabetes treated with sulphonylureas or insulin.
2. The DVLA has introduced new guidelines on blood glucose monitoring in those with insulin-treated diabetes.

Page points

1. Many patients do not routinely monitor postprandially or overnight.
2. Subcutaneous sensors to continuously monitor glucose may be considered in those having difficulties maintaining glucose levels or receiving subcutaneous insulin infusion therapy.

The DVLA provides further guidelines for those wishing to drive Group 2 vehicles.

Those treated with tablets which may induce hypoglycaemia (sulphonylureas and glinides):

- Must not have had more than one episode of hypoglycaemia requiring the assistance of another person within the preceding 12 months.
- It may be appropriate to monitor blood glucose regularly and at times relevant to driving to enable the detection of hypoglycaemia.
- Must be under regular medical review.

When to test

Although SMBG is a vital part of the management of glycaemia in people with type 1 diabetes, many people do not routinely monitor glucose levels either postprandially or overnight, which may leave undetected episodes of hyperglycaemia and hypoglycaemia respectively.

Fasting levels, pre-meal levels or both are a good indication of effectiveness of therapy but post-meal spikes can be an indicator of future cardiovascular risk. The International Diabetes Federation (2011) has published guidance on post-meal testing. If HbA_{1c} remains above target but pre-meal self-monitoring levels remain well controlled (<7.0 mmol/L), consider self-monitoring to detect postprandial hyperglycaemia (>8.5 mmol/L), and manage to below this level if detected.

Reliance on HbA_{1c} as a marker of long-term glycaemic control is an accepted practice, but self-monitoring data and patient history should also be taken into consideration as frequent hypoglycaemic events may result in a low HbA_{1c} level, while adversely affecting quality of life. Systems using continuous monitoring of glucose by means of subcutaneous sensors which measure interstitial glucose levels have been developed. These systems are generally only considered for use by patients who experience particular difficulties in maintaining normal glucose levels or who have been transferred to continuous subcutaneous insulin infusion therapy (SIGN, 2010).

Involving the person with diabetes in setting self-monitoring goals and targets should be the norm. They should recognise that SMBG is an educational tool that is available to them and to use it wisely. It should not simply be a paper record that they bring into clinic for interpretation. Three questions to consider asking to aid effective use of strips are:

1. Why did you do that test?
2. What did you learn from the result?
3. What action did you take?

If they cannot answer these questions perhaps they need to be more involved in education and meaningful goal-setting, or

Box 1. Case example.

Mr A, age 52 and with type 2 diabetes treated with insulin, attended clinic on 19 July with his wife where his HbA_{1c} was 68 mmol/L (8.4%). He had not been self-monitoring his blood glucose effectively, with only one test (2 June in the record below) as he felt well. He was also treated for hypertension and dyslipidaemia. He was obese (BMI, 32kg/m²) and took little exercise. His insulin requirement had increased substantially over the years and he was now taking 80 units of a pre-mixed insulin morning and evening. His injection sites showed no fatty lumps (lipohypertrophy) and his diet, although not good, had not changed. He, and his wife, discussed the risks to his future health with the practice nurse. Mr A started monitoring his blood glucose and took the practice nurse's lifestyle advice seriously (with support from his wife). Although he did not contact his care team for advice he substantially reduced his insulin in response to his monitoring record, achieving much improved results, with reduced insulin need. The success of seeing how effective increased exercise and improved diet could be motivated Mr A to continue to take better care of his health.

Date	Insulin injection		Blood		Glucose level (mmol/L)				Key events/notes
	Pre-meal	Evening	Fasting	Post-meal	Pre-meal	Post-meal	Overnight	Overnight	
2/6	60		14.2						
19/7	80	80	15.9	4.9	8.1				
20/7	80	88	12.6	11.5	17.8			11.50pm	
21/7	60	55	9.9	9.8	9.1				Felt low at night
22/7	50	50	11.9	8.4	8.3				Felt low at night
23/7	50	50	7.3	6.3	7.4				Felt low at night
24/7	50	50	7.6	9.6	8.5				Felt low at night

perhaps they are gaining little from self-monitoring.

Who should monitor?

NICE guidance states that self-monitoring of blood glucose should only be offered as an integral part of diabetes self-management education and to specific groups (Box 2; NICE, 2009).

Costs

In 2011/12 this area of prescribing represented 14.9% of total items and 20.8% of the total cost of prescribing for the treatment of diabetes. It was second only in cost to the prescribing of analogue insulins (The Information Centre, 2012).

Quality Control

The Medicines and Healthcare Products Regulatory Agency (MHRA; 2010) has published updated guidance for healthcare professionals to ensure accuracy on blood glucose meters including where to report any adverse incidents. It also issues alerts on problems with meters.

Standard Operating Procedure (SOP)

There must be an SOP in place wherever blood glucose testing is performed. SOPs must include the manufacturer's instructions for use and should be directly available to the user and be kept with the equipment.

Internal Quality Control (IQC)/

External Quality Assessment (EQA)

IQC: Appropriate control material must be analysed according to local hospital procedures and manufacturers' recommendations. It can provide reassurance that the device is working correctly and assure the operator of the reliability of patient results.

EQA: It is advisable that all sites performing blood glucose analysis also undertake the analysis of EQA samples. EQA is the analysis of samples with an undisclosed value from an external source.

Participation in an EQA scheme will establish comparability between sites.

Record keeping

It is essential that accurate records are kept for all aspects of blood glucose testing. This could include test strip lot number, meter maintenance, calibration, quality control, patient results, patient and operator identity and battery change. In the event of an adverse incident or product recall, such information would be essential in performing a risk analysis of the situation, enabling appropriate action to be taken.

Training

Training must be provided for staff who use blood glucose meters and should be refreshed at appropriate intervals. Only staff whose training and competence has been established and recorded should be

Page points

1. NICE guidance states that self-monitoring of blood glucose should only be offered as an integral part of diabetes education and to specific groups.
2. The Medicines and Healthcare Products Regulatory Agency has provided guidance on blood glucose meters, including where to report any adverse incidents.

Box 2. Guidance for self-monitoring of blood glucose (adapted from NICE [2009]).

- | | |
|--|--|
| Self-monitoring of plasma glucose should be available to: | <ul style="list-style-type: none"> ● Those on insulin treatment. ● Those on oral glucose-lowering medications to provide information on hypoglycaemia. ● Assess changes in glucose control resulting from medications and lifestyle change. ● Monitor changes during intercurrent illness. ● Ensure safety during activities, including driving. |
| Include in the discussion: | <ul style="list-style-type: none"> ● The purpose of self-monitoring. ● How to interpret and act on results. |
| Action: | <ul style="list-style-type: none"> ● Offer to a person newly diagnosed only as an integral part of self-management education. |
| Monitoring: | <ul style="list-style-type: none"> ● Assess at least monthly and in a structured way: <ul style="list-style-type: none"> □ Self-monitoring skills. □ The quality and frequency of testing. □ The use made of results obtained. □ The impact on quality of life. □ The continued benefit. □ The equipment used. |

Page points

1. Training must be provided for staff who use blood glucose meters.
2. Self-monitoring of blood glucose, if combined with education on its use, can be effective and assist people with diabetes to self-care.

permitted to carry out blood glucose testing. Staff involved in training and advising people with diabetes should ensure that they inform them of potential sources of error and give advice on how to interpret results. Training should include:

- Basic principles of measurement.
- Expected results in normal and pathological states.
- Demonstration of the proper use of the equipment in accordance with the manufacturer's specification.
- Demonstration of the consequences of improper use.
- Knowledge of operator-dependent steps.
- Instruction in the collection of appropriate blood samples.
- Health and safety aspects.
- Instruction in the importance of complete documentation of all data produced.
- Appropriate calibration and quality control techniques.
- Practical experience of the procedures, including a series of analyses to satisfy the instructor that the trainee is competent.
- Information regarding contra-indications.
- Information on basic troubleshooting, error messages and potential sources of error.

Conclusions

Health professionals undertaking blood glucose monitoring must ensure quality control procedures are in place on the meters that they use and remember that HbA_{1c} does not identify blood glucose highs and lows. SMBG, if combined with education on its use, can be effective and can assist people with diabetes to self-care. The costs to the NHS will continue to fuel the debate as to its effectiveness in type 2 diabetes treated with agents other than insulin or sulphonylureas. Education of people with diabetes and healthcare professionals alike is vital to effective monitoring. ■

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Online CPD activity

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Participants should read the preceding article before answering the multiple choice questions below. There is ONE correct answer to each question. After submitting your answers online, you will be immediately notified of your score. A pass mark of 70% is required to obtain a certificate of successful participation; however, it is possible to take the test a maximum of three times. A short explanation of the correct answer is provided. Before accessing your certificate, you will be given the opportunity to evaluate the activity and reflect on the module, stating how you will use what you have learnt in practice. The new CPD centre keeps a record of your CPD activities and provides the option to add items to an action plan, which will help you to collate evidence for your annual appraisal.

- 1. Which of the following is the MOST appropriate reason for a person with type 2 diabetes to routinely self-monitor blood glucose levels? Select ONE option only.**
 - A. To check postprandial blood glucose levels
 - B. To check that average blood glucose is close to the target of 7 mmol/L
 - C. To check whether metformin is lowering average blood glucose levels
 - D. To detect potential hypoglycaemia
 - E. None of the above
- 2. According to SIGN guidelines, which people with type 2 diabetes gain MOST benefit from self-monitoring of blood glucose? Select ONE option only.**
 - A. Those showing an interest in knowing their blood glucose scores
 - B. Those taking alpha-glucosidase inhibitors
 - C. Those taking DPP-4 inhibitors
 - D. Those with an HbA_{1c} close to 58 mmol/mol (7.5%)
 - E. None of the above
- 3. According to NICE guidelines, which one of the following is NOT a recommended potential reason for people with type 2 diabetes to regularly self-monitor blood glucose? Select ONE option only.**
 - A. During an episode of acute illness
 - B. During antidiabetes agent changes
 - C. During significant lifestyle changes
 - D. When taking a sulphonylurea as monotherapy
 - E. When taking a thiazolidinedione as monotherapy
- 4. Which is the MOST appropriate statement regarding the evidence base for self-monitoring of blood glucose in people with type 2 diabetes? Select ONE option only.**
 - A. There is clear evidence demonstrating the cost-effectiveness of self-monitoring
 - B. There is clear evidence demonstrating higher levels of depression when self-monitoring
 - C. There is clear evidence demonstrating improved quality of life due to self-monitoring
 - D. There is no clear guidance to help health care professionals identify who would benefit from self-monitoring
 - E. None of the above
- 5. Which people with type 2 diabetes gain the LEAST benefit from self-monitoring of blood glucose? Select ONE option only.**
 - A. People expressing a strong preference to self-test
 - B. People lacking motivation to make lifestyle alterations
 - C. People with type 1 diabetes
 - D. People with type 2 diabetes taking a meglitinide
 - E. People with type 2 diabetes and a HbA_{1c} >75 mmol/mol (9%)
- 6. According to DVLA guidance, which is the MOST appropriate advice for people with type 1 diabetes regarding driving and hypoglycaemia? Select ONE option only.**
 - A. Always carry glucose meter and testing strips in the vehicle
 - B. Check blood glucose every three hours driving
 - C. Start driving once blood glucose is > 4 mmol/L
 - D. Start driving no sooner than 30 minutes after an episode
 - E. Stop the vehicle immediately symptoms occur as long as it is safe to do so
- 7. A 42-year-old male motorcyclist has had one severe hypoglycaemic episode in the preceding 12 months. He takes the following medication:**

Aspirin 75 mg once daily
Gliclazide 80 mg twice daily
Ramipril 5 mg twice daily
Simvastatin 40 mg once daily

Which is the SINGLE MOST appropriate advice to give regarding driving? Select ONE option only.

 - A. Must be under regular medical review
 - B. Must not drive until 6 months without any severe hypoglycaemia
 - C. Must not drive until 12 months without any severe hypoglycaemia
 - D. Must not drive without a passenger
 - E. Must take glucose tablets before commencing a long journey
- 8. A 59-year-old woman has epilepsy and type 2 diabetes. She has had three admissions to A&E in the past 9 months with suspected hypoglycaemia. Her latest HbA_{1c} is 64 mmol/mol (8%) and she takes the following medication:**

Carbamazepine 400 mg twice daily
Gliclazide 80 mg once daily
Metformin 1 g twice daily

Which is the SINGLE MOST appropriate recommendation? Select ONE option only.

 - A. Ensure she takes a complex carbohydrate as soon as she is aware of hypoglycaemic symptoms
 - B. Start self-monitoring of blood glucose
 - C. Start self-monitoring of urine glucose
 - D. Stop metformin and gliclazide
 - E. Switch gliclazide to repaglinide
- 9. According to NICE guidance, what is the MINIMUM frequency that a structured review of self-monitoring by a health professional should occur? Select ONE option only.**
 - A. No guidance given
 - B. 3 monthly
 - C. 6 monthly
 - D. 9 monthly
 - E. Annually
- 10. What APPROXIMATE PROPORTION of the total cost of prescribing in England for the treatment of diabetes is accounted for by self-monitoring of blood glucose? Select ONE option only.**
 - A. 10%
 - B. 20%
 - C. 30%
 - D. 40%
 - E. 50%