Glucose monitoring

The aim of determining and achieving glycaemic targets is to achieve the optimal balance between preventing complications associated with hyperglycaemia and mitigating the risk of hypoglycaemia.

In tandem with managing glycaemia (refer to the section 'Medical management of glycaemia'), cardio-renal risk management is of paramount importance. Refer to the section 'Type 2 diabetes and cardiovascular risk'.

Recommendations

Recommendation	Reference	Grade*
Glycated haemoglobin (HbA1c) measurement should be used to assess long-term blood glucose control	1 NHMRC, 2009	A
Self-monitoring of blood glucose (SMBG) is recommended for patients with type 2 diabetes who are using insulin and have been educated in appropriate alterations in insulin dose	2 Scottish Intercollegiate Guidelines Network, 2017	B
For people with type 2 diabetes not receiving insulin therapy: • frequency of SMBG should be individualised, depending on type of glucose-lowering medications, level of glycaemic control and risk of hypoglycaemia • when glycaemic control is not being achieved, SMBG should be instituted and should include periodic pre- and post-prandial measurements and training of healthcare providers and people with diabetes in methods to modify health behaviours and glucose-lowering medications in response to SMBG values	3 Diabetes Canada, 2018	 D, consensus B, level 2
A reasonable HbA1c goal for many non-pregnant adults is <7% (53 mmol/mol)	4 American Diabetes Association, 2019	A
Less stringent HbA1c goals (such as <8% [64 mmol/mol]) may be appropriate for patients with a history of severe hypoglycaemia, limited life expectancy, advanced microvascular or macrovascular complications, extensive comorbid conditions, or long-standing diabetes in whom the goal is difficult to achieve despite diabetes self-management education, appropriate glucose monitoring, and effective doses of multiple glucose-lowering agents including insulin	4 American Diabetes Association, 2019	B
Targets for self-monitoring of blood glucose levels are 4.0–7.0 mmol/L for fasting and preprandial, and 5.0–10.0 mmol/L for two-hour postprandial	3 Diabetes Canada, 2018	B, level 2
*Refer to 'Explanation and source of recommendations' for explanations of the levels and grades of evidence.		

Accuracy and limitations of HbA1c measurements

HbA1c has been the gold standard for monitoring long-term glycaemic management since 1976, and it is one method used to diagnose diabetes. Monitoring is usually recommended at three-month intervals (four per year); however, with stable diabetes a six-month interval may be appropriate.

HbA1c measurement and natural test variation

HbA1c can be measured and reported using two different standards:

- as a percentage measure of glycated N-terminal residue of the β chain of haemoglobin (eg 7%)
- in units of mmol/mol, according to the International Federation of Clinical Chemistry (IFCC) standardised reporting (eg 53 mmol/mol).

The variability of laboratory HbA1c test results in Australia is acceptably low.[5] However, there may be some variability,[6,7] which needs to be considered when monitoring long-term glucose control. Conditions such as the following that affect HbA1c results also need to be considered.

Conditions that affect HbA1c results

A number of conditions can cause HbA1c discordance, where HbA1c does not accurately reflect mean blood glucose.

Any condition that shortens erythrocyte survival or decreases mean erythrocyte age will falsely lower HbA1c test results, regardless of the assay method used.

The presence of abnormal haemoglobin variants can occur in people of Mediterranean, African or Southeast Asian heritage. Screening for haemoglobinopathies before HbA1c testing should be considered.[7] If a haemoglobinopathy is suspected, then a haemoglobin electrophoresis is suggested.

Some important clinical situations may indicate the presence of a haemoglobinopathy, such as when:

- results of self-monitoring of blood glucose (SMBG) have a poor correlation with HbA1c results
- an HbA1c result is discordant with measured alternate laboratory glycaemic values
- an HbA1c result is more than 15% or less than 4%
- a patient's HbA1c test result is radically different from a previous test result following a change in laboratory HbA1c measurement methods.

Other causes of HbA1c discordance are shown in Box 1.

Alternative forms of diabetes monitoring such as SMBG, continuous glucose monitoring and flash glucose monitoring (refer to the section 'Use of technology in type 2 diabetes management') should be considered for these patients.

Note that fructosamine as an alternative longer-term glucose measure may not be suitable in people with iron deficiency anaemia, as this condition raises both HbA1c and fructosamine; conversely, iron infusion spuriously lowers both HbA1c and fructosamine.[8–10]

Box 1. Other causes of HbA1c discordance

Abnormally low HbA1c can be caused by:

- anaemia
  - haemolytic anaemia – congenital (eg spherocytosis, elliptocytosis)
  - haemoglobinopathies
  - acquired haemolytic anaemias (eg drug-induced, such as with dapsone, methyldopa)
- recovery from acute blood loss
- blood transfusions, iron infusions
- chronic blood loss
- chronic renal failure (variable).

Abnormally high HbA1c can be caused by:

- iron deficiency anaemia[8]
- splenectomy
- alcoholism.

HbA1c is an unreliable measure of glycaemic management in the first four weeks of pregnancy.

Self-monitoring of blood glucose

SMBG in patients with type 2 diabetes is recommended:[2,3]

- for people on insulin and sulfonylureas, which can cause hypoglycaemia
- for people not on insulin who are having difficulty achieving glycaemic control (patients and their healthcare providers should be trained in methods to modify health behaviours and glucose-lowering medications in response to SMBG values)
- when monitoring hypo/hyperglycaemia arising from intercurrent illness (refer to the sections 'Medical management of glycaemia' and 'Managing risks and other impacts of type 2 diabetes')
- during pre-pregnancy and pregnancy management for people with established diabetes or gestational diabetes
- when there is a clinical need for monitoring, such as during changes in management or lifestyle, or for conditions or medications (such as corticosteroids) that require data on glycaemic patterns that HbA1c cannot provide
- when HbA1c estimations are unreliable (eg haemoglobinopathies).

Routine SMBG for people with type 2 diabetes who are considered low risk and who are using oral glucose-lowering drugs (with the exception of sulfonylureas) is not recommended.[11–15]

The method and frequency of monitoring need to reflect individual circumstances and therapeutic aims. SMBG is most effective where the person with diabetes and their healthcare providers have the knowledge, skills and willingness to incorporate SMBG and therapy adjustments into diabetes care plans.

Targets for self-monitored glycaemic control in type 2 diabetes (where stringent glycaemic management is recommended) are shown in Table 1.

The National Diabetes Services Scheme (NDSS) provides subsidised blood glucose monitoring strips for SMBG for a six-month period after an initial diagnosis of diabetes. Ongoing access, in six-monthly increments, is available when assessed as clinically necessary and authorised by a general practitioner, credentialled diabetes educator, endocrinologist, nurse practitioner or other registered medical practitioner, in the following categories: intercurrent illness, medications affecting blood glucose, critical need for self-monitoring, diabetes management change, diabetes management not stable. Refer to the NDSS website for further information.

There is an emerging role for continuous glucose monitoring and flash glucose monitoring in patients with type 2 diabetes on complex insulin regimens who have not achieved their glycaemic targets; however, this technology is not available through the NDSS for people with type 2 diabetes. Refer to the section 'Use of technology in type 2 diabetes management' for more information.

Table 1. Targets for self-monitored glycaemic control in type 2 diabetes[3]

Fasting blood glucose (FBG; mmol/L)	Preprandial blood glucose (mmol/L)	Postprandial blood glucose (mmol/L)	Comment
4.0–7.0	4.0–7.0	5.0–10	Diabetes Canada guidelines

HbA1c targets and individualisation

The general HbA1c target in people with type 2 diabetes is HbA1c ≤7% (≤53 mmol/mol).[1]

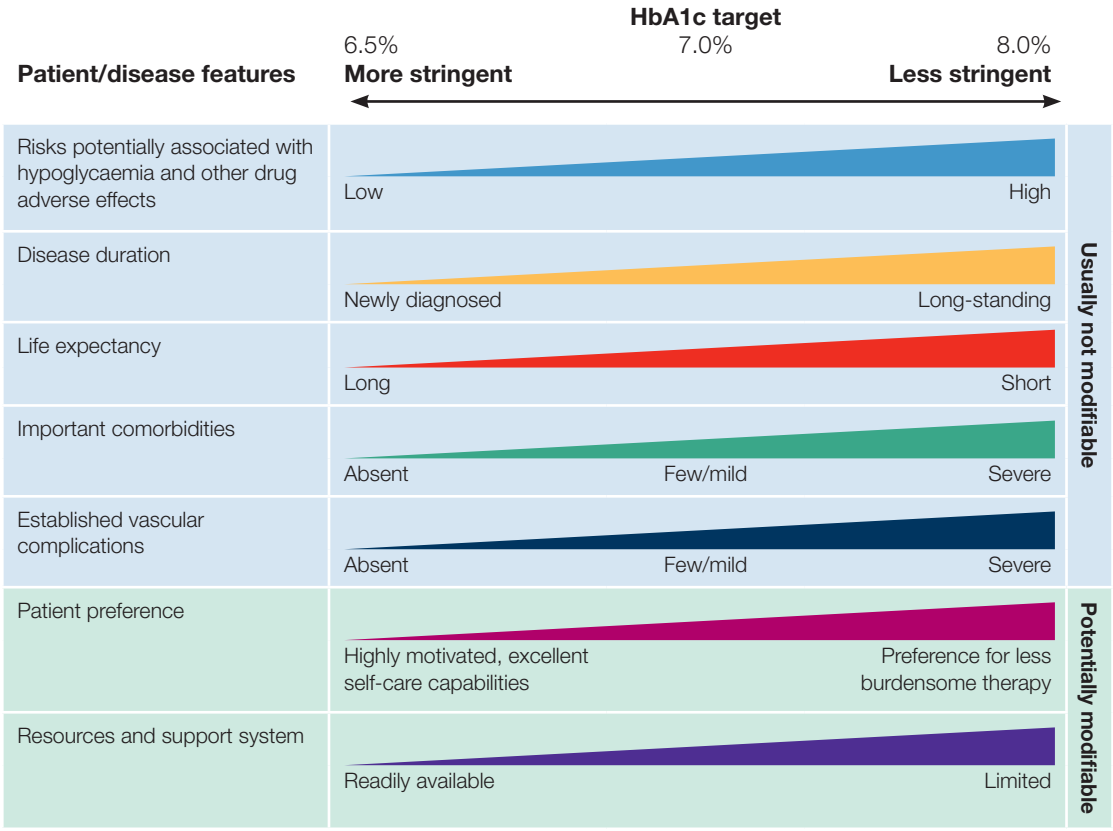
In the vast majority of patients with diabetes, optimising their blood glucose control may improve specific short-term and long-term health outcomes. However, what is 'optimal' will vary, depending on the balance between benefits and risks and the patient's priorities (Figure 1). Thus, there is no single glycaemic target that suits all patients.

For example, HbA1c targets may vary in selected patients as follows:[16]

- A more stringent target of 6.5% (48 mmol/mol) might be appropriate for people with short disease duration, long life expectancy and no significant cardiovascular disease, if this can be easily and safely achieved without hypoglycaemia or other adverse effects of treatment.
- Less stringent targets might be more appropriate for patients with reduced life expectancy or extensive comorbid conditions; those who have difficulty attaining targets despite intensive self-management education, repeated counselling, and effective doses of multiple glucose-lowering agents (including insulin); or those at risk of hypoglycaemia.

Diabetes symptoms (eg polydipsia, polyuria) are related to increasing glycaemia, as measured by HbA1c levels above 8% (64 mmol/mol).[17]

Figure 1. Approach to individualising HbA1c targets



Some important patient characteristics to consider when individualising HbA1c targets are listed on the left. More stringent efforts to lower HbA1c are justified for people who fall to the left of the range; those toward the right may have other priorities and require less stringent efforts.

Source: Adapted from Inzucchi SE, Bergenstal RM, Buse JB, et al. Management of hyperglycemia in type 2 diabetes, 2015: A patient-centered approach: Update to a position statement of the American Diabetes Association and the European Association for the Study of Diabetes. Diabetes Care 2015;38(1):140–49, with permission of the American Diabetes Association.

Glycaemic variability and time in range

Glycaemic variability represents the degree of stability of the glucose profile and refers to swings in blood glucose levels. Glycaemic variability can be measured as within-day, between-days or, most commonly, as mean glucose and standard deviation of glucose over two weeks.

Emerging evidence in randomised controlled trials of people using multiple daily insulin shows an association between within-day or between-days glycaemic variability or 'time spent in range' observations and diabetes-related complications;[18] however, more clinical evidence is needed. Additional observational studies have linked same-day or between-days glycaemic variability to higher rates of both hypo- and hyperglycaemia for a given HbA1c, as well as peripheral neuropathy and retinopathy.[19] Lower levels of HbA1c are not directly linked to increased hypoglycaemia risk.[20]

References

1. Colagiuri S, Dickinson S, Girgis S, et al. National evidence based guideline for blood glucose control in type 2 diabetes. Canberra: National Health and Medical Research Council, 2009.
2. Scottish Intercollegiate Guidelines Network. Management of diabetes: A national clinical guideline (updated 2017). Edinburgh: SIGN, 2017.
3. Diabetes Canada Clinical Practice Guidelines Expert Committee. Diabetes Canada 2018 clinical practice guidelines for the prevention and management of diabetes in Canada. Can J Diabetes 2018;42:S1–S325.
4. American Diabetes Association. Standards of medical care in diabetes: 6. Glycemic targets. Diabetes Care 2019;42:S61–S70.
5. d'Emden MC, Shaw JE, Colman PG, et al. The role of HbA1c in the diagnosis of diabetes mellitus in Australia. Med J Aust 2012;197(4):220–21.
6. Heinemann L, Freckmann G. Quality of HbA1c measurement in the practice: The German perspective. J Diabetes Sci Technol 2015;9:687–95.
7. Ang S, Thevarajah M, Alias Y, Khor SM. Current aspects in hemoglobin A1c detection: A review. Clin Chim Acta 2015;15:202–11.
8. Sundaram RC, Selvaraj N, Vijayan G, et al. Increased plasma malondialdehyde and fructosamine in iron deficiency anemia: Effect of treatment. Biomed Pharmacother 2007;61(10):682–85.
9. Tarim O, Kucukerdogan A, Gunay U, Eralp O, Ercan I. Effects of iron deficiency anemia on hemoglobin A1c in type 1 diabetes mellitus. Pediatr Int 1999;41(4):357–62.
10. Coban E, Ozdogan M, Timuragaoglu A. Effect of iron deficiency anemia on the levels of hemoglobin A1c in nondiabetic patients. Acta Haematol 2004;112:126–28.
11. Bosi E, Scavini M, Ceriello A, et al. Intensive structured self-monitoring of blood glucose and glycemic control in noninsulin-treated type 2 diabetes: The PRISMA randomized trial. Diabetes Care 2013;36(10):2887–94.
12. Schnell O, Barnard K, Bergenstal R, et al. Clinical Utility of SMBG: Recommendations on the use and reporting of SMBG in clinical research. Diabetes Care 2015;38(9):1627–33.
13. Farmer AJ, Perera R, Ward A, et al. Meta-analysis of individual patient data in randomised trials of self monitoring of blood glucose in people with non-insulin treated type 2 diabetes. BMJ 2012;344.
14. Malanda UL, Welschen LM, Riphagen, II, Dekker JM, Nijpels G, Bot SD. Self-monitoring of blood glucose in patients with type 2 diabetes mellitus who are not using insulin. Cochrane Database Syst Rev 2012;1:CD005060.
15. Nauck MA, Haastert B, Trautner C, et al. A randomised, controlled trial of self-monitoring of blood glucose in patients with type 2 diabetes receiving conventional insulin treatment. Diabetologia 2014;57(5):868–77.
16. American Diabetes Association. Glycemic targets: Standards of medical care in diabetes 2019. Diabetes Care 2019;42:S61–S70.
17. Kleefstra N, Ubink-Veltmaat L, Houweling S, Groenier KH, Meyboom-de Jong B, Bilo HJ. Cross-sectional relationship between glycaemic control, hyperglycaemic symptoms and quality of life in type 2 diabetes (ZODIAC-2). Neth J Med 2005;63(6):215–21.
18. Zinman B, Marso S, Poulter N, et al. Day-to-day fasting glycaemic variability in DEVOTE: Associations with severe hypoglycaemia and cardiovascular outcomes (DEVOTE 2). Diabetologia 2018;61(1):48–57.
19. Xu F, Zhao L, Su J, et al. The relationship between glycemic variability and diabetic peripheral neuropathy in type 2 diabetes with well-controlled HbA1c. Diabetol Metab Syndr 2014;6(1):139.
20. Engler B, Koehler G, Hoffmann C, et al. Relationship between HbA1c on target, risk of silent hypoglycemia and glycemic variability in patients with type 2 diabetes mellitus. Exp Clin Endocrinol Diabetes 2011;119(1):59–61.

We acknowledge the Traditional Custodians of the lands and seas on which we work and live, and pay our respects to Elders, past, present and future.

20635