Consensus Report

The management of type 1 diabetes in adults. The updated 2026 consensus report by the American Diabetes Association (ADA) and the European Association for the Study of Diabetes (EASD)

Keywords Adjunctive therapy, Diabetic ketoacidosis, Diagnosis, Exercise, Glucose monitoring, Hypoglycaemia, Insulin, Nutrition, Psychosocial care, Schedule of care, Transplantation, Type 1 diabetes

Abbreviations

AID	Automated insulin delivery
App	Application
BGAT	Blood glucose awareness training
BGM	Blood glucose monitoring
CGM	Continuous glucose monitoring
DCCT	Diabetes Control and Complications Trial
DIY	Do it yourself
DKA	Diabetic ketoacidosis
DSMES	Diabetes self-management education and support
EDIC	Epidemiology of Diabetes Interventions and Complications
EMA	European Medicines Agency
FDA	U.S. Food and Drug Administration
GLP-1 RA	Glucagon like peptide-1 receptor agonists
GMI	Glucose management indicator
IAH	Impaired awareness of hypoglycaemia
MDI	Multiple daily injections
PTA	Pancreas transplants alone
SGLT	Sodium–glucose cotransporter
SPK	Simultaneous pancreas and kidney
TAR	Time above range
TBR	Time below range
TIR	Time in range

Abstract

This 2026 consensus report from the European Association for the Study of Diabetes (EASD) and the American Diabetes Association (ADA) builds on the 2021 report to provide guidance for managing type 1 diabetes in adults. Reflecting the rapid advances in the field, all sections have been updated to account for novel therapies, interventions to delay disease onset, and the integration of new technologies. It also broadens its scope to screening for long-term diabetes complications, and the management of obesity and cardiovascular risk factors. Psychosocial care and diabetes self-management education and support (DSMES) remain key section elements.

The report was developed using the Accurate Consensus Reporting Document (ACCORD) framework. The guidance aligns with current ADA Standards of Care and relevant EASD and ADA documents and aims to support clinicians globally in delivering high-quality, individualized care for adults with type 1 diabetes, adaptable across diverse healthcare systems and resource settings.

<H1>Section 1: Introduction and rationale for the consensus report

Type 1 diabetes is an autoimmune condition characterized by destruction of insulin-producing beta cells, resulting in profound insulin deficiency. It affects an estimated 9 million people worldwide and accounts for 5–10% of all diabetes cases.[1] While incidence peaks in adolescence and early adulthood, it can develop at any age; in the U.S. the median age at onset is 24 years with over half of new cases occurring in adults.[2] Owing to long survival after diagnosis, the prevalence is higher among adults than children.[3]

Since insulin's discovery over a century ago, advances in insulin formulations, delivery systems, and glucose monitoring technologies have transformed care. However, many individuals still do not meet the glycaemic goals needed to prevent complications, contributing to the persistent physical and emotional burden of living with type 1 diabetes. In response to these challenges and the rapid pace of development, the European Association for the Study of Diabetes (EASD) and American Diabetes Association (ADA) published a consensus report in 2021 on the management of type 1 diabetes in adults focusing on glycaemic management and acute complications.[4,5]

This updated version addresses recent developments, including interventions to delay the onset of diabetes, emerging therapies, and new technologies. It also broadens the scope to screening for long-term diabetes complications, and management of obesity and cardiovascular risk factors. Psychosocial care and diabetes self-management education and support (DSMES) remain integral components of this report. Our aim is to support clinicians in optimising care for people with type 1 diabetes. We have added key points at the beginning of each section. Although developed by authors from Europe and the U.S., both organisations serve an international membership, and the guidance is intended to apply across diverse healthcare systems in high-, middle- and low-income countries. Where possible, we have considered the disparity in resources available for healthcare.

This report follows the Accurate Consensus Reporting Document (ACCORD) principles.[6] The 14-member writing group was appointed by the EASD Committee on Clinical Affairs on behalf of the Board and the ADA's scientific leadership on behalf of the Board based on their clinical and research expertise in type 1 diabetes. It included equal representation from both organisations across different clinical disciplines, with attention to gender and geographical balance. All members of the original writing group participated in this update, which was co-chaired by xxxx (EASD) and xxxx (ADA). Two or four members of the writing group were assigned to be the primary authors of each section. These individuals had specific knowledge of the area and were tasked with reviewing and summarising the available literature.

Before the evidence review and writing began, the authors met twice online to agree on goals, content, methodology, and the writing teams to lead the report sub-sections. The section leads conducted literature searches to identify additional English-language studies published between January 2021 and July 2025. Evidence is drawn from observational and interventional studies, reflecting the limited availability of high-quality randomized controlled trials in many areas. Questions on clinical practice and interprofessional team collaboration for the management of type 1 diabetes provide the core of this report.

Recorded monthly virtual meetings (January 2025 - August 2025) and on-going email and web-based collaboration supported development. Meetings were held under the auspices of EASD, and a member of the ADA scientific team was present for all discussions. Writing group members collaboratively identified the topic areas and sections that need to be updated in a non-anonymous setting. Topic areas and questions were posed to the full group by the chairs and other writing group members during meetings. Discussions were carried out in detail to clarify the meaning, resolve questions, and bring forth new ideas. Qualitative meeting summaries were shared with writing group members and allowed reflection and opportunity to air discussion points throughout the development of the report until consensus was reached. All writing group members collectively reviewed all sections to verify scientific rigour, language and utility to the intended readership. Each section, in turn, was revised and approved by the entire working group.

The guidance aligns, where possible, with current ADA Standards of Care[7] and relevant EASD and ADA guidance documents. The draft report was presented at the EASD meeting in Vienna in 2025, after which public comments were invited from healthcare professionals and people with lived experience of type 1 diabetes. Revisions were made in light of this input. The revised consensus report was peer reviewed by the EASD and ADA, and suggestions were incorporated as appropriate by the authors.

The report represents the consensus of the writing group, acknowledging limitations in the evidence base.

<H1>Section 2: Diagnosis of type 1 diabetes

Key points

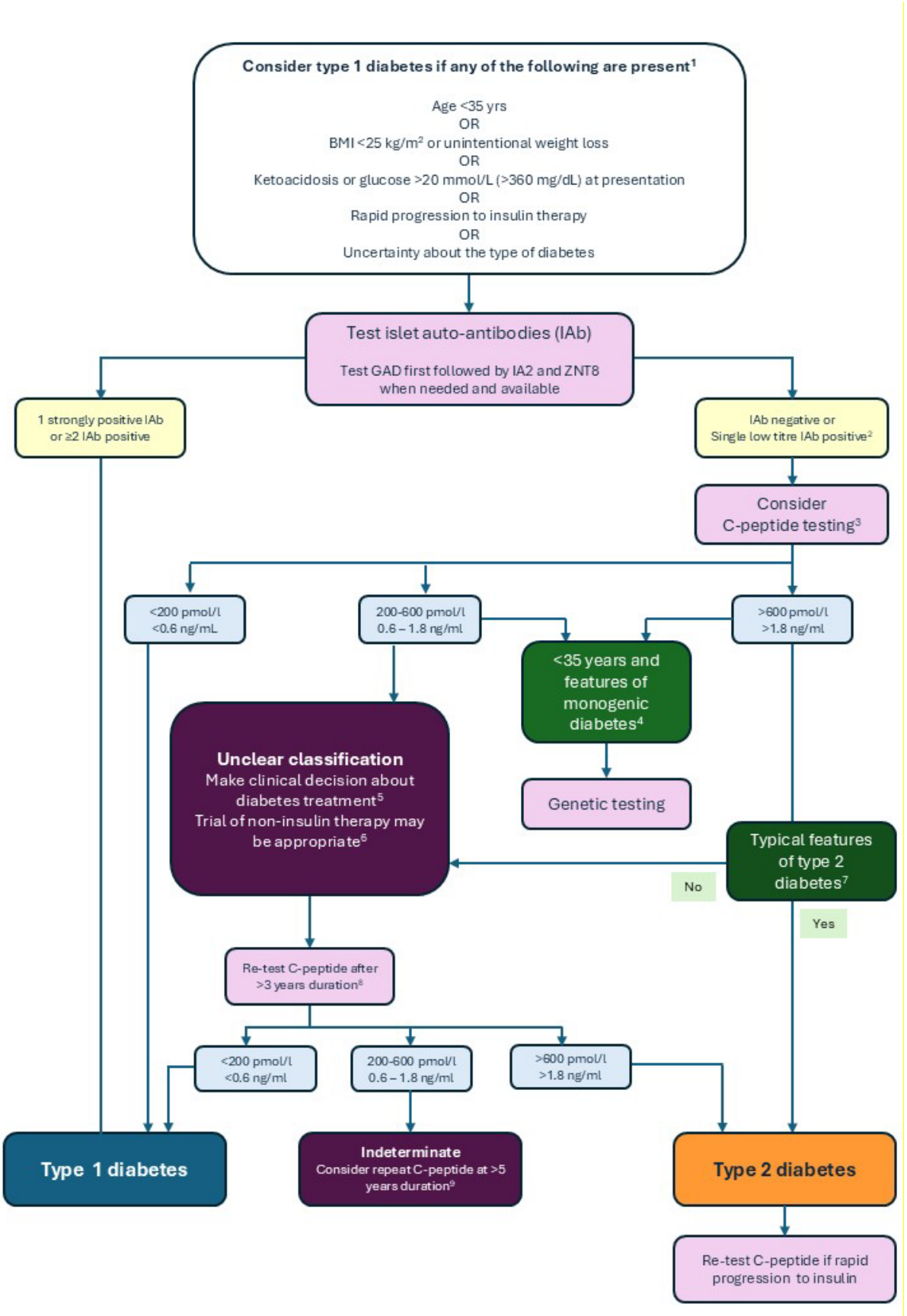
- An algorithm can aid the diagnosis of type 1 diabetes, particularly where the diagnosis is not self-evident, but suggested by one or more typical features
- Three stages of type 1 diabetes are known, to guide screening efforts and development of therapeutics to intervene early in the disease process

- A fully sensitive and specific marker to diagnose type 1 diabetes is lacking, particularly for people with adult-onset type 1 diabetes.

Adults with new-onset type 1 diabetes can present with a short duration of illness of 1–4 weeks or a more slowly evolving process that can be mistaken for type 2 diabetes. Several other types of diabetes can be misdiagnosed as type 1 diabetes; for example, in older adults, pancreatic cancer may present with diabetes and weight loss. Another example is the development of profound insulin deficiency associated with the use of immune check-point inhibitors, which may present with hyperglycaemia and diabetic ketoacidosis (DKA).[8]

Most diagnostic data are derived from populations of White European ancestry and may not be representative of other ethnic groups. Furthermore, most studies of the pathophysiology and natural history come from children, and adult-onset type 1 diabetes may differ.[9] The clinical presentation may vary, but the classical triad of thirst and polydipsia, polyuria and weight loss are common symptoms of type 1 diabetes. Accurate classification of the type of diabetes carries implications beyond insulin treatment. Education, insulin regimen, use of adjuvant therapies, access to newer technologies, need for psychosocial support and concurrent disease screening may all depend on the diagnosis an individual receives. Furthermore, accurate diagnosis allows an assessment of the risk of diabetes in first-degree relatives and appropriate counselling. Although profound insulin deficiency is the hallmark of type 1 diabetes, some adults with type 1 diabetes retain some insulin secretion for years post-diagnosis and may not require insulin treatment initially.[10] This can create diagnostic ambiguity about the diabetes type and its optimal management. The use of a diagnostic algorithm for the investigation of adults with suspected type 1 diabetes can help mitigate this uncertainty (Fig. 1).

176 Figure 1. Flowchart for investigation where type 1 diabetes is considered in adults



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[1]No single clinical feature confirms type 1 diabetes in isolation. Weaker discriminators include: presence of autoimmunity, osmotic symptoms, ketosis without acidosis, first degree relatives with type 1 diabetes. [2]The definition of low titre is dependent on the assay and laboratory used. Please refer to local advice. [3]A random C-peptide test should be performed with concurrent glucose within 5 h of eating. If the result is ≥600 pmol/L (1.8 mg/ml), the circumstances of testing do not matter. If the result is <600 pmol/L (1.8 mg/ml) and the concurrent glucose is <4 mmol/L (<72 mg/dL) or the person may have been fasting, consider repeating the test. Results showing very low levels (<80 pmol/L [0.24mg/ml]) do not need to be repeated. Where a person is insulin-treated, C-peptide must be measured prior to insulin discontinuation to exclude severe insulin deficiency. Do not test C-peptide within 2 weeks of a hyperglycaemic emergency, within 12 h of a hypoglycaemic episode or in people with end-stage renal failure (due to altered clearance). [4]Monogenic diabetes is suggested by the presence of one or more of the following features: HbA_{1c} <58 mmol/mol (7.5%) at diagnosis, one parent with diabetes, features of specific monogenic cause (e.g., renal cysts, partial lipodystrophy, maternally inherited deafness, severe insulin resistance in the absence of obesity), and high monogenic diabetes prediction model probability (www.diabetesgenes.org/exeter-diabetes-app/ModyCalculator; accessed 5 August 2025). [5]Type 2 diabetes should be strongly considered in older individuals. In some cases, investigation for pancreatic or other types of diabetes may be appropriate. [6]A person with possible type 1 diabetes who is not treated with insulin will require careful monitoring and education so that insulin can be rapidly initiated in the event of glycaemic deterioration. [7]Features of type 2 diabetes include increased BMI (≥25 kg/m^2 [≥23 kg/m^2 in people of South Asian ethnicity)), absence of weight loss, absence of ketoacidosis, and less marked hyperglycemia. [8]Consider earlier testing if clinically indicated. C-peptide <200 pmol/l (<0.6 ng/ml) will confirm type 1 diabetes. [9]C-peptide values 200–600 pmol/L (0.6 – 1.8 ng/ml) are usually consistent with type 1 diabetes but may occur in insulin-treated type 2 diabetes, particularly in people with normal or low BMI or after long duration.

<H2>Differentiating type 1 diabetes from type 2 diabetes

Identifying type 1 diabetes in adults with newly diagnosed diabetes may be challenging, particularly when clinical features overlap with those of type 2 diabetes, such as an older adult with a low or normal body mass index (BMI) or young adult with an elevated BMI. Diabetic ketoacidosis (DKA), once considered pathognomonic of type 1 diabetes, may occur in ketosis-prone type 2 diabetes. This sub-

type is typically characterised by obesity, absence of islet autoantibodies and measurable C-peptide shortly after resolution of the initial ketoacidosis.[11]

Misclassification of type 1 diabetes in adults is common; over 40% of individuals diagnosed after age 30 years are initially treated as having type 2 diabetes.[12-14] This misdiagnosis of type 2 diabetes is particularly likely in those with overweight or obesity, and may cause confusion and distress. No single clinical feature confirms type 1 diabetes in isolation.[15] The most discriminative feature is younger age at diagnosis (<35 years), with lower BMI (<25 kg/m^2), unintentional weight loss, ketoacidosis and glucose >20 mmol/l (>360 mg/dl) at presentation also being informative. Other features classically associated with type 1 diabetes, such as ketosis without acidosis, osmotic symptoms, family history or a history of autoimmune diseases are weak discriminators.[14,15]

The strong relationship between age and type 2 diabetes incidence means that even 'classical' features of type 1 diabetes may have a limited predictive value in older adults, where type 2 diabetes is far more common.[16] Most older adults with low BMI will have type 2 diabetes,[15,17,18] especially in ethnic groups with a high risk of type 2 diabetes.[19] Rapid progression to insulin treatment (<3 years) is highly suggestive of type 1 diabetes at any age.[12,14,20] However, the diagnosis becomes more difficult in adults who progress to insulin therapy more slowly. Controversy remains as to whether latent autoimmune diabetes of adulthood (LADA) is a discrete subtype, a milder form of type 1 diabetes, or a mixture of some individuals with type 1 diabetes and others with type 2 diabetes.[21,22]

Some individuals have features of both type 1 diabetes and type 2 diabetes, for example, the person may have obesity or insulin resistance, as judged by high insulin requirements, as well as islet autoimmunity. There are no diagnostic criteria enabling a later diagnosis of type 2 diabetes in people with established type 1 diabetes. Nevertheless, recognising such a second diabetes diagnosis may be important for access to non-insulin therapies (Section 8).

<H2>Differentiating type 1 diabetes from monogenic diabetes

Depending on the population, monogenic diabetes accounts for up to approximately 4% of those diagnosed with diabetes before 30 years of age. The likelihood of monogenic diabetes rises to 20% where islet autoantibodies are negative and C-peptide secretion is maintained.[23] Monogenic diabetes is commonly mistaken for type 1 diabetes because of the young age at onset. Accurate diagnosis of monogenic diabetes enables tailored treatment, often allowing discontinuation of insulin, and carries important implications for screening for concurrent conditions and for genetic counselling in family members.[24,25]

<H2>Investigation of an adult with suspected type 1 diabetes

Although an initial diagnosis of type 1 diabetes is generally made on clinical grounds in adults presenting with hyperglycaemia, the measurement of islet autoantibodies and C-peptide can help distinguish type 1 diabetes from other types of diabetes.

<H3>Islet autoantibodies

Assessment of islet autoantibodies at diagnosis is recommended as the primary investigation of an adult with suspected type 1 diabetes, where available. GAD should be the first antibody measured; if negative, follow-up testing with islet tyrosine phosphatase 2 (IA2) and/or zinc transporter 8 (ZNT8) should be performed, where available, as this can reduce the false negative rate of the test. Islet cell antibody (ICA) measurement is no longer recommended because of its imprecision and replacement by direct single antibody assay.[26,27]

In people with clinical features suggesting type 1 diabetes, the presence of two or more positive islet autoantibodies strongly predicts rapid progression and severe insulin deficiency. These individuals should be considered to have type 1 diabetes, even if not requiring insulin at diagnosis.[28,29] As positive GAD antibodies may be found at a low level in adults without autoimmune diabetes and false positive results may occur, GAD should only be measured where type 1 diabetes is considered.[29]

The absence of islet autoantibodies does not exclude type 1 diabetes. Approximately 5-10% of White European people with new-onset type 1 diabetes test negative for islet autoantibodies,[14,15,30] and further diagnostic consideration is warranted. Furthermore, islet autoantibodies may disappear over time increasing the false negative rate with longer duration of diabetes.[31] In those diagnosed below 35 years of age, type 1 diabetes remains the most likely diagnosis, particularly in the absence of clinical features of type 2 diabetes or monogenic diabetes. In those aged over 35 years, type 2 diabetes becomes increasingly likely with absent islet autoantibodies and older age. However, differentiating between type 1 diabetes and type 2 diabetes based solely on age and clinical features alone is not always accurate in non-White European populations.

A clinical decision regarding treatment is essential. Regardless of features suggestive of type 2 diabetes or absent islet autoantibodies, individuals with suspected type 1 diabetes should be offered insulin treatment. However, in some individuals, where the clinical course aligns more closely with type 2 diabetes, a trial of non-insulin therapy may be appropriate. Those managed without insulin will require close monitoring and education to ensure prompt initiation of insulin if glucose levels deteriorate.

<H3>C-peptide measurement

Plasma C-peptide measurement assesses endogenous insulin secretion and should be considered where there is uncertainty about the type of diabetes in someone with absent islet autoantibodies. It should not be measured within 2 weeks of a hyperglycaemic emergency or 12 h of a hypoglycaemic episode. C-peptide may be falsely elevated in people with end-stage renal failure due to altered clearance. C-peptide should be measured with concurrent glucose within 5 h of eating. If the concurrent glucose is <4 mmol/L (<72 mg/dL) and the C-peptide is result is <600 pmol/L (1.8 mg/ml), the test should be repeated.

C-peptide levels fall progressively in people with type 1 diabetes and are usually low or undetectable by 3 years after diagnosis. Consequently, the discriminative value of C-peptide for distinguishing type 1 diabetes increases with time since the initial diagnosis. Beyond 3 years after diagnosis, when diabetes type remains uncertain, a random C-peptide is recommended. In individuals treated with insulin, this test should be performed prior to insulin tapering or discontinuation to exclude severe insulin deficiency. A persistent non-fasting C-peptide >600 pmol/l (1.8 mg/ml) strongly suggests type 2 diabetes and people with C-peptide in this range are often able to transition to non-insulin therapies.[32-35] Routine C-peptide testing in those with clinically diagnosed type 1 diabetes of at least 3 years duration has led to reclassification in 11% of those with adult-onset diabetes.[36] By contrast, except in rare circumstances, low or absent C-peptide confirms the diagnosis of type 1 diabetes. Although low C-peptide concentrations may occur in some types of secondary diabetes and very long-standing type 2 diabetes, these situations are rarely mistaken for type 1 diabetes; however, in some cases, investigation of other types of diabetes may be appropriate. Nevertheless, conditions, where C-peptide is low, such as post-pancreatomy or check-point inhibitor diabetes, require similar treatment to type 1 diabetes.

A C-peptide measurement may have clinical utility earlier after diagnosis. However, clinicians should be aware that normal C-peptide values may be seen in people with type 1 diabetes shortly after diagnosis. The scenario is more likely in adults than children because average C-peptide is higher at diagnosis in adults and falls more slowly.[37] Consequently, while a low C-peptide confirms insulin deficiency, a normal C-peptide does not exclude type 1 diabetes.

<H3>Genetic testing

Molecular genetic testing for neonatal diabetes should be considered for all people diagnosed with type 1 diabetes under 6 months of age, regardless of current age, as over 80% have monogenic

neonatal diabetes, and the 30-50% with ATP-sensitive potassium (K_{ATP}) channel mutations can replace insulin with sulfonylureas.[38,39]

Monogenic diabetes should be considered in those with one or more of the following features: diagnosis before 35 years of age, HbA_{1c} <58 mmol/mol (7.5%) at diagnosis, one parent with diabetes, and features of specific monogenic cause (e.g. renal cysts, partial lipodystrophy, maternally inherited deafness, severe insulin resistance in the absence of obesity).[40] A monogenic diabetes prediction model is available at www.diabetesgenes.org/mody-probability-calculator (accessed 5 August 2025) to help identify individuals diagnosed between 6 months and 35 years who are at increased risk of monogenic diabetes.[41] For people with diabetes from Hispanic or other than white ethnicity, the probability of monogenic diabetes is lower because of the much higher prevalence of young-onset type 2 diabetes. Low BMI and age of diagnosis are the most important discriminators for monogenic diabetes versus type 2 diabetes in these groups.[42] Those at increased risk should have islet autoantibody and C-peptide testing. Molecular genetic testing should only be considered if the islet autoantibodies are negative and non-fasting C-peptide is >200 pmol/l (0.6 ng/ml).[43-45] Molecular genetic testing is not universally available.

<H2>Stages of type 1 diabetes

Three stages of type 1 diabetes have been defined, characterized by the presence of multiple islet autoantibodies (which may disappear in Stage 3) and differentiated by the presence of normoglycaemia (stage 1), dysglycaemia (stage 2), or clinical diabetes (stage 3) (Table 1).[46]

Table 1. Stages of diabetes in people with ≥2 islet autoantibodies

Stage 1	Stage 2	Stage 3
No IFG, no IGT, no increase in HbA_{1C}	IFG: FPG 5.6–6.9 mmol/L (100–125 mg/dL) or IGT: 2-h PG (7.8–11.0 mmol/L 140–199 mg/dL) or HbA_{1C}: 39–47 mmol/mol (5.7–6.4%) or ≥10% increase in HbA_{1C}	Diabetes by standard criteria

IFG: impaired fasting glycaemia; IGT: impaired glucose tolerance; FPG: fasting plasma glucose; PG: plasma glucose.

Screening programs for type 1 diabetes are being implemented, though their risks and benefits remain unclear. Those found to have Stage 2 type 1 diabetes may benefit from teplizumab, an anti-CD3 antibody approved in the U.S. to delay or prevent progression to Stage 3 (section 10). Early diagnosis at this stage may also lower the risk of DKA at diagnosis.[46,47] However, the cost-effectiveness and psychosocial impact of screening needs further evaluation.[48]

<H1>Section 3: Overview of the management of type 1 diabetes

Key Points

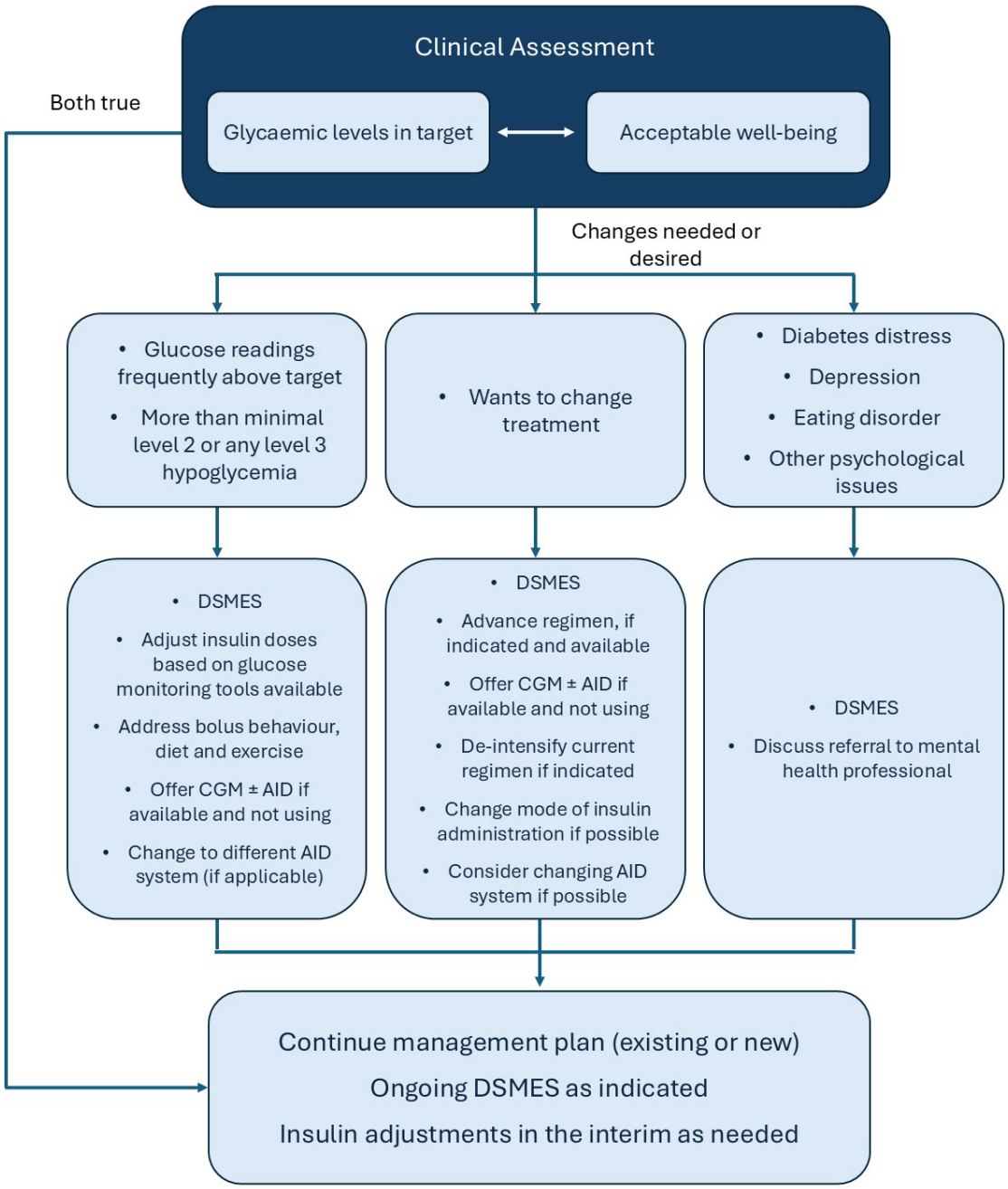
- Diabetes care should support people with type 1 diabetes to optimise health and quality of life
- Care should be tailored to the needs of the individual with type 1 diabetes

Type 1 diabetes is a complex and demanding condition that requires ongoing medical, educational and psychosocial support from healthcare professionals with the appropriate skills, training and resources. Care may differ at particular times of life, such as at the point of diagnosis, during concomitant illness or pregnancy, onset of complications and later in life. The aim of diabetes care and management is to support people with type 1 diabetes to live a long and healthy life. The management strategies to achieve this aim broadly include:

- Effectively delivering exogenous insulin to maintain glucose levels as close to the individual's target range as is safely possible to prevent the development and progression of diabetes complications while minimising episodes of hypoglycaemia.
- Effectively managing cardiovascular risk factors.
- Providing approaches, treatments and devices that minimise the psychosocial burden of living with type 1 diabetes, while promoting engagement in self-care and psychological wellbeing.

Although optimising glycaemic levels is critical for the prevention of acute and long-term complications, interactions with the healthcare team should not solely focus on glycaemia, but include consideration of well-being and treatment satisfaction. Fig. 2 provides a framework for such interactions, integrating glycaemia-focused interventions with assessments of diabetes distress, other psychosocial issues, and satisfaction with the current treatment regimen.

Figure 2: A framework for the management of an individual with type 1 diabetes, considering both glycaemic levels and other psychosocial issues



DSMES: diabetes self-management education and support. CGM: continuous glucose monitoring. AID: automated insulin delivery

Management begins with a detailed evaluation at the initial consultation, followed by more targeted interval contacts with a focus on person-centred care (Table 2). A personalised approach for visit frequency is recommended but visits should occur at least annually. In some cases, an annual in-person consultation with their primary care team is sufficient. More frequent contact, however, may be needed for many individuals, for example, those who have been recently diagnosed, those who are not achieving their diabetes goals, those who require cardiovascular risk management, and those who would benefit from additional self-management education and psychosocial support. Additional visits can also be useful when the therapeutic regimen changes, for example, when the insulin regimen is modified or when a new device is started. Trouble shooting technology, preparation and back up if systems fail and review of the treatment of hypoglycaemia should be reviewed at least annually.

Visits can be performed in-person or via telemedicine.[49] Despite the value of telemedicine, people should have the option to schedule an in-person visit, where possible.[50] An annual in-person visit permits a physical examination, including the feet and insulin injection or infusion sites. Requirements for visit types depend on the setting and health system requirements. The use of telemedicine, however, should be individualised and will vary depending upon individual needs, computer literacy and access to care.[51] Additionally, systems of asynchronous remote monitoring visits are being developed that identify issues which occur in-between regularly scheduled visits.[52]

Table 2: **Schedule of care**

Component of care	**Details of evaluation**
Medical and family history	
Diabetes history	Date of diagnosis Islet autoantibodies (date) C-peptide and simultaneous glucose (date) Episodes of DKA Episodes of level 3 hypoglycaemia Hypoglycaemia awareness
Family history	Type 1 diabetes or type 2 diabetes in first-degree relatives Other autoimmune disorders
Diabetes-related complications	Microvascular: retinopathy, macular oedema, laser/injection therapy, date of last retinal evaluation (exam or photos); peripheral neuropathy, autonomic neuropathy; nephropathy Macrovascular: heart, cerebrovascular and peripheral arterial disease

	Foot ulcers or amputations
Common comorbidities	Autoimmune disorders: thyroid, coeliac, others[a] Hypertension Lipid disorder Overweight and obesity Eating disorders Hearing loss Sleep disorder Dermopathy Fractures Joint and soft tissue disorders: cheiroarthropathy, trigger finger, capsulitis, carpal tunnel syndrome Dental and gum health
Other	Pregnancy and contraception history Vaccination history if applicable
Additional behavioural/lifestyle factors	Diet and nutrition: use of carbohydrate counting, weight history Physical activity Smoking, alcohol, substance use Sleep Occupation
Diabetes management	
Glycaemic target	HbA_{1c} Time in range
Current insulin regimen	MDI: pens, including connected insulin pens; syringes; needles Insulin pump or AID system (type/model): settings; backup injection plan
Glucose monitoring	Continuous glucose monitoring: type/model, data sharing (if yes, with whom) Capillary glucose monitoring: type of meter/strips, frequency of use, mean (SD), range, pattern
Other	Non-insulin diabetes medications Glucagon prescribed and in date Ketone testing supplies prescribed (where available) Software/app use
Psychosocial issues	Monitor psychological wellbeing: diabetes-specific distress; depressive symptoms; anxiety symptoms Consider, also, the potential presence of fear of hypoglycaemia and disordered eating

	Consider the role of social determinants of health and organise social support Assess cognitive status
Diabetes self-management education and support	Assess and plan for meeting individual needs Consider contraception and pregnancy planning
Physical examination and complication screening	
General	Height Weight, BMI: every visit if not stable, otherwise annual Skin including injection/infusion sites: every visit if skin complaints or erratic glucose readings, otherwise annual
Retinopathy	Initial examination after 5 years of diabetes followed by examinations every 1-4 years depending on prior findings, glycaemic levels and blood pressure Performed using validated approaches and methodologies, most commonly by retinal photography
Nephropathy	Initial examination within 5 years of diabetes followed by examinations every 1-2 years Urine albumin to creatinine ratio (uACR) in a random spot urine sample (annual) with repeat confirmatory test if elevated (repeat spot urine or 24-h collection) Creatinine and eGFR (annual; may be more often if kidney disease)
Peripheral neuropathy	Initial examination within 5 years of diabetes followed by annual examination Initial assessment with 10 g monofilament If neuropathy is present, check TSH and vitamin B_{12} Foot ulceration or deformity
Autonomic neuropathy	Initial examination within 5 years of diabetes followed by annual examination, if peripheral neuropathy and resting tachycardia are present. Screening is initially by history and physical examination History: ask about orthostatic hypotension, syncope, early satiety, erectile dysfunction, changes in sweating patterns (especially gustatory sweating), or dry cracked skin of the extremities Examine for resting or fixed tachycardia (after ruling out hyperthyroidism), orthostatic hypotension, or evidence of peripheral dryness or cracking of the skin can be found. More details tests include heart rate variability with an electrocardiogram, heart rate and blood pressure response to standing, and heart rate response to a Valsalva manoeuvre
Macrovascular disease	Annual but more often if previous abnormality or symptoms

	Blood pressure and pulse Lower limb pulses Cardiovascular Lipid profile: frequency dependent on the presence of previous lipid abnormality or treatment
Laboratory testing	HbA_{1c} every 3–12 months ALT and AST: at least once and as indicated clinically Serum potassium: if taking ACE-I, ARB or diuretic TSH, coeliac screen: at least once and as indicated clinically[a]
Goal setting	Individualised, attainable, realistic: behavioural considerations (diet and nutrition, activity, smoking cessation) Glycaemic: HbA_{1c}, time in range (TIR), hypoglycaemia
Treatment plan	Formulate treatment plan with shared decision-making
Referrals	As needed: podiatry, cardiology, nephrology, ophthalmology, vascular surgery, gynaecology, urology, orthopaedic surgery, mental health specialist, others

[a]Individuals with type 1 diabetes are at increased risk of other autoimmune diseases, including autoimmune thyroid disorders, pernicious anaemia, coeliac disease, collagen vascular diseases and Addison's disease.[53] The optimal frequency of screening for these conditions in adults has not been established. ACE-I, ACE inhibitor; ALT, alanine aminotransferase; ARB, angiotensin II receptor blocker; AST, aspartate transaminase; TSH, thyroid stimulating hormone

<H1>Section 4: Diabetes self-management education and support

Key points

- Diabetes Self-Management Education and Support is recommended for all people with type 1 diabetes at the following time frames: at diagnosis, annually or when not meeting targets, if complications develop and if transitions occur.
- Educational and psychosocial needs should be assessed at key transition points to enable the individualised tailoring of diabetes self-management education and support.

Diabetes Self-Management Education and Support (DSMES) is an essential component of type 1 diabetes care to allow all other diabetes interventions to work optimally. The objective of DSMES is to provide those living with type 1 diabetes (and their caregivers, if applicable) with the knowledge, skills

and confidence to successfully self-manage the diabetes on a daily basis and, thereby, reduce the risks of acute and long-term diabetes complications while maintaining quality of life.[54] DSMES aims to empower people with type 1 diabetes, with an emphasis on shared decision-making and active collaboration with the healthcare team. Where possible, DSMES programmes should be evidence-based and conform to local and national standards to demonstrate effectiveness.

<H2>Methods and content of diabetes self-management education and support

The methods and content of DSMES delivery should be guided by a comprehensive assessment, tailored to each individual's unique needs. This includes consideration of the time of diagnosis, prior education, psychosocial and cognitive status, literacy level, family history, and comorbidities, as well as ethnic, socio-cultural, financial, geographical, and lifestyle factors.[55] A structured, periodic assessment of educational needs and barriers should be an integral part of ongoing diabetes care (Box 1). As not all topic areas are useful or necessary for every person with diabetes every time DSMES is offered, the purpose of the assessment is to closely examine and discover current knowledge and self-management needs unbiased by the opinions of healthcare professionals.

Box 1: Needs Assessment for Diabetes Management, Education, and Support

Key assessment features

- Health history
- Cognition, functional health literacy and numeracy
- Health beliefs and attitudes
- Emotional health and support systems
- Religious and cultural influences
- Physical limitations
- Social determinants of health e.g., financial status
- Barriers

DSMES can be delivered by various methods ranging from provision of diabetes information and one-to-one advice, through ongoing learning that may be informal, perhaps through a peer group, to structured education that meets nationally agreed criteria, including an evidence-based curriculum, quality assurance of teaching standards and regular audit.[56] These programmes are guided by learning and behaviour change theories, applying effective behaviour change techniques.[57]

435 Structured programmes for adults with type 1 diabetes are effective in improving both glycaemic
436 outcomes and psychosocial outcomes.[56] In the past, most programmes used a group format, however,
437 DSMES is increasingly supplemented with digital support, including text messaging and cloud-based
438 solutions and telemedicine.[58,59] Structured DSMES programmes most often include multiple
439 components and cover a broad range of topics, from pathophysiology to medical technology and
440 healthy coping (Table 3).

441

442 **Table 3 Key content areas of DSMES**

Content areas	Examples that focus on type 1 diabetes
Diabetes pathophysiology and treatment options	Immunology of beta cell destruction
Healthy eating	Basic and advanced carbohydrate counting vs intuitive dosing Impact of composition of meals (fat, protein, glycaemic index, fibre, sugar, alcohols) on glucose levels Use of technology to enhance dosing recommendations
Physical activity	Impact on glucose and insulin dose recommendations
Medication usage	Types of available insulins Methods of insulin delivery
Monitoring and using patient-generated health data	Technology and its ability to provide more frequent remote communication between the person with type 1 diabetes and their healthcare professional Review of CGM, pump and connected insulin pen downloads, and apps
Preventing, detecting and treating acute complications (including hypoglycaemia, hyperglycaemia and DKA), sick day guidelines, and severe weather or situation crisis and diabetes supplies management	Signs and symptoms of DKA, including euglycemic DKA Trouble shooting insulin pumps; addressing infusion occlusions Back-up plan for pump/CGM failure (e.g. availability of insulin for injection and doses, meter and test strips, etc) Glucagon use Ketone testing
Preventing, detecting and treating chronic complications, including immunisations and	Understanding the individual risk for complications in type 1 diabetes

preventive eye, foot, dental and renal examinations, as indicated per the individual participant's duration of diabetes and health status	How to prevent development and progression of complications in the future
Healthy coping with psychosocial issues and concerns	Discussing strategies to help reduce diabetes distress and prevent 'diabetes burnout'
Problem solving	Goal setting Developing personal strategies to promote health and behaviour change Problem identification and solutions Identifying and accessing resources Sick day rules Management of pump failure or pump holiday Planning for procedures or surgery Pre-conception planning Pregnancy and diabetes

443 CGM: continuous glucose monitoring. DKA: diabetic ketoacidosis. MDI: multiple daily injection

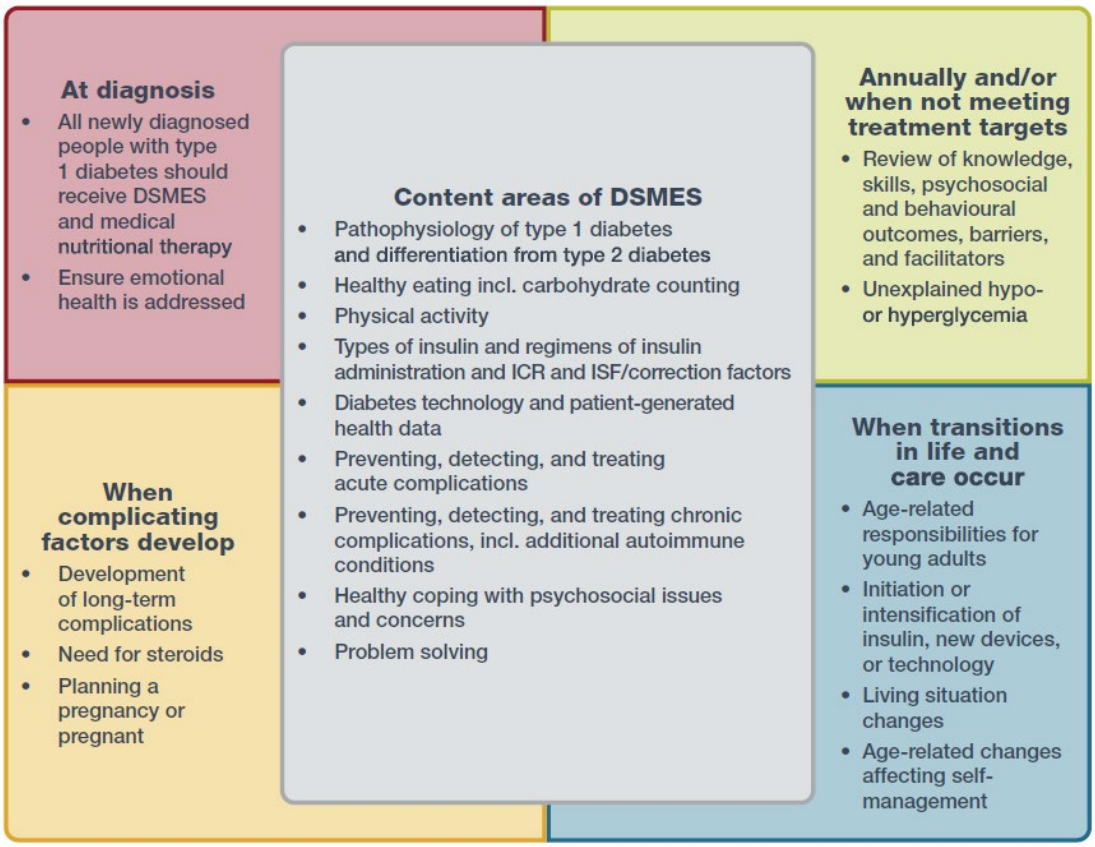
444

445 Specific DSMES should not be confined to one particular moment but offered on a continuous basis
446 and tailored to the ever-evolving individual's educational needs. People with type 1 diabetes may be
447 diagnosed at a young age or during adulthood, and many live with type 1 diabetes throughout
448 different life stages. There are four key moments when DSMES is especially important: (1) at the time
449 of diagnosis; (2) when glycaemic targets are not being met; (3) during periods of transition; and (4)
450 upon the development of diabetes-related complications (Fig. 3).[60] DSMES should be revisited when a
451 child transitions to adult diabetes services, as there may be significant knowledge gaps in someone
452 diagnosed early in life, when education at the time was directed to the parents and caregivers. DSMES
453 should also be revisited when there is a transfer of healthcare services or when a caregiver takes over
454 any diabetes management to identify any new educational requirements.

455 DSMES should be individualized, taking into account each person's psychosocial development,
456 cognitive function, literacy, family history, and comorbidities, as well as their ethnic background, socio-
457 cultural context, financial situation, geographic location, and lifestyle.[55] A structured, periodic
458 assessment of educational needs and barriers should be an integral part of ongoing diabetes care (Box

1). Diabetes device technology is increasingly used in diabetes self-management and requires ongoing education for the person with diabetes and healthcare professionals.[61]

Figure 3: The four critical times when DSMES is particularly needed for people with diabetes (and their caregivers, when applicable). ICR, insulin to carbohydrate ratio; incl., including; ISF, insulin sensitivity factor.



An emerging area is the rise in individuals diagnosed with pre-stage 3 type 1 diabetes, as a result of type 1 diabetes screening efforts and DSMES is needed for this group of people and their family.[46] DSMES should be provided based on current needs, which include both practical and psychosocial implications of their antibody status, benefits of regular monitoring, and symptom awareness.

A wide range of smartphone and web-based applications are available to support people with type 1 diabetes in managing the complexities of daily self-care. While these tools are increasingly popular, the evidence supporting their safety, accuracy, and clinical effectiveness remains limited. Key concerns include insufficient validation of app algorithms, lack of standardized training for users, poor interoperability with other devices and systems, and inadequate data privacy protections.[62]

Effective use of diabetes health apps requires ongoing dialogue between the healthcare team and the individual with diabetes.[63] This includes assessing the person's understanding of the app's content, their digital literacy, and the influence of social determinants of health on their ability to engage with the technology. It is equally important that healthcare professionals maintain up-to-date knowledge and competency regarding the apps their patients use. This enables an informed evaluation of whether a given app is appropriate, safe, and beneficial for the individual's care needs.

<H1>Section 5: Health-related behaviours

Health-related behaviours, such as eating patterns, physical activity, sleep, and stress management, play a critical role in optimizing glycaemic levels, reducing the risk of complications, and enhancing overall quality of life.[64] These behaviours often cluster, such that individuals may simultaneously engage in multiple healthy or unhealthy habits, which can amplify their impact on health outcomes. Religious and other cultural considerations, such as fasting, may also impact self-management of type 1 diabetes and healthcare professionals need to provide appropriate guidance and support to accommodate this.[65] Healthcare professionals should adopt an integrated, person-centred approach to type 1 diabetes care that considers individual behavioural profiles and tailors interventions accordingly.

<H2>Nutrition therapy

Key points

- Nutrition therapy is individualized based on the person's preferences and needs
- Composition of meals may have a variable impact on glucose levels, which will require experimentation to identify actual insulin needs
- Low-carbohydrate and very-low carbohydrate eating patterns may be safely used provided healthy eating guidelines are also incorporated

Nutrition, in particular carbohydrate intake, has a major effect on blood glucose levels, and people with type 1 diabetes need to understand the effect of food on their diabetes and plan meals accordingly (Box 2). People with type 1 diabetes should be referred for individualised medical nutrition therapy provided by a registered dietitian who is knowledgeable and skilled in providing diabetes-specific nutritional advice in conjunction with the diabetes technology being used. Medical nutrition therapy delivered by a registered dietitian is associated with a reduction in HbA_{1c} of 1.0-1.9% (11-21

mmol/mol) for people with sub-optimally managed type 1 diabetes when integrated into an overall management programme.[66]

Box 2: Goal of Nutrition Therapy for Type 1 Diabetes[66]

- Promote healthy eating patterns, emphasizing a variety of nutrient-dense foods in appropriate sizes to improve overall health and to improve HbA_{1c}, blood pressure, and cholesterol and aid maintenance of weight or achievement of weight goal
- Individualize nutrition advice based on personal and cultural preferences, health literacy, and access to healthy food choices
- Provide practical tools for day-to-day meal planning
- Focus on helping people dose their prandial insulin based on their ability to master carbohydrate counting skills

Nutritional recommendations for people with type 1 diabetes are based on personal preferences, socioeconomic status, cultural backgrounds and comorbidities. Carbohydrate counting is the most common meal planning approach in type 1 diabetes. In conjunction with promoting healthy eating patterns, carbohydrate counting and insulin to carbohydrate ratios can be a useful method for adjusting mealtime insulin dosing for optimal glycaemic outcomes.[67] When carbohydrate counting is not possible, teaching carbohydrate consistency is an alternative approach. While low-carbohydrate and very-low-carbohydrate eating patterns are increasingly popular, reduce HbA_{1c} levels and increase time-in-range in the short term, it is important to incorporate these alongside healthy eating guidelines. Additional components of the meal, including high fat and/or high protein, may contribute to delayed hyperglycaemia and the need for insulin dose adjustments. Since the impact of a mixed meal is highly variable between individuals and differs between people on multiple daily injection (MDI) compared to automated insulin delivery (AID) systems, which automatically delivers autocorrect doses, postprandial glucose measurements for up to 3 h or more may be needed to determine initial and subsequent correction doses.[66]

New interactive technologies using mobile phones to provide information, insulin bolus calculations based on insulin to carbohydrate ratios and telemedicine communications with care providers may be used to aid in reducing both weight gain and the time required for education.[62] Artificial intelligence can increasingly evaluate meal composition and is being integrated into various devices. In the case of

extreme low weight, unhealthy eating habits should be reviewed, including the possibility of insulin omission. Disordered eating is discussed further in section 6.

<H2>Physical activity

Key points

- Unless there are specific contraindications to exercise, people with type 1 diabetes should be encouraged to engage in regular physical activity, including sports
- Education about the effect of different types, intensities and duration of physical activity (e.g., aerobic, resistance, interval training) on glucose levels is needed
- Diabetes-related technologies, such as AID systems, may support the optimization of glucose levels during and after exercise if adjusted appropriately in advance of exercise

A combination of aerobic and resistance exercise on most days is associated with improved fitness, increased insulin sensitivity, leading to reduced insulin requirement, improved cardiovascular health with better lipid profile and endothelial function, and decreased mortality.[68-70] Independent effects on beta cell function in early type 1 diabetes and HbA_{1c} have not been established beyond doubt but appear beneficial.[71,72] Regular physical activity is also associated with reduced risk of microvascular complications and osteoporosis.[70,73] Exercise helps maintain a healthy BMI and promotes sleep quality and mental wellbeing.

Although most people with type 1 diabetes should be encouraged to undertake physical activity safely, it is important to consider cardiovascular and lower extremity comorbid conditions. Advice should be given regarding appropriate footwear and foot inspection for those with peripheral neuropathy to avoid the risk of ulceration. Walking does not increase the risk of ulceration in people with peripheral neuropathy, but weight-bearing exercise should be avoided in active foot disease.[74] In individuals with proliferative or severe non-proliferative diabetic retinopathy, vigorous aerobic or resistance exercise involving straining should be avoided because of the risk of vitreous haemorrhage or retinal detachment.[75] These individuals should consult an ophthalmologist before beginning any high-intensity exercise programme.

Education regarding physical activity should focus on the acute effects of exercise on glucose concentrations, which depend on several factors, including: the baseline fitness of the individual; type, intensity and the duration of activity; the amount of insulin in the circulation; the blood glucose concentration before exercise; and the composition of the last meal or snack. People with type 1

diabetes should learn about the effects of exercise on glucose levels and how to balance exogenous insulin delivery and carbohydrate intake for the different forms and intensities of exercise to minimise the risk of hypoglycaemia and hyperglycaemia (Box 3). Post-exercise hypoglycaemia can occur up to 24 h after the end of physical activity, and the risk of their occurrence is higher in untrained individuals and those engaging in physical activity irregularly.[76] While general recommendations can be made (Appendix 1), the glycaemic effects of physical activity and exercise can differ within and between individuals, pointing at the importance of experiential learning. Nevertheless, diabetes healthcare professionals can guide and support persons with type 1 diabetes in helping them decrease worries and build confidence.

Box 3: Issues to consider to reduce the risk of hypoglycaemia and hyperglycaemia during and after physical activity

- Duration of exercise
- Intensity of exercise
- Time of day
- Acute and delayed effects of exercise on glucose concentrations
- Previous episodes of hypoglycaemia
- Presence of ketosis
- Glucose monitoring before, during and after physical activity
- Insulin dose adjustments up to 2-3 h before beginning and after the physical activity
- Insulin on board
- Management of hypoglycaemia and hyperglycaemia during and after physical activity
- Safety measures such as a medical ID, availability of carbohydrates to consume before, during and after exercise, exercising with others, glucagon, adequate hydration, back-up supplies if AID/CGM fails for longer duration or more remote exercise

The introduction of continuous glucose monitoring (CGM) and AID systems has meant that more detailed recommendations can be made to reduce risk of hypoglycaemia and hyperglycaemia during and after physical activity, but these still require an individualized approach.[77] Detailed guidance is beyond the scope of this report but the consensus statement for management of exercise in type 1 diabetes provides detailed suggestions regarding the use of CGM trend arrows and adjustment of insulin doses and carbohydrate intake.[75] The EASD and ISPAD have developed a position statement on the use of AID systems during exercise.[78]

<H2>Sleep

Key points

- Many people with type 1 diabetes have disrupted sleep that may directly and indirectly adversely affect glucose levels
- Healthcare professionals should ask about and support management of sleep disorders

Sleep patterns may be disrupted in people with type 1 diabetes as a result of both behavioural and physiological aspects of diabetes and its management.[79-81] Many individuals with type 1 diabetes sleep less than current recommendations and have increased risk of sleep-disordered breathing, which is associated with increased risk of long-term diabetes complications.[80-82] There are mixed reports about the effect of sleep duration on glycaemic management.[80-82]

<H2>Alcohol and recreational drug use

Key point

- The use of alcohol and recreational drugs should be discussed to assess the potential risks and impact on glucose levels and diabetes self-management

Many individuals with type 1 diabetes consume alcohol, although its effects on glycaemic management are not always adequately considered. Increased alcohol consumption is associated with a higher risk of glycaemic variability, typically with hyperglycaemia initially and the potential of hypoglycaemia hours later.[83] Factors within the alcoholic beverage that impact glucose include the amount of carbohydrate and glucose, alcohol by volume, and volume of beverage consumed in conjunction with food. Excessive alcohol consumption impairs cognitive function and symptom awareness, leading to a diminished ability to self-manage the diabetes.[83] Alcohol consumption also appears to increase the risk of ketoacidosis and lactic acidosis, particularly in those with suboptimal glycaemic management and in the context of reduced endogenous insulin. Alcohol inhibits hepatic gluconeogenesis, leading to an increased risk of hypoglycaemia for up to 24 h after the last drink.[83] Hypoglycaemia is particularly hazardous because of the potential to confuse hypoglycaemic symptoms with alcohol intoxication.[83] Some of this glycaemic variability may occur through the association with other risk-taking behaviours.

An association between recent recreational cannabis consumption and a more than twofold increased risk of DKA has been reported from countries where cannabis has been legalised, possibly related to the emergence of higher potency formulations of cannabis and other synthetic cannabinoids.[84,85] Heavy users can develop cannabis hyperemesis syndrome, which mimics gastroparesis.[86] Use of cocaine and other stimulant-like drugs, increases glucose production and inhibits glucose clearance, which increases DKA risk. Having a diagnosis of a substance use disorder confers an increased all-cause mortality in populations with diabetes across many substances, including cocaine, opioids and cannabis, regardless of consumption.[85]

Healthcare professionals should ask about alcohol and/or drug use and inform people with type 1 diabetes about the effects of drugs and alcohol on diabetes and related risks, otherwise people with diabetes will seek information elsewhere, which is frequently incorrect and misleading.[87] Brief interventions to reduce risky drinking and drug use have been well validated in various populations and offer the potential to improve diabetes medication taking and outcome.[88] However, targeted research specifically in people with type 1 diabetes remains limited, and more tailored interventions are needed. In the case of addiction, referral to a specialised clinic is warranted.

<H2>Smoking

Key points

- Smoking status should be assessed during routine consultations
- Smoking cessation should be promoted and supported in all individuals with type 1 diabetes

Smoking is a risk factor for both macrovascular and microvascular complications in individuals with type 1 diabetes.[89-91] People who smoke tend to have suboptimal glycaemic management, with reduced time in range, increased time in hyperglycaemia, greater glucose variability, and a higher incidence of morning hypoglycaemia.[92] These findings emphasise the importance of smoking cessation as a crucial component of diabetes management.

<H2>Travel and driving

Key points

- Planning ahead is the key to safe travel for individuals with type 1 diabetes

- Safe driving practices should be discussed regularly with people who drive

Individuals with type 1 diabetes should ensure they are well-prepared for travel with all necessary diabetes-related and emergency supplies, keeping them easily accessible throughout the journey (Box 4).[93]

Unrecognised hypoglycaemia and rapidly dropping glucose levels are the most relevant hazards for drivers with type 1 diabetes.[94] These risks may be reduced by monitoring glucose prior to driving and at 2 h intervals. Local regulations and recommendations should be followed for driving with type 1 diabetes.

Box 4: Travel Considerations for People with Type 1 Diabetes

- **Preparation:** Always carry diabetes-related and emergency supplies
- **Insulin Adjustment:** Plan insulin dosing, especially when crossing time zones, to minimize glucose fluctuations. This should be supported by frequent glucose monitoring
- **Environmental Factors:** Be mindful of changes in routine, climate, stress levels, and physical activity that can affect glucose levels.
- **Diet:** Research local foods to estimate carbohydrate content for better insulin management.
- **Communication:** Carry note cards in the local language indicating the person has type 1 diabetes and may need urgent help in case of hypoglycaemia. Smart phone apps can provide useful translation tools

<H2>Employment

Key points

- People with type 1 diabetes can pursue a wide range of careers and should be reasonably accommodated to do so based on local and national guidelines. If a job cannot be performed safely, either for the person with diabetes or others around them, a different position may need to be considered.
- Individuals should be encouraged and supported to work in any role they are qualified for and can perform safely

People with type 1 diabetes are able to successfully undertake many different jobs; however, stigma and misconceptions about diabetes, particularly concerns about hypoglycaemia and insulin access in challenging environments, can still limit employment opportunities.[95] Chronic complications may also affect suitability for certain roles. While some occupations continue to restrict individuals with diabetes due to perceived safety risks, progress has been made in expanding access, including roles like commercial airline pilots. It is not always necessary to disclose having type 1 diabetes, but some workplaces have specific protocols for safe employment for those with type 1 diabetes. People should coordinate with their human resources department if there is an issue. The ADA is currently updating its guidance for the management of diabetes in the workplace.

To support safe and equitable employment, individuals with type 1 diabetes should be encouraged to pursue any role they are qualified for and can perform safely. Workplaces should provide reasonable accommodations, if possible, including access to insulin, glucose monitoring, and time for self-management of blood glucose levels. Employment laws differ between countries and within states in the U.S.

<H1>Section 6: Psychosocial care

Key points:

- Psychosocial factors should always be considered as part of routine adult diabetes care
- Periodic screening of mental well-being is recommended, at least annually using validated questionnaires
- The diabetes team should preferably include a mental healthcare professional to advise the team and consult with people with diabetes in need of psychological support

Type 1 diabetes is a psychologically challenging chronic condition, impacting all domains of life, with treatment outcomes highly dependent on the person's ongoing self-management. In this context, psychosocial factors play a significant role, pertaining to a person's cognitive functioning, beliefs, motivation, attitudes, ways of coping, feelings and relationships with others.[96] Poor mental health in type 1 diabetes is prevalent and associated with sub-optimal glycaemic levels and increased complication risk.[97] It is therefore imperative to adopt a biopsychosocial approach to type 1 diabetes, to achieve optimal diabetes outcomes, both in terms of metabolic and psychosocial outcomes.

<H2>Psychological problems

People living with type 1 diabetes are not different from the general population when it comes experiencing chronic stress, for example, related to work or financial hardship, and major stressful life events, such as loss of a job or bereavement. Although not diabetes-related, it is relevant to consider because psychosocial stress can complicate diabetes self-management, thereby increasing the risk of not reaching glycaemic targets.[98]

Diabetes-specific emotional distress is common, affecting 20-40% of adults with type 1 diabetes, and can be experienced at any point in time from early adulthood to older age.[99] Examples of 'critical' times, however, are following the diagnosis, when complications develop, and when there is a loss of social support, for example, when an older adult loses their spouse or carer.[100] Feeling powerless and overwhelmed by the daily self-care demands, fear of hypoglycaemia and worries about complications are among the most cited sources of distress by people with type 1 diabetes.[101] Stigma, lack of social support or feeling 'policed' by family, friends or co-workers can also evoke emotional distress in individuals with type 1 diabetes.[102] Prolonged elevated diabetes distress can lead to 'diabetes burnout' and is associated with an increased risk of depression, less engagement in self-care, and higher HbA_{1c}.[103]

Depression and anxiety symptoms are twice as prevalent among adults with type 1 diabetes compared to adults without diabetes, and negatively impact daily functioning and quality of life.[104,105] Anxiety and depression often co-exist and may partly overlap with symptoms of diabetes distress.[106] Depression, at all levels of severity, is a risk factor for suboptimal self-care, hyperglycaemia, long-term complications, and excess mortality.[107] The association between generalised anxiety disorder and sub-optimal blood glucose levels is less clear.[108] Fear of hypoglycaemia affects up to 10% of adults with type 1 diabetes, particularly among those experiencing repeated episodes of level 3 hypoglycaemia.[109] Fear of hypoglycaemia may translate into 'phobic' avoidance behaviours aimed at keeping blood glucose at a 'safe' level, resulting in persistent hyperglycaemia. Although less common, lack of fear of hypoglycaemia and/or fear of hyperglycaemia may also be problematic, particularly in those with impaired hypoglycaemia awareness and frequent severe hypoglycaemic events.[110,111]

Dysfunctional eating behaviours and eating disorders, including anorexia nervosa, bulimia nervosa and binge eating, are over-represented in people with type 1 diabetes, particularly in young women, but may also occur in men.[112] However, people with type 1 diabetes receive less outpatient treatment for their eating disorders than their diabetes-free peers despite their greater risk for major adverse health outcomes.[113] Insulin omission as a weight-loss strategy may occur particularly in girls and younger women resulting in elevated HbA_{1c} levels.[114]

Intellectual disabilities and neurodiversity warrant attention as they may limit a person's capacity to self-manage diabetes. Type 1 diabetes has been linked with attention deficit hyperactivity disorder (ADHD) and autism,[115] with a Swedish nationwide cohort study reporting comorbid neurodevelopmental disorders, primarily ADHD and intellectual disability, to be associated with sub-optimal glycaemic levels and a higher risk of diabetes-related complications in childhood-onset type 1 diabetes.[116]

As life expectancy of people with type 1 diabetes increases, normal cognitive decline associated with ageing may impact mental health and the capacity to self-manage the diabetes and treatment outcomes. Importantly, the 32 years follow-up of the Diabetes Control and Complications Trial/Epidemiology of Diabetes Interventions and Complications (DCCT/EDIC) study demonstrated that in type 1 diabetes cognitive decline accelerates exponentially after 18 years of follow-up, and clinically significant cognitive impairment was found in up to 50% of older individuals with type 1 diabetes.[117]

<H2>Social determinants of health

Life circumstances can significantly impact health in people with type 1 diabetes. In a review of social determinants of health and diabetes, the following domains all affect people with type 1 diabetes: (1) neighbourhood and physical environment (e.g. housing stability and interpersonal safety); (2) built environment (e.g. walkability, access to green spaces and access to transportation); (3) environmental exposures (e.g. pollution); (4) food access, availability and affordability; and (5) healthcare access, affordability and quality.[118] Socioeconomic challenges, particularly the inability to pay for food, insulin, other medications and supplies, and utilities need to be recognised and where possible addressed.

<H2>Psychosocial screening and monitoring

Monitoring of wellbeing and quality of life issues using person-reported outcome measures should always be considered in routine consultations and not restricted to those who report to have psychological difficulties (Appendix 2).[119,120] Assessment and periodic monitoring of the person's mental and social health status, at least on an annual basis, is recommended to identify individual needs and promote emotional wellbeing, engagement in self-management and satisfaction with care.[121,122] Given the prevalence of psychological issues in type 1 diabetes, screening can assist in case-finding and timely referral for those in need of additional care, not least because psychological comorbidities tend to negatively affect diabetes outcomes and vice versa.[123]

Implementing a standardised psychosocial evaluation is feasible, but may require changes to current service provision, for example, inviting people with diabetes to complete a set of questionnaires online or at the clinic prior to their visit.[124] Practical, validated psychosocial screening tools are available for use in type 1 diabetes care, in multiple languages (Appendix 2).

There is no universally agreed core set of psychosocial measures for use in clinical care for adults with type 1 diabetes across countries, but there is consensus that emotional wellbeing, diabetes distress (including worries around hypoglycaemia, complications, treatment burden), depressive symptoms and social stress are among the most important domains to assess.[120,125,126]

When disordered eating behaviours are reported, a referral to a mental health specialist to conduct a diagnostic interview for eating disorders should be considered.[127] In case of suspected cognitive impairment, a brief cognitive screening is recommended, if needed followed by a referral for more elaborate cognitive testing.

Clinicians conducting psychosocial screening should possess a solid understanding of the psychosocial challenges commonly faced by individuals with type 1 diabetes, particularly those that may complicate diabetes management. They should also demonstrate strong communication skills, including active listening, a nonjudgemental approach to discussing sensitive issues, and the ability to constructively explore the option of referral to in-house or external specialised psychosocial services when appropriate.

<H2>Psychosocial interventions

People living with type 1 diabetes may, at various stages, experience adjustment problems and diabetes distress, that should be recognise as a normal response normative, rather than a clinical condition.[128] However, this does not imply that diabetes distress should be ignored. All members of the diabetes care team have a shared responsibility to provide supportive care as an integral component of diabetes management, helping people cope with the ongoing demands of the condition. Ideally, the diabetes care team should include a mental health professional (psychiatrist, clinical psychologist and/or social worker) with diabetes expertise, who can offer guidance to the team and direct support to those requiring psychosocial care.[129,130] Social needs may be addressed by social workers and community organisations. Social support from family and friends, peer-led initiatives, and digital self-help programmes can play a valuable role in helping individuals cope effectively with the psycho social demands of living with type 1 diabetes.[131,132]

Psychological therapies, including time-limited in-person or online cognitive behavioural therapy (CBT), mindfulness, acceptance and commitment therapy (ACT) and interpersonal therapies are

effective with regard to self-management and a range of psychological issues, including diabetes distress and depression.[133-135] The effects of individual and group psychotherapy on glycaemic levels are generally small but tend to increase when diabetes self-management education is incorporated in the treatment.[136] A small proportion of adults with type 1 diabetes are diagnosed with psychiatric conditions that requires psychotropic medication that may impact glycaemic management. In these cases close collaboration with a mental health specialist is warranted.[137,138]

<H1>Section 7: Interventions to manage glycaemia

Key points:

- Continuous glucose monitoring is the preferred method for monitoring glucose as it provides a complete view of glycaemia, both real-time and retrospectively, for making treatment decisions.
- Regardless of CGM use, all individuals need capillary blood glucose testing supplies and a method of testing blood or urine ketones, with instructions as to when and how to use these methods.
- HbA_{1c} is the traditional measure of chronic glycaemia
- Analogue insulins are preferred for subcutaneous insulin replacement.
- Automated Insulin Delivery (AID) systems are the optimal method of insulin delivery if used consistently.

<H2>Monitoring Glycaemia

People with type 1 diabetes should have real-time access to information about their glucose levels and trends, with warning alarms and alerts, in order to take action to maintain glucose in the target range or to treat hypo- and hyperglycaemia. People with type 1 diabetes and their healthcare team should review glucose data as often as needed to achieve or sustain glucose targets.

<H3>Continuous glucose monitoring

CGM is the standard of care for glucose monitoring for adults with type 1 diabetes. CGM supports the optimisation of glycaemic levels, reduces rates of hypoglycaemia, and improves quality of life.[61] A meta-analysis of 24 studies comparing CGM to blood glucose monitoring (BGM) found that on average

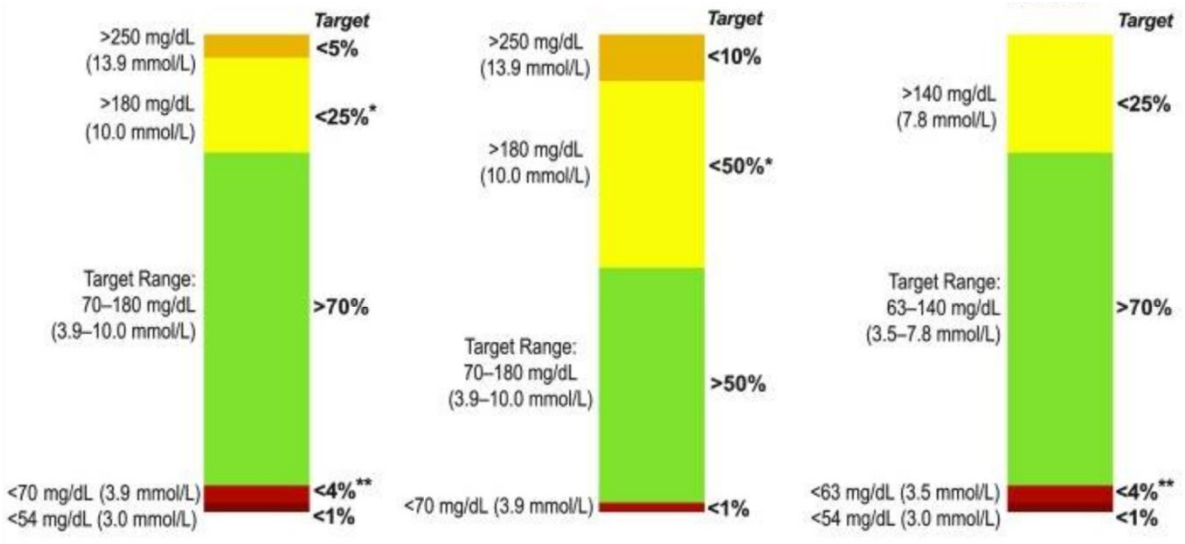
854 HbA_{1c} declined by 3 mmol/mol (0.24%), time in range (TIR) increased by 5.6%, and time below range
855 (TBR) decreased by 2.4%.[139] CGM has also proven beneficial in reducing the burden of hypoglycaemia
856 in older adults with type 1 diabetes[140] as well as severe hypoglycaemia in those with impaired
857 awareness for hypoglycaemia (IAH).[141]

858 Historically, two types of CGM devices were available, one providing a continuous value of current
859 interstitial glucose and trends to a receiver, smartphone or smartwatch, and/or insulin pump (real-
860 time (rt)-CGM), while the other required the glucose level to be determined by scanning a small reader
861 or smartphone across the transmitter (intermittently scanned CGM). The latter, however, has been
862 superseded by rt-CGM. CGM devices provide the opportunity for both real-time interaction by the
863 user as well as retrospective analysis by user and healthcare team. CGM devices offer predictive or
864 threshold alerts that can be set by the individual to notify them when they are predicted to or actually
865 reach certain hyper- or hypoglycaemic thresholds, facilitating actions that prevent hypo- or significant
866 hyperglycaemia, or immediate safety measures such as treating hypoglycaemia. Additionally, users
867 can respond to trends in glucose to allow proactive treatment decisions (e.g., to avoid hypoglycaemia)
868 rather than reactive responses. Most CGM devices allow users to share their data in real time with a
869 carer or family member so the latter can also be alerted of dangerous glucose levels.

870 For retrospective analysis, devices can be uploaded to cloud-based programs that allow people with
871 diabetes and healthcare professionals to easily view the data at or between clinic visits, enhancing
872 therapeutic decision-making, understanding and engagement, and behaviour change. However, this
873 requires a smartphone and/or a computer with internet connectivity which may be limited in under-
874 resourced settings. CGM downloads should be performed and reviewed at each diabetes
875 management visit. People using CGM should help determine and understand their individualized
876 treatment goals (average glucose, TIR, TBR, and other metrics), and if they are not meeting these
877 goals, what changes can be implemented to help. Examples of CGM target goals are shown in Fig. 4.
878 Standardized glucose reports, such as the ambulatory glucose profile (AGP) and daily tracings,
879 facilitate these discussions.[61]

880 The accuracy of CGM devices has improved consistently over time to the point where sensors no
881 longer require confirmatory capillary BGM. The U.S. FDA requires CGM systems to meet standards for
882 accuracy and precision prior to approval. However, in the EU the requirements for European
883 Conformity (CE) marking are more vague, and proposals have been issued for strengthening them.[142]
884 Even for those using CGM, access to BGM testing is required when there are concerns that CGM
885 readings may not be accurate for any reason (e.g., when symptoms do not match CGM glucose
886 reading), when CGM is warming up or otherwise unavailable, and during correction of hypoglycaemia
887 (due to the lag between interstitial and blood glucose readings).[143]

Figure 4: CGM targets for adults with type 1 diabetes. Left panel: most adults with type 1 diabetes; Centre panel: older adults, those at higher risk or those with impaired awareness of hypoglycaemia, in whom less stringent targets may be indicated or desired; Right panel: those who are pregnant or for whom more stringent targets are indicated or desired. For most adult GMI should be <53 mmol/mol (<7.0%) and glycaemic variability (%CV) ≤36% although some studies suggest that lower %CV targets (<33%) provide additional protection against hypoglycaemia.[144]



People with type 1 diabetes should be encouraged to review their own reports regularly and follow their progress over time, contacting their healthcare team as needed for worsening or changing trends. Users can, for example, set up alerts from certain CGM devices to inform them of what their TIR was for the week and how it changed compared to the previous weeks. Alerts such as these can be helpful motivational tools and alert the person with diabetes to contact the healthcare team as needed.

<H3>Capillary blood glucose monitoring

Capillary BGM involves the use of a handheld meter that provides a measurement of plasma calibrated capillary glucose. Frequent BGM monitoring should be advised for individuals not using CGM. In such cases, frequent BGM measurements are important as an integrated part of diabetes

management to guide insulin dosage, food intake and prevention of hypoglycaemia. Every person with type 1 diabetes should have the equipment to undertake BGM, regardless of whether they are using CGM.[61] Capillary BGM targets are shown in table 4.

Table 4: Capillary Blood Glucose and HbA_{1c} targets for most adults with type 1 diabetes

Variable	Target value
Outside pregnancy	
HbA_{1c}	<53 mmol/mol (<7.0%)
Pre-prandial glucose	4.4–7.2 mmol/l (80–130 mg/dl)
1–2 h postprandial glucose[a]	<10.0 mmol/l (<180 mg/dl)
During pregnancy	
Fasting	<5.3 mmol/l (<95 mg/dL)
1-h after meals	<7.8 mmol/l (<140 mg/dL)
2-h after meals	<6.7 mmol/l (<120 mg/dL)

[a]A postprandial glucose target of <7.8 mmol/l (<140 mg/dl) may be recommended if this can be achieved safely. Higher targets in those with limited life expectancy or where the harms of treatment are greater than the benefits are recommended. In some individuals at notably higher risk for Level 3 hypoglycaemia, it may be necessary to increase the glucose target range to decrease the TBR.

<H3>Ketone measurement

Ketone bodies are produced when insulin concentrations are too low and/or counter-regulatory hormones are too high to prevent lipolysis. If left untreated, ketosis can lead to progressive dehydration and DKA. Ketone measurement is important during periods of illness or hyperglycaemia to facilitate the management of the hyperglycaemia and prevent and/or treat DKA.

Adults with type 1 diabetes should have the ability to check ketones at home and be instructed on when to test and how to respond to concerning levels. This measurement can be done using either blood or urine. Blood measurements are preferred as they are easy to do, give specific values, and represent current ketone concentrations, while urine values lag.[145] However, blood ketone testing is more costly and may not be accessible. Methods for continuous ketone measurement are being actively developed.[146]

<H3>Glycated haemoglobin (HbA_{1c}) measurement

Monitoring of glycaemia over time has traditionally been by HbA_{1c}, which has been used in most studies demonstrating the benefits of lowering glucose on the development and progression of diabetes complications.[147] There is a strong correlation (r = >0.9) between HbA_{1c} and mean blood glucose levels during the preceding 3 months if glucose levels have been stable. In several conditions, however, HbA_{1c} does not reflect mean glucose; these are mainly situations where erythrocyte turnover is altered or in the presence of some haemoglobinopathies.[145,148] Although there is variability in the relationship between mean glucose and HbA_{1c} between individuals, the relationship within an individual tends to be stable over time.[149] HbA_{1c} is an indicator of mean glucose, but does not inform about glycaemic variability and hypoglycaemia and, therefore, should not be the only method to evaluate glycaemia in type 1 diabetes.[149,150] With the widespread adoption of CGM, the necessity of frequent HbA_{1c} testing is being reconsidered, as CGM provides the Glucose Management Indicator (GMI) alongside other detailed metrics. However, there is limited evidence linking CGM-derived metrics to long-term diabetes complications independently of HbA_{1c}. Some argue that if CGM data are consistently shared with healthcare providers, HbA_{1c} testing could be performed less frequently than the current ADA recommendation of 2–4 times per year.[148] An HbA_{1c} target of <53 mmol/mol (<7.0%) is appropriate for most adults with type 1 diabetes. Variability in HbA_{1c} itself has been associated with increased risk of vascular complications and mortality, regardless of average HbA_{1c}.[151]

<H2>Insulin therapy

Barring successful beta cell replacement, exogenous insulin is the primary treatment of type 1 diabetes. The ideal regimen of insulin replacement maintains blood glucose within recommended ranges while allowing flexibility in terms of mealtimes, carbohydrate consumption, and activity levels. Insulin regimens all comprise two key elements: a basal insulin to restrain gluconeogenesis and ketogenesis in the fasting or post-absorptive state, and a mealtime or bolus insulin to cover food intake and hyperglycaemia. These basal and mealtime components can come from either multiple injections of insulin (MDI) or insulin pump therapy. Regardless of the regimen chosen, glucose monitoring remains a critical and consistent component to guide insulin administration.

<H3>Multiple daily injections (MDI)

MDI regimens comprise a subcutaneous basal insulin analogue, usually given as a single daily injection, together with separate injections of a mealtime rapid-acting or ultra-rapid-acting insulin analogue. Ultra-rapid analogues have a slightly earlier time of onset and peak action than rapid-acting analogues. Compared to rapid-acting analogues, they reduce postprandial hyperglycaemia but do not reduce HbA_{1c} or hypoglycaemia further.[152] Hence, both analogue forms are usually referred to as rapid acting analogues. Basal insulins have evolved over time from animal (later human) regular insulin with additives to enhance their duration (such as neutral protamine Hagedorn [NPH] insulin), through more "peakless" analogues, to current "second generation" basal insulin analogues with long duration and more consistent blood levels.[152] Compared to the original basal analogue glargine U-100, newer basal insulin analogues (insulin glargine U-300, insulin degludec) are associated with less hypoglycaemia, longer duration of action, and more flexible dosing schedules.[153] As such, second generation basal analogues are preferred in MDI regimens.

Once-weekly basal insulin preparations have been developed, with two (insulin icodec and insulin efsitora) having completed Phase 3 trials in adults with diabetes. In type 1 diabetes trials, both weekly insulins (compared to degludec as the basal insulin) demonstrated non-inferiority for HbA_{1c}-lowering but significantly higher rates of level 2 and level 3 hypoglycaemia clustering at days in the middle of the dosing interval.[154,155] Currently, insulin icodec is approved by European Medicines Agency (EMA) for use in the EU, but the U.S. FDA has not approved either icodec or efsitora, in part due to concerns about safety in people with type 1 diabetes. Once-weekly basal insulins are currently not recommended for routine use in people with type 1 diabetes.

<H4>Method of Injection

Insulin was traditionally administered using vials and insulin syringes, but since the 1980s insulin pens that use cartridges, or are pre-filled and disposable, have become the commonest mode of insulin administration in high-income countries. Insulin pens administer insulin to the nearest 1-unit (in some cases 0.5-unit) increments, and have benefits of increased convenience, easier instruction in use, and perhaps increased accuracy compared to vial and syringe use.[156] Some newer basal analogues no longer come in vials. In lower resource settings or for people without health insurance, insulin pens are more costly and therefore vials and syringes may be used. Whether in pens or syringes, smaller gauge and shorter needles provide almost painless injections and reduce the risk of intramuscular (vs. subcutaneous) injection. Contrary to common wisdom, skin thickness is not significantly increased in

994 individuals with overweight or obesity. Needles as short as 4 mm, injected at a 90° angle, enter the
995 subcutaneous space with minimal risk of intramuscular injection in most adults.[157]

996

997 **<H4>Connected pens and bolus calculators**

998 Technology is emerging to help MDI users with the management of insulin doses and timing.
999 Connected, or "smart" insulin pens are either reusable injector pens with embedded electronics or
1000 standard pens with an add-on cap. Connected pens record each insulin dose and timestamp and
1001 transmit the data wirelessly to a smartphone or cloud-based platform. The systems may include dose
1002 reminders, bolus calculators and insulin-on-board tracking, logging of insulin type, and other
1003 variables. Some also integrate with CGM. There is a significant negative impact of missed basal and
1004 bolus insulin injections on glycaemic levels, while more interaction with the smart pen data is
1005 associated with improved glucose self-management.[158-160] An observational study showed an increase
1006 in TIR by up to 2 h per day by switching to a smart pen system.[161] However, significant improvements
1007 in glycaemic levels have not been proven by randomized trials. Several smart pens are approved by
1008 the FDA and/or carry the CE mark. In development is the incorporation of artificial intelligence (AI)
1009 into connected pen platforms that analyses recent data and provide users with optimised dosing
1010 advice.[162]

1011

1012 **<H3>Insulin pumps**

1013 Insulin pumps deliver a continuous supply of rapid acting analogue insulin throughout the 24-h day.
1014 Most pumps are worn externally and connected via tubing to a thin cannula inserted under the skin,
1015 although other systems deliver insulin via a pod connected to the cannula without external tubing.
1016 Insulin pumps were designed to mimic endogenous insulin kinetics more closely, delivering both basal
1017 and bolus components of insulin therapy. The basal component is a low-level infusion of insulin that
1018 may vary by time of day based on insulin needs. Bolus doses are larger amounts of insulin given over
1019 short periods of time before meals and/or to treat hyperglycaemia. Users can manually adjust bolus
1020 doses based on carbohydrate intake, current blood glucose levels, and physical activity. Historically,
1021 insulin pumps did not integrate with CGM systems, and thus users had to monitor glucose with BGM
1022 or CGM and perform most actions of the pump manually. Integration of pump functions with CGM
1023 data initially led to "threshold low glucose suspend" or "predictive low glucose suspend" features to
1024 avert hypoglycaemia. Today's pumps integrate more fully with CGMs to form "hybrid" closed-loop
1025 systems (basal delivery automated but most bolus functions controlled by the user), referred to herein
1026 as AID systems.[61]

<H3>Automated insulin delivery systems

AID systems comprise three components: (1) an insulin pump to deliver insulin; (2) a continuous glucose monitor and; (3) an algorithm that interprets integrated CGM and pump data to determine whether changes in insulin delivery are needed (either more or less insulin).

With these systems, glucose values from the CGM are interpreted in an ongoing fashion to either alter the amount of basal insulin given or deliver correction bolus (in some systems). These systems are generally capable of handling slow drifts in glucose values (up or down) but still require the user to inform the pump when they are eating either by entering carbohydrates or announcing a meal (depending on the system). Physical exercise also needs to be announced, triggering the algorithm to set a higher glucose target to reduce the risk of hypoglycaemia. AID systems have rapidly become the preferred mode of insulin delivery for many people with type 1 diabetes, as studies with different devices have consistently shown improved glucose levels (lower HbA_{1c} and/or improved TIR) with reductions or no increase in CGM-detected hypoglycaemia.[61,163] Furthermore, quality of life is often improved.[61]

This is a rapidly evolving area, and several AID systems are available in different countries with different CGM compatibility (Table 5). Each system has unique attributes, therefore selection must be individualized. Individuals should be encouraged to explore each option and consider key elements such as the capability of the CGM and pump, whether the pump has external tubing or not, size of the pump, reservoir size (how much insulin the pump holds), battery vs. rechargeable, waterproof status, personal management ease and others. For the latest information, readers may wish to keep abreast by referring to the 'Technology' section of the ADA Standards of Care, which is a frequently updated living document.[61] It is important for both users and clinicians to be familiar with how the different AID systems' algorithms work, and what parameters can and cannot be adjusted to change glycaemic outcomes.

Table 5: Examples of widely used automated insulin delivery (AID) systems at the time of publication, with key characteristics and differences between the systems, and which settings can be adjusted to optimise glycaemic outcomes while in automated mode.

AID-systems	MiniMed 780G™	Omnipod 5™	Tandem Control-IQ™ (t:slim X2 or mobi)	MyLife CamAPS FX™ (ypsopump)	iLet ACE Closed-Loop Insulin Pump
Characteristics					
Infusion mode	Tubing	Tubeless Pod	Tubing	Tubing	Tubing
CGM compatibility	Medtronic Simplera Guardian 4	Dexcom G6 Dexcom G7 Abbott Libre 2+	Dexcom G6 Dexcom G7 Libre 2+	Dexcom G6 Abbott Libre 3+	Dexcom G6 Dexcom G7 Libre 3+
Control Algorithm	SmartGuard™	SmartAdjust™	Control-IQ™	CamDia APS FX™	iLet Dosing Decision
Automation mode	Proportional Integral Derivative with insulin feedback + Correction bolus	Model Predictive Control and Adaptive	Model Predictive Control + Correction bolus	Model Predictive Control and Adaptive	Model Predictive Control and Adaptive
Specific features	7-day infusion set, Correction bolus every 5 min	Bolus calculator including basal active insulin	Extended bolus option, Multiple basal profiles	Broad glucose target (80-200 mg/dl [4.4-11.1 mmol/l]), Boost and Ease-Off modes	Carb counting not required
Settings which can be adjusted to optimise glycaemic outcomes in automated mode					
Insulin/Carb ratio	Yes	Yes	Yes	Yes	No
Insulin sensitivity	No	No	Yes	No	No
Active insulin time	Yes	Yes	No	No	No
Glucose target	Yes	Yes	No*	Yes	Yes
Basal rate	No	No	Yes	No	No
Exercise mode	Yes	Yes	Yes	Yes	No
Sleep mode	No	No	Yes	No	No

*Target can be changed with sleep mode (but not independently). Targets always changed with exercise mode.

This is not a comprehensive list of all available AID systems

Some people with type 1 diabetes are using User-driven Open-Source or 'Do-It-Yourself' (DIY) AID systems. These use commercially available CGM systems and pumps, with downloaded open-source software algorithms that communicate with CGM and pump data and control basal and corrective doses.[164] These systems began in response to initial delays in commercial development of AID systems, and perceived limitations of early commercial systems. In the U.S. the use of the DIY "Loop" app was approved by the FDA and is now part of a new AID system. Regulatory bodies do not allow healthcare professionals to prescribe the algorithms outside of Loop, but the hardware for the systems can be prescribed and managed. Healthcare teams should respect an individual's right to make informed choices about their care and continue to offer support to the people using these systems, although such support may be limited by lack of full knowledge of the control algorithm settings.

Fully closed-loop AID systems, which would require almost no user input even for meals or exercise, are currently being evaluated in clinical trials in both North America and Europe.[165] The expectation is that some of these will receive regulatory approval in the next few years. This should allow people with type 1 diabetes to spend more time in the target range with minimal risk of hypoglycaemia and reduced daily burden.

<H3>Alternative routes of administration

Although subcutaneous insulin therapy has been the mainstay of treatment for over a century, this mode does not mimic physiological insulin secretion well. Healthy beta cells secrete insulin into the portal circulation at the onset of glucose intake, with approximately 70% of the insulin cleared by the liver and not entering the systemic circulation. Peak blood levels of endogenous insulin occur within 15-30 minutes after the start of the meal. Conversely, injected subcutaneous rapid-acting insulin enters the systemic circulation with some delay, show peak action around 120 minutes and relatively slow removal.[166,167] Other modes of administration of insulin have been designed to generate pharmacokinetics and pharmacodynamics more similar to the action of endogenous insulin.

An inhaled human insulin, available only in the U.S., consists of powdered human insulin coated onto microparticles for oral inhalation.[168] This delivery mechanism provides very rapid onset and short duration of action. Compared to mealtime rapid-acting analogue insulin injections, inhaled mealtime insulin resulted in lower post-meal glucose but equivalent TIR, hypoglycaemia, and time above range (TAR). Cough occurred in about 25% of users, with slight but not significant reductions in forced expiratory volume (FEV1) seen on spirometry.[168,169] People using inhaled insulin should be monitored with periodic spirometry because of possible effects on lung function.[170]

Implantable intraperitoneal programmable pumps are available in some areas in Europe. These comprise a pump embedded in a subcutaneous pocket of the abdominal wall that infuse regular insulin with a stabilizing agent through the peritoneal route.[171] Despite not being connected to CGM, these systems improve glucose levels when compared to subcutaneous insulin pumps, including sustained lower HbA_{1c} levels and reduction of severe hypoglycaemic events.[172] Integration with CGM may allow fully automated insulin delivery using the peritoneal route.[173]

<H3>Adverse effects of insulin

The main adverse effect associated with insulin therapy is hypoglycaemia, which is discussed in the section 9. Insulin, especially when targeting near-normoglycaemia, can cause body weight gain and can lead to some people with type 1 diabetes reducing their insulin doses. The sections on management of overweight and obesity and on psychosocial care provide more information.

Skin reactions to subcutaneous insulin therapy include local inflammation (often due to the pH of or additives to the insulin), insulin-induced lipohypertrophy, insulin-induced lipoatrophy and allergy. Lipohypertrophy is common, typically resulting from repeated use of the same injection or pump sites. It contributes to increased insulin requirements and causes glycaemic variability, leading to both hyper- and hypoglycaemia.[174,175] The condition is underdiagnosed but can be improved with self-management education. In a single-arm study of 171 insulin-users, two-thirds of whom had lipohypertrophy, often injecting preferentially into affected areas, incorrectly rotating sites, and/or re-using needles. An intervention involving education and provision of single-use 4 mm needles reduced severe and unexplained hypoglycaemia and glycaemic variability.[176] People with type 1 diabetes should receive instruction about proper injection and pump site insertion techniques, including regular site rotation, at insulin initiation and periodically thereafter. Clinicians should inspect and palpateinjection and infusion sites at least annually. While ultrasound can detect earlier and smaller lesions than physical examination,[174] but its added clinical value remains uncertain.

Insulin-induced lipoatrophy has become rare due to improvements in the purity of human and analogue insulin. True insulin allergy is rare and typically presents as recurrent local or systemic immediate- or delayed-type hypersensitivity reactions elicited by each injection, with symptoms centred on the injection sites. In some cases, switching to different insulin preparations or changing from MDI to insulin pump therapy may alleviate allergic responses.[177]

<H1>Section 8: Adjunctive therapies for glycaemic management

Key point:

- Evidence supporting the use of adjunctive therapies in type 1 diabetes to improve glycaemic management is generally insufficient to recommend their use.
- Off-label use of adjunctive therapies is increasing, but requires a full understanding of risks and benefits in an individual with type 1 diabetes

While insulin therapy is essential for people with type 1 diabetes, obtaining glycaemic goals with insulin alone is difficult because of the risks of hypoglycaemia, the slow action of "rapid acting" insulins, insulin resistance, difficulty with carbohydrate counting, and many additional factors. Furthermore, insulin therapy is often associated with undesirable weight gain which may worsen insulin resistance. Insulin therapy does not address other pathophysiological abnormalities present in people with type 1 diabetes, such as alpha cell dysfunction, and does not fully protect individuals from an increased risk of cardiovascular disease. Thus, the potential role of "adjunctive therapies" is to improve glycaemic management without increasing hypoglycaemia and body weight.

The evidence supporting the use of adjunctive therapies is limited, preventing a general recommendation about their use. However, these therapies can be considered in individual cases (Table 6). In all cases, before these drugs are prescribed, insulin therapy should be optimised. The use of incretin-based drugs and SGLT2 inhibitors for obesity and cardiovascular risk management is described in the respective sections.

Table 6: Adjunctive therapies for glycaemic management in type 1 diabetes

Variable	Metformin	Pramlintide	GLP-1 ± GIP receptor agonists	SGLT-2 or SGLT-1/2 inhibitors
HbA_{1c} reduction	~1 mmol/mol (~0.1%)	3–4 mmol/mol (0.3–0.4%)	2–4 mmol/mol (0.2–0.4%)	2–4 mmol/mol (0.2–0.4%)
Fasting glucose	Minimal effect	No effect	Minimal effect	Modest decrease (0.8 mmol/l [15 mg/dl])
Postprandial glucose	Minimal effect	Significant decrease	Modest decrease	Modest decrease
TIR	No data	No data	No data	Increased (~12% at higher doses)
Insulin dose	Unchanged	Mealtime reductions	Predominantly mealtime reductions	Mealtime and basal reductions (~10% total reduction)
Body weight reduction	Modest (~1 kg)	Modest (~1 kg)	Significant (~5-15 kg)	Moderate (2–3 kg)

Systolic blood pressure	No change	No change	4 mmHg decrease Increase in heart rate	3–4 mmHg decrease
Hypoglycaemia	Low risk	Potential increase in Level 3 hypoglycaemia if prandial insulin doses are not decreased	Increase in hypoglycaemia	Low risk
Side effects	GI side effects	GI side effects	GI side effects; increase in ketosis	Genital mycotic infections; increased risk of DKA; dehydration
Approval status for type 1 diabetes in EU/US	Not approved	US approved	Not approved	Not approved
Cardiovascular benefits shown	-	-	+	+

EU, European Union; GI, gastrointestinal; TIR: time in range

<H2>Metformin

Metformin has been evaluated in numerous small trials in people with type 1 diabetes with hopes that its insulin-sensitising properties would improve glycaemic management and/or reduce cardiovascular risk.[178,179] The largest study to date assessed the use of metformin 1 g, twice daily, in 428 people with type 1 diabetes who were treated for 3 years, with a primary endpoint of changes in mean carotid intima–media thickness, a marker of cardiovascular disease risk. The study ultimately found no difference in the primary endpoint, minimal and non-sustained effects on HbA_{1c}, minimal effects on weight (~1 kg reduction) and no change in total daily insulin dose.[180] Thus, metformin therapy is generally not recommended for people with type 1 diabetes.

<H2>Pramlintide

Pramlintide, an amylin analogue, is the only approved adjunctive therapy to insulin, in the U.S. but not in Europe. Injection prior to meals acts to suppress glucagon secretion, delay gastric emptying and promote satiety.[181-184] Clinical trials have shown a reduction in HbA_{1c} (3-4 mmol/mol [0.3-0.4%]) and modest (~1 kg) weight loss.[185-188] As a result of its adverse effects and need for additional injections, clinical uptake of pramlintide has been limited. However, co-formulations of amylin with insulin are currently in development, as is the possibility of use of pramlintide in pumps or artificial pancreas systems.

<H2>Glucagon like peptide-1 receptor agonists

Glucagon like peptide-1 receptor agonists (GLP-1 RA) have been explored in people with type 1 diabetes for two indications; the first aimed to ameliorate beta cell decline at the time of diagnosis and there are ongoing trials of this approach. In one study of 308 people with recently diagnosed type 1 diabetes, liraglutide, when used in combination with anti-IL-21, preserved beta cell function.[189] The second indication is as an adjunctive therapy in established type 1 diabetes by blunting glucagon secretion, decreasing gastric emptying, and promoting satiety and thereby weight loss.[190] The largest clinical trials in people with type 1 diabetes were conducted with liraglutide and showed decreases in HbA_{1c} at daily doses of 1.8 mg (0.2-0.4% [2-4 mmol/mol]), decreases in weight (~5 kg) and reductions in insulin doses.[191,192] However, increased rates of hypoglycaemia and ketosis were shown. A recent study showed semaglutide to be safe in people treated with AID, with similar effects on HbA_{1c} and body weight,[193] while a proof of concept study showed that tirzepatide significantly reduced HbA_{1c} and body weight in adults with type 1 diabetes.[194]

<H2>SGLT inhibitors

In several Phase III programmes in people with type 1 diabetes, the use of SGLT-1 or SGLT-1/2 inhibitors reduced HbA_{1c}, improved TIR, reduced body weight and improved blood pressure.[178] However, an increased rate of DKA led to rejection of market authorisation for type 1 diabetes by the FDA. Whereas the EMA previously approved low-dose dapagliflozin (5 mg) and sotagliflozin (200 mg) for those with a BMI ≥27 kg/m^2, their market authorization was subsequently withdrawn on request of the market authorization holders.[195] While no risk mitigation strategies have been proven to lower the risk of DKA, a consensus statement on SGLT2 inhibitors and DKA suggested careful patient selection, appropriate insulin dose adjustment to avoid insulinopaenia, starting with a low dose of SGLT2 inhibitors, and regular ketone measurements with prompt action to address elevated values as sensible precautions aimed at preventing DKA.[196] The development and clinical use of continuous ketone monitors may provide the additional safety required in the future to allow for more widespread use of SGLTi in people with type 1 diabetes, although this will require formal testing.

<H1>Section 9: Acute metabolic emergencies

Key points:

- Clinicians should proactively identify impaired awareness of hypoglycaemia (IAH) using validated questionnaires or via simple questions such as, “Can you always feel when your blood sugar is low?” and “At what blood sugar level do you feel symptoms?”
- IAH is a significant risk factor for severe hypoglycaemia, but the risk can be reduced through use of CGM, physiological insulin regimens, and structured or personalized education.
- Risk factors for DKA include younger age, lower socio-economic status, infections, intercurrent illnesses, psychological stress, omission of or under-dosing of insulin, and adjunctive use of SGLT-2 inhibitors.
- DKA prevention strategies include DSMES and awareness of “sick day rules” that include intensified glucose and ketone monitoring.

<H2>Hypoglycaemia

Hypoglycaemia, the most important limiting factor in the glycaemic management of type 1 diabetes,[148] is classified into three levels:

- Level 1: plasma or interstitial glucose concentration below 3.9 mmol/l (70 mg/dl) and greater than or equal to 3.0 mmol/l (54 mg/dl); an alert value at which people on insulin should take action;
- Level 2: glucose concentration below 3.0 mmol/l (54 mg/dl), considered clinically important hypoglycaemia;
- Level 3: hypoglycaemia characterised by altered mental state and/or physical status needing the intervention of a third party for recovery, also called severe hypoglycaemia.

<H3>Epidemiology and risk factors for hypoglycaemia in type 1 diabetes

Rates of hypoglycaemia are generally determined from self-report, CGM data (for level 1 or 2 hypoglycaemia), and data from hospitals and emergency departments. CGM data can include false-positive hypoglycaemia, including compression lows, and should be validated. Hospital and emergency department data primarily describes, but likely underestimates, severe hypoglycaemia.

Hypoglycaemia, including severe episodes, remains troublingly common in people with type 1 diabetes. In a study of approximately 67,000 adults with type 1 diabetes, adjusted rates of severe hypoglycaemic emergencies increased from 25.7 to 32.9/1,000 person-years between 2011 and 2019 and then decreased to 25.6/1,000 person-years in 2020. Although the trends were not statistically significant, these analyses suggest that rates of severe hypoglycaemia are not declining despite advances in therapies.[197] In a cross-sectional survey of adults with type 1 diabetes (92% using CGM and almost half using AID systems), 20% reported having had at least one episode of severe hypoglycaemia in the prior year, with 12% reporting at least 2 episodes. Although reported history of severe hypoglycaemia was lower with use of technology (e.g. 34% of non-users of CGM vs. 18% of CGM users), 16.6% of those using AID still reported an episode within the past year. However, the timing of initiation of AID use was not ascertained.[198]

Risks for hypoglycaemia, particularly Level 3 hypoglycaemia, include longer duration of diabetes, older age, history of recent Level 2 or 3 hypoglycaemia, high glycaemic variability, alcohol ingestion, exercise, lower education levels, lower household incomes, chronic kidney disease and impaired awareness of hypoglycaemia (IAH).[148] IAH is the reduced ability to recognise low blood glucose levels, typically due to loss of counter-regulatory hormone responses and their associated symptoms.[199] Confusion or loss of consciousness may be the first sign of hypoglycaemia, pre-empting appropriate corrective behaviours. The prevalence of IAH is estimated to be 25-30% in people with type 1 diabetes but is likely to be underestimated judging by CGM data.[200] IAH markedly increases the risk of severe hypoglycaemia. The subsequent fear of hypoglycaemia may lead to the person with diabetes to omit insulin injections intentionally or loosen glycaemic targets to prevent their reoccurrence. IAH is associated with, but not fully explained by, autonomic neuropathy.[201] It can be induced or worsened by recurrent hypoglycaemia and alcohol use.[148]

Diabetes healthcare professionals should proactively ask people with type 1 diabetes whether, and at what glucose level, they feel hypoglycaemia in order to identify IAH and adjust individual glucose targets to reduce the risk of severe hypoglycaemia. Validated questionnaires, such as the Clarke,[202] Pedersen-Bjergaard,[203] and Hypoglycaemia Awareness Questionnaire (HypoA-Q) tools[204] can also identify IAH. However, simple questions such as, “Can you always feel when your blood sugar is low?” and “At what blood sugar level do you feel symptoms?” also identify IAH and significant risk of severe hypoglycaemia.[148]

Significant discrepancies have been shown between CGM-detected and patient-reported hypoglycaemia.[143] Hence, both modes of capturing hypoglycaemia occurrence should be considered, especially because only patient-reported hypoglycaemia has been shown to have a significant impact on daily functioning.[205]

<H3>Consequences of and prevention of hypoglycaemia

Hypoglycaemia has significant impacts on quality of life and emotional health. Severe hypoglycaemia may lead to injury to the person with diabetes or to others, such as when driving. Hypoglycaemia in type 1 diabetes is estimated to account for more than 8% of deaths for those younger than age 56 years.[206] The long-term association of severe hypoglycaemia with subsequent cognitive function has been examined in the DCCT-EDIC cohort. In these analyses, severe hypoglycaemia in younger or middle-aged adults did not appear to affect neurocognitive function after 18 years of follow-up.[207] However, after 32 years of follow-up (median age 59 years), more episodes of severe hypoglycaemia were independently associated with greater decrements in psychomotor and mental efficiency.[117]

Several strategies can be used to reduce risk of clinically significant or severe hypoglycaemia. Structured education programmes, such as Dose Adjustment For Normal Eating (DAFNE) and Blood Glucose Awareness Training (BGAT), which provide informed support for active insulin dose self-adjustment, have been shown to reduce severe hypoglycaemia rates in those at high risk.[208] Since these specific programmes are not widely available, periodic DSMES addressing modifiable risks of hypoglycaemia and optimization of insulin therapy is indicated in all adults with type 1 diabetes, with enhanced education and support needed for those with problematic episodes.

The use of insulin analogues and carefully titrated basal-bolus regimens are standard of care in those with type 1 diabetes, due to their closer mimicry of physiological endogenous insulin secretion and reduced risk of hypoglycaemia. CGM, compared to BGM, has been shown to reduce TBR and episodes of severe hypoglycaemia in those at high risk of hypoglycaemia.[140,141,208] AID systems have great potential to detect impending or early hypoglycaemia, and to ward off more severe events. AID systems are associated with further reductions in CGM-detected hypoglycaemia compared to use of CGM and insulin pump in open loop mode, including in populations with high rates of severe hypoglycaemia.[209] Despite evidence that AID technology reduces risk of non-severe hypoglycaemia, randomized and real-world studies have not generally demonstrated reductions in episodes of severe hypoglycaemia, with occasional exceptions.[210] This may be due to power issues, participant selection, or insensitive detection of severe hypoglycaemia.

Early clinical physiology studies suggested that strict avoidance of hypoglycaemia helped restore hypoglycaemia awareness. [201] However, several clinical trials have not shown reductions in rates of IAH with CGM use despite reduced incidence of hypoglycaemia.[208] In a survey of adults with type 1 diabetes, rates of IAH (by Gold questionnaire) were about 30% in all subgroups (CGM users vs BGM

users, AID vs open-loop pump or MDI use), despite differences in rates of reported severe hypoglycaemia episodes.[198]

In some situations, it may be necessary to increase the glucose target range if hypoglycaemia cannot be rectified through other means. Intractable severe hypoglycaemia is an indication for islet or pancreas transplantation (Section 10).

<H3>Treatment of hypoglycaemia

The standard recommendation for correcting Level 1 or 2 hypoglycaemia is the oral intake of approximately 15 g of glucose or equivalent simple carbohydrate when capillary or interstitial blood glucose concentration is <3.9 mmol/l (<70 mg/dl). This should be repeated every 15 min until any symptoms have resolved and the blood glucose level is above 3.9 mmol/l (70 mg/dl). As there may be a 5-15 min lag between changes in capillary blood glucose and interstitial glucose, CGM may have delayed detection of the restoration of normoglycaemia. For those with a tendency to over-treatment, use of BGM is recommended to determine when hypoglycaemia has resolved.[148] Less glucose (5-10 g) may be needed to correct hypoglycaemia experienced while using AID, because the delivery system should have already reduced or stopped basal insulin delivery, and because over-correction may trigger additional insulin delivery.[211,212]

When there is a reduced level of consciousness, oral glucose intake is contraindicated because of risk for aspiration. Instead, caregivers or bystanders should administer glucagon via subcutaneous or intramuscular injection or via nasal delivery. Intravenous glucose injection is a possible alternative for healthcare professionals in cases of Level 3 hypoglycaemia. For many years, glucagon was dispensed as a powder and separate diluent that required mixing prior to administration. Newer forms of glucagon that are stable in solution and ready to inject, or that can be given intranasally, are easier for bystanders to use and may lead to more rapid correction of severe hypoglycaemia.[148] However, these preparations may be significantly more expensive and may not be available in all locations.

After the acute symptoms have resolved, a further 20 g of carbohydrate as part of a snack or meal may need to be ingested if there is still significant insulin on board or if exercise was the cause of the episode. If possible, the cause of the hypoglycaemic episode should be ascertained to determine preventive actions for future episodes.

<H2>Diabetic ketoacidosis

DKA is a life-threatening but preventable acute complication of type 1 diabetes, characterised by hyperglycaemia, metabolic acidosis and ketosis. Occasionally, DKA can be present when glucose levels are normal or only minimally elevated (< 200 mg/dl or <11.1 mmol/L); this "euglycaemic" DKA is more common with pregnancy, insulin pump use or adjunctive use of SGLT-2 inhibitors. The underlying cause of DKA is insulin deficiency, either absolute (new diagnosis of type 1 diabetes or omission of insulin in those with diagnosed disease) or relative (increased counter-regulatory hormones due to infection or other stressors without an adequate increase in insulin doses).[213] Omission of, or inadequate doses of, insulin may be iatrogenic, such as when clinicians mischaracterize adult type 1 diabetes as the more prevalent type 2 diabetes.

The prevalence of DKA and risk factors for its development have been less-well studied in adults with type 1 diabetes than in children. In the U.S., national surveillance of emergency department visits and hospital admissions suggests a rate of 28 cases per 1000 adults with diabetes per year, with a worrisome increase in emergency department visits and admissions for DKA seen since 2009.[214] In Denmark, the incidence of DKA in adults doubled between 1996 and 2008, with a subsequent minor decrease from 2008 to 2020.[215] In a European (predominantly Germany and Austria) registry, adults with type 1 diabetes had DKA at a rate of 2.5 per 100 patient years.[216]

DKA is commoner in younger adults (ages 18-44 years) with type 1 diabetes than in older individuals, and in people who are uninsured or of lower socioeconomic status. DKA can be the presenting manifestation of type 1 diabetes in 6-21% of adults at the time of diagnosis. In those with known diabetes, risk factors include infections, intercurrent illnesses, psychological stress, and omission of or under-dosing of insulin.[213] A subset of individuals with type 1 diabetes has recurrent episodes of DKA, with some studies suggesting that 22% of adults admitted for DKA in the U.S. are readmitted for the same diagnosis within the following year, 14% of whom have 4 or more subsequent admissions. Recurrent DKA is more common in younger adults, women, and those of low socioeconomic status.[217]

The use of sodium–glucose cotransporter (SGLT) inhibitors in adults with type 1 diabetes increases the risk of DKA by an estimated 15-fold, even in carefully selected and monitored participants in clinical trials.[218] About a third of cases of DKA in the setting of SGLT inhibitor use are "euglycaemic" DKA, suggesting that glucose monitoring alone will be insufficient for detection.[219] Future addition of continuous ketone measurement to CGM systems may be of benefit.

Diabetes self-management education is an effective tool in reducing DKA risk. Additional medical, behavioural health interventions, including home ketone testing, and psychosocial support are often needed. Telemedicine offers the potential to reach populations with decreased access to care, and 24

h access to advice about managing hyperglycaemia and ketosis or ketonaemia at home can reduce the risk of hospital admission.[213]

A detailed description of the management of DKA is beyond the scope of this report but the general principles of treatment are replacement of fluid, insulin and potassium. Addressing the underlying cause(s) and contributing factors is essential, as is a careful plan for outpatient follow-up. For further information regarding treatment of DKA, refer to the recent consensus report developed by ADA, EASD, and other organizations.[213]

<H3>Sick day and illness management

Stressful events, including illness, may affect glucose levels and increase risk of DKA. More frequent glucose and ketone measurements are necessary to identify insulin adjustments. Individuals should devise a sick day management plan in consultation with their healthcare professional.[220] Such protocols should specify ingestion of adequate amounts of fluids and carbohydrates, how often to monitor glucose and ketone levels, how and when to give supplemental insulin, and under what circumstances a person with diabetes should seek urgent medical care.[148] Those who use AID systems should be aware that the underlying algorithms may not be able to adapt quickly to marked increases in insulin needs, such as with initiation of glucocorticoid therapy or with severe illness. Conversion to open-loop mode may be needed.

<H1>Section 10: Preservation and replacement of beta cell function

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Key points:

- Current strategies aim to preserve endogenous beta cell function through immunomodulatory and metabolic therapies in early-stage type 1 diabetes
- Clinical approaches to beta cell replacement include whole-organ pancreas and pancreatic islet transplantation
- Evolving diabetes technologies are impacting patient eligibility and the role of transplantation in the current treatment landscape
- Emerging alternatives to donor-derived islets, include stem cell–based therapies and porcine islet xenotransplantation

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<H2>Prevention of immune destruction to preserve beta cell function

Several immunotherapy approaches are being evaluated for their potential use in Stage 1 or Stage 2 type 1 diabetes to prevent Stage 3 clinical type 1 diabetes, and for the preservation of beta cell function before and shortly after onset of Stage 3 clinical type 1 diabetes.[221] Many interventions have been tested in clinical trials but, to date, the most promising results have been from the anti-CD3 monoclonal antibody teplizumab,[222] low-dose anti-thymocyte globulin (ATG),[223] the anti-TNF drug, golimumab,[224] and the JAK-inhibitor baricitinib.[225] They preserve beta cell function in recent-onset type 1 diabetes and teplizumab also has delayed the clinical onset of type 1 diabetes.[226] Teplizumab is the first FDA-approved disease-modifying therapy for type 1 diabetes to delay the onset of stage 3 type 1 diabetes in individuals aged 8 and older who are in stage 2 of the disease. Clinical trials have shown that a single 14-day course of teplizumab can delay the onset of clinical diabetes by an average of two to three years in high-risk individuals.[47]

GLP-1 receptor agonists and verapamil both improve beta cell health and consequently preserve beta cell function.[189,227,228] Several trials are underway with the hope of not only preserving but even improving beta cell function and being able to interdict the type 1 diabetes disease process sufficiently to prevent the development of the disease. This includes trials commenced in those found at birth to be genetically at risk of type 1 diabetes.[229] Family members of individuals with type 1 diabetes are being encouraged to be screened for islet autoantibodies. Many countries have established networks that facilitate screening and follow people with potential to be enrolled in clinical trials.

<H2>Replacement of Beta Cells

Whole-organ pancreas transplantation and pancreatic islet transplantation remain the primary clinical methods for beta cell replacement in individuals with type 1 diabetes. Both approaches have demonstrated efficacy in achieving normoglycaemia, preventing hypoglycaemia, and potentially stabilizing or reversing diabetes-related complications.[230-235] However, the necessity for chronic systemic immunosuppression to prevent allogeneic rejection necessitates a careful assessment of the risk-benefit ratio, incorporating both medical and psychological factors.[236] Both whole-organ pancreas and pancreatic islet transplantation continue to evolve as viable therapeutic options for individuals with T1D. Recent developments have focused on enhancing the efficacy and accessibility of islet transplantation by the exploitation of alternative cell sources and means to reduce or avoid immunosuppression.[237,238]

<H3>Whole-Organ Pancreas Transplantation

The majority of pancreas transplants are performed simultaneously with kidney transplants (simultaneous pancreas and kidney [SPK] transplantation), representing the standard treatment for individuals with type 1 diabetes and end-stage renal disease, provided there are no contraindications such as malignancies, chronic infections, inadequate self-management, or severe cardiovascular conditions. SPK transplants have demonstrated a 5-year pancreas graft survival rate of more than 80%, surpassing the outcomes of pancreas transplants alone (PTA) or pancreas after kidney transplants.[230,232] Recipients of SPK transplants often experience significant amelioration of problematic hypoglycaemia for extended periods.[232,239,240]

PTA is typically considered for younger individuals (under 50 years of age) without obesity (body mass index less than 30 kg/m²) or coronary artery disease.[241] These criteria help minimize operative mortality to less than 1% and reduce early technical pancreas graft loss to less than 10%.[230,241] The primary indications for PTA include a history of frequent, acute, and severe metabolic complications (e.g., hypoglycaemia, hyperglycaemia, ketoacidosis), significant clinical and emotional challenges with exogenous insulin therapy, or consistent failure of insulin-based management, including technological aids.[242]

<H3>Pancreatic islet transplantation

Pancreatic islet transplantation, a less invasive procedure, is indicated for individuals with excessive glycaemic lability and frequent severe hypoglycaemia despite optimal medical therapy.[243] This approach allows for the inclusion of older people and those with coronary artery disease who may not be suitable candidates for whole-pancreas transplantation.[244-247] Advancements in patient selection and protocol optimization have led to substantial clinical improvements, leading to the maintenance of insulin independence for five years in approximately 50% of recipients.[247,248] Beyond achieving insulin independence, recent multicentre clinical trials have emphasized the importance of attaining near-normal glycaemic levels (HbA_{1c} less than 53 mmol/mol [7.0%]) alongside the elimination of severe hypoglycaemia as primary endpoints, reflecting clinically relevant goals. These outcomes have been associated with improved patient-reported outcomes.[231,248-251]

<H3>Impact of advancements in diabetes technology on transplant eligibility

The continuous advancements in diabetes technology, particularly AID systems, have significantly improved glycaemic management. As a result, the number of individuals who meet the strict eligibility

criteria for pancreas transplantation alone (PTA) or islet transplantation alone (ITA) has declined. These technological improvements offer a less invasive and lower-risk alternative to transplantation for many people, shifting the risk-benefit balance and reserving PTA and ITA for those with the most severe glycaemic instability or insulin resistance that cannot be managed with current diabetes technology.[235,252]

<H3>Stem cell strategies

A major limiting factor for pancreas or islet transplantation is a limited supply of organs, given the need for cadaver donors. To solve the problem of availability, options under investigation include use of stem-cell derived islets,[253] and the xenotransplantation with porcine islets.[254,255] Stem cell strategies have used either patient-specific stem cells or universal allogeneic cells. In the former, the patient's own stem cells are reprogrammed or transdifferentiated to become beta cells.[256] By contrast, generic allogeneic cells may be used for multiple recipients and centrally produced from a bank of human embryonic stem cells (hESCs) or of induced pluripotent stem cells (iPSCs).[257] One of the key issues is protecting the cells from immune attack, both rejection and recurrent autoimmunity. Three general strategies are being investigated: (1) use of immunomodulatory drugs; (2) use of a physical barrier (e.g. encapsulation);[258] and (3) gene editing for immune evasion and/or immune protection.[259] Both academic and commercial groups are pursuing these approaches, and some are already in clinical trials. Nonetheless, for stem-cell based strategies, there remain both challenges and opportunities for achieving successful reversal of type 1 diabetes.[238]

<H2>Regeneration of beta cells

Several approaches have been studied to generate or regenerate beta cells. Most of these studies have been conducted in isolated cell systems or in animal models.[260-262] These include DYRK1A inhibitors, menin inhibitors, and a combination of GLP-1 receptor agonist, gastrin, and GABA. Clinical trials are expected to be underway in the not too distant future.

<H1>Section 11: Screening for microvascular complications

Key points:

- Screening for microvascular complications in type 1 diabetes does not need to be performed until five years after diagnosis

- Fundus photography, a 10-gram monofilament test, urinary albumin to creatinine ratio and eGFR testing are pivotal screening tests

As there are many guidelines available on management of microvascular complications,[263,264] this section will concentrate on the detection of microvascular complications.

<H2>Diabetic Retinopathy

In the modern era of type 1 diabetes management, the incidence and prevalence of diabetic retinopathy has decreased. In a comparison of the US T1D Exchange (N = 1283, mean diabetes duration = 32 years) and the German/Austrian DPV (N = 2014, diabetes duration = 29 years) registries, diabetic retinopathy was reported in 34% and 40% respectively.[265]. In the US, this compares to 75-82% at the beginning of the current century.[266]

Retinal photography with remote reading by experts can provide screening services in areas where qualified eye care professionals are not readily available[267,268] and increase efficiency with reduced costs where these professionals are available.[263] It is patient friendly as pupil dilation is not always required and can be done within primary diabetes health settings. Interpretation of the images should be performed by a trained eye care professional or reading centre technician or by approved artificial intelligence (AI) programs. A comprehensive eye examination can also be provided by an ophthalmologist or optometrist. If sight-threatening diabetic retinopathy is noted on screening, referral to an ophthalmologist is recommended. Subsequent examinations are generally recommended annually for those without or with mild diabetic retinopathy, but examinations every 1-2 years or even less frequently may be cost-effective after one or more normal eye examinations.[269] More frequent examinations will be required if retinopathy is progressing, and risk factors, such as glycaemia and hypertension, are not adequately managed. Similarly, for advanced diabetic retinopathy or macular oedema, more frequent examinations are recommended.

Treatment by the primary medical provider should include optimising glycaemic and blood pressure management to reduce the risk or slow the progression of the diabetic retinopathy. There is also growing evidence that fenofibrate is effective in slowing the progression of diabetic retinopathy in both type 1 diabetes and type 2 diabetes.[270]

<H2>Diabetic Kidney Disease

Diabetic kidney disease historically impacts 30-40% of individuals with type 1 diabetes.[271] However, with better treatment of glycaemia and blood pressure, the prevalence is decreasing in some,[272] but not all settings.[273,274] One report from the US noted the weighted estimate to be 21.5%, however, there are large variations in the burden of diabetic kidney disease around the world, much due to economic factors.[275]

Screening for albuminuria should be by the assessment of urine albumin-to-creatinine ratio (uACR) in a random spot urine collection.[263] In case of pathological uACR in a random spot urine collection, confirmation by repeated examination is needed. Normal level of urine albumin excretion is defined as <30 mg/g creatinine, moderately elevated albuminuria is defined as ≥30–300 mg/g creatinine, and severely elevated albuminuria is defined as ≥300 mg/g creatinine. Because of high biological variability of >20% between measurements in urinary albumin excretion, two of three specimens of uACR collected within a 3-to 6-month period should be abnormal before considering an individual to have moderately or severely elevated albuminuria.[276]

Estimated glomerular filtration rate (eGFR) is usually calculated from serum creatinine using a validated formula.[263] An eGFR persistently <60 mL/min/1.73 m^2 and/or a urinary albumin value of >30 mg/g creatinine is considered abnormal.

The current recommendation is to assess uACR and eGFR in adults with type 1 diabetes yearly in people with ≥5 years of disease,[271] although less frequent measurement may be considered. Treatment of established moderately elevated albuminuria starts with renin-angiotensin-aldosterone system (RAAS) inhibition. Individuals should be referred to a nephrologist if urinary albumin levels increase progressively, a more than 30% eGFR decrease following initiation of haemodynamically active therapy (antihypertensives, esp. RAAS or SGLT2 inhibitors), or eGFR is <30 mL/min/1.73 m^2.[277]

<H2>Neuropathy

Recent Danish data show a decreasing and low risk of diabetes-related foot complications in type 1 diabetes, with a cumulative 3-year risk of 0.2% in low-risk individuals (around 50%) and 3.9% in high-risk individuals.[278] However, changes in prevalence in other countries are less well documented.

Yearly screening for peripheral neuropathy, also termed distal symmetric polyneuropathy, is recommended,[263,279] although recent data strongly suggest that screening intervals can be prolonged in low-risk individuals.[278] In low-risk individuals, screening for loss of protective sensibility should be done with a 10-g monofilament. Full assessment for peripheral neuropathy includes a careful history

and assessment of either temperature or pinprick sensation (small-fibre function) and vibration sensation using a 128-Hz tuning fork (for large-fibre function).[263,279] The most common early symptoms are induced by the involvement of small fibres and include pain and dysaesthesia (unpleasant sensations of burning and tingling). The involvement of large fibres may cause balance issues, numbness, and loss of protective sensation. Importantly, up to 50% of diabetic peripheral neuropathy may be asymptomatic, and if not recognized and preventive foot care is not implemented, there is a higher risk of diabetes-related foot ulcers and amputations.

While there are many other aetiologies of peripheral neuropathy, for those with type 1 diabetes it is important to consider hypothyroidism and vitamin B_{12} deficiency, which are more often seen in this population.[280]

Awareness for diabetic autonomic neuropathy is especially relevant if other microvascular complications are present, specifically diabetic retinopathy and peripheral neuropathy. History includes asking about orthostatic hypotension, syncope, early satiety, erectile dysfunction, changes in sweating patterns (especially gustatory sweating), or dry cracked skin of the extremities. On examination, resting tachycardia (after ruling out hyperthyroidism, and other causes of tachycardia), orthostatic hypotension, or evidence of peripheral dryness or cracking of the skin may be found. While a resting heart rate greater than 100 beats/minute is generally noted early in those with autonomic neuropathy and can be used as an early screen,[281] more detailed testing such as the measurement of heart rate variability with an electrocardiogram, heart rate response to standing, heart rate response to a Valsalva manoeuvre and systolic response to standing are required for a definitive diagnosis.[282]

<H1>Section 12: Cardiovascular risk management

Key Points

- Cardiovascular risk management in type 1 diabetes includes striving for optimal glycaemic, blood pressure and cholesterol management
- A clear role for GLP-1 based drugs and SGLT2 inhibitors is emerging

The prevention of cardiovascular disease in people with type 1 diabetes, extends beyond glycaemic management to include the optimal management of blood pressure and use of lipid-lowering medication. There is an absence of cardiovascular outcome studies in people with type 1 diabetes, and so extrapolation from studies done in other populations, mainly type 2 diabetes, is unavoidable.[283,284]

<H2>Glycaemia

In the EDIC cohort study following the DCCT randomised trial, a 42% and 30% reduction in cardiovascular events at 17 years and after 30 years, respectively was seen in those originally assigned to the intensive therapy cohort compared to those originally assigned to conventional therapy.[285,286]

The benefits of GLP-1 receptor agonists and SGLT2 inhibitors have convincingly been shown in reducing heart failure, cardiovascular mortality, renal function decline and other emerging outcomes. People with type 1 diabetes were excluded from these studies because of an increased risk of ketoacidosis, much more with SGLT2 inhibitors than with GLP-1 receptor agonists. Given the effect sizes in the accumulating outcome studies in other populations, the benefit risk ratio is likely to strongly positive, in the absence of recent or recurrent ketoacidosis. Currently, several studies are reassessing the use of both classes of drugs for type 1 diabetes.

<H2>Blood pressure

Large RCTs in people without diabetes and Chinese people with type 2 diabetes and have demonstrated that treatment of hypertension to a blood pressure <120/80 mmHg reduces cardiovascular events.[287,288] Blood pressure targets should be individualised with higher targets in the presence of, for example, orthostatic hypotension, but a target of <120/80 mmHg is recommended for those at higher cardiovascular disease risk or with evidence of microvascular complications, particularly renal disease. ACE inhibitors, angiotensin receptor blockers, calcium antagonists and thiazides are recommended first-line therapies, with a preference for RAAS inhibition in case of moderately elevated albuminuria. Beta blockers are generally contraindicated as they may diminish symptoms of hypoglycaemia and should only be used when clearly indicated and with caution.[283]

<H2>Cholesterol lowering

An observational study reported that lipid-lowering therapy is associated with a 22-44% reduction in the risk of cardiovascular disease and death among individuals with type 1 diabetes without a prior history of cardiovascular disease.[289] Based on type 2 diabetes guidelines, statins should be considered for people aged over 40 years, and in those aged between 20-39 years when the 10-year cardiovascular risk estimated by one of the risk calculators suitable for people with type 1 diabetes exceeds 10%.[90,290,291] Coronary artery calcium scores may be helpful for individuals who are at intermediate risk of atherosclerotic cardiovascular disease, as a 0 score substantially decreases the

risk estimate. Coronary artery scores are not helpful to assess the effect of statin therapy as statins can increase the score by increasing plaque density and stabilization.[292] The treatment goal is to aim for at least a 50% drop from the initial LDL-cholesterol to a target of <1.8 mmol/l (70 mg/dL) for primary prevention and <1.4 mmol/l (55 mg/dl) for those with established cardiovascular disease. Further information related to cholesterol lowering, for example, secondary prevention, statin intolerance, pregnancy, is available elsewhere.[283]

<H2>Aspirin

Aspirin is indicated for all people with type 1 diabetes and existing cardiovascular disease but is not recommended for primary prevention in type 1 diabetes and is associated with an increased risk of gastrointestinal bleeding.

<H2>Screening in asymptomatic individuals

Investigations for coronary artery disease should be considered if the person has any of the following: signs or symptoms of cardiac or associated vascular disease, including carotid bruits, transient ischaemic attacks, stroke, claudication or peripheral arterial disease or electrocardiographic abnormalities (e.g., Q waves).[283] However, routine screening for coronary artery disease is not recommended as it does not improve outcomes as long as atherosclerotic cardiovascular risk factors are treated.

<H2>Heart failure

Heart failure is becoming increasingly common in type 1 diabetes, especially with women.[293] NT-proBNP is recognized as a diagnostic and prognostic marker for heart failure and its measurement mat help identify those at risk.[283] RAAS blockers and diuretics remain the preferred agents for early heart failure, but a cardiologist should be involved for those with more advanced disease. Given the improved outcomes seen in heart failure in those with type 2 diabetes and those without diabetes, people with heart failure and type 1 diabetes are likely to benefit from SGLT2 inhibitors as well. SGLT2 inhibitors, if used, require caution with planned ketone monitoring, especially during intercurrent illness due to the risk of ketoacidosis, which is often euglycaemic.[196]

<H1>Section 13: Management of obesity

Key points:

- Overweight and obesity is at least as common in people with type 1 diabetes as in the general population
- Additional contributing factors include increased food intake to prevent hypoglycaemia and the effects of hyperinsulinaemia
- Treatment should include behavioural interventions, pharmacotherapy using second-generation anti-obesity drugs and if indicated bariatric surgery

Contrary to the common perception that people with type 1 diabetes are lean, obesity rates in type 1 diabetes mirror those in the general population and warrant clinical attention, not least because of substantially higher risk of cardiovascular disease.[294,295] In addition to the usual aetiological factors, recurrent food intake to prevent or correct hypoglycaemia and the unphysiological subcutaneous administration of insulin further contribute to weight gain in this population.[296] Consequently, obesity management in type 1 diabetes presents a significant clinical challenge.

<H2>Behavioural modification

<H3>Meal planning

Currently, there is insufficient evidence to support one specific meal planning approach for weight loss in individuals with type 1 diabetes. Nutrition education and individual preferences should be prioritized to ensure long-term sustainability. A 3-month pilot study in young adults found no significant difference in weight loss (average 2.7 kg) among participants randomized to a hypocaloric low-carbohydrate diet, a hypocaloric moderate low-fat diet, or a Mediterranean diet.[297] Additionally, a review of eight studies investigating low-carbohydrate diets in type 1 diabetes reported mixed outcomes regarding changes in BMI and total daily insulin requirements. The limited sample sizes in these studies precluded a valid meta-analysis.[298]

Any meal planning strategy aimed at reducing caloric intake in type 1 diabetes must demonstrate safety, particularly concerning the risks of hypoglycaemia and hyperglycaemia. Very low-carbohydrate (ketogenic) diets raise ongoing concerns, including increased risk of hypoglycaemia, diminished glycogen stores that may blunt the glucagon response, and the potential for relative insulin deficiency leading to diabetic ketoacidosis.[298,299]

<H3>Exercise

As in the general population, there is limited research specifically examining weight loss through exercise in individuals with type 1 diabetes. Although exercise offers numerous health benefits, a meta-analysis of 24 studies found no consistent reduction in BMI associated with physical activity alone.[300] However, regular exercise when combined with strategies, such as reducing total daily insulin doses and avoiding excessive caloric intake to treat hypoglycaemia, may aid weight loss and blunt loss of lean body mass.[72]

<H2>Pharmacotherapy

<H3>First generation obesity medications

For individuals with diabetes, current guidelines recommend considering obesity medications for those with BMI >27 kg/m^2. In the US there are six medications approved for chronic weight management, three approved for short term use only (phentermine, phendimetrazine, diethylpropion).[301] None of these are approved in Europe and none have been studied in individuals with type 1 diabetes. All are rarely used today in this population.

Metformin, pramlintide, and SGLT-2 inhibitors, while not approved for weight loss, when used as adjunctive agents can cause small weight reductions (table 6).

<H3>GLP-1 and dual receptor agonists

There are currently six GLP-1 or dual receptor agonists available, all of which are approved for the treatment of type 2 diabetes. Among these, liraglutide, semaglutide, and tirzepatide, are also approved for the treatment of obesity. While the prescribing information for these medications explicitly states that they are not approved for diabetes management in type 1 diabetes, the labelling for their obesity indications does not mention type 1 diabetes. As such, when prescribed for obesity, these agents are not contraindicated in individuals with type 1 diabetes and may be considered for selected people under appropriate clinical supervision.

Retrospective observational studies have demonstrated the potential effectiveness of GLP-1 receptor agonists in individuals with type 1 diabetes. In one study with a matched control group, participants receiving treatment experienced an average weight loss of 7.2 kg over 12 months, compared to a 1.0 kg weight gain in the control group.[302] Additionally, there was a modest, non-significant improvement

in HbA_{1c} of 3 mmol/mol (0.3%), along with a statistically significant reduction in hypoglycaemia as measured by CGM.

Another study reported a 10.1% reduction in body weight at 8 months among individuals with type 1 diabetes treated with tirzepatide.[194] However, the use of these agents in this population requires support for insulin dose adjustments in response to the effects of incretin therapy, whether the individuals are using multiple daily injections (MDI) or insulin pump therapy, including AID systems. It is also important to consider the need for insulin dose adjustments in the context of weight loss. When initiating GLP-1 receptor agonist therapy, delayed gastric emptying, typically a short-term effect, can increase the risk of immediate postprandial hypoglycaemia, particularly during the early phase of treatment or in the presence of nausea or vomiting.

<H2>Bariatric Surgery

People with a BMI >35 kg/m² accompanied by weight-related complications, or a BMI >40 kg/m², meet the criteria for bariatric surgery.[303] To date, bariatric surgery remains the most effective long-term treatment for severe obesity, though it carries the highest risk among available interventions.

As with the use of anti-obesity medications, the evidence base for bariatric surgery is still emerging in individuals with type 1 diabetes. A systematic review and meta-analysis involving over 600 individuals with type 1 diabetes reported substantial benefits after just under three years, including a reduction in mean BMI from 42.6 kg/m² to 29 kg/m², decreased insulin requirements, and improved HbA_{1c} levels.[304]

However, important clinical questions remain regarding which individuals with type 1 diabetes and severe obesity are most likely to benefit from surgical intervention, and which type of procedure should be recommended. Hypoglycaemia is the most frequently reported complication following bariatric surgery in this population, with an incidence exceeding 50%.[305,306] Furthermore, there have been several cases of iatrogenic DKA, when insulin is stopped after surgery in line with guidance for type 2 diabetes.

<H1>Section 14: Older people

Key Points:

- Patient safety, particularly avoidance of hypoglycaemia, is a key priority for older individuals

- Glycaemic treatment approaches and targets should be based on functional and cognitive status, available care partner support, history of hypoglycaemia and impaired awareness, fear of hypoglycaemia and hyperglycaemia and life expectancy, rather than chronological age
- The use of advanced technologies in older individuals living independently, including those with mild cognitive impairment, is effective and safe and should not be discontinued or a priori excluded because of the older age
- Simplification of insulin management may be needed to maintain patient safety and prevent diabetes symptoms. In some cases, this may require that a caregiver administers the insulin or the older person is supervised while self-dosing.

The population of older adults with type 1 diabetes is growing due to increasing incidence, more individuals being diagnosed in adulthood, and rising life expectancy.[307,308] This group is highly heterogeneous. Many older adults remain healthy and should be managed in a similar way to younger individuals. However, as comorbidities and frailty develop, reassessment of diabetes management, including potential modifications to insulin therapy, is essential.

Glycaemic treatment strategies and targets should be individualized based on functional and cognitive status, availability of care partner support, history of hypoglycaemia and impaired unawareness, fear of both hypo- and hyperglycaemia, and life expectancy, rather than chronological age. Patient safety is paramount. Given the heightened vulnerability to hypoglycaemia, older adults with type 1 diabetes may require adjusted glucose targets to reduce the risk of hypoglycaemia.[309] If insulin administration becomes challenging, simplification of insulin regimens may be appropriate, especially in those with frailty or significant functional or cognitive decline.[309]

Advanced diabetes technologies can be highly beneficial in older adults and should not be discontinued or excluded solely based on age.[140,310,311] CGM reduces hypoglycaemia without increasing hyperglycaemia in both healthy older adults and those with mild cognitive impairment.[140,310] However, older individuals may be less familiar with and more apprehensive about new technologies. Clear explanations and training, tailored to both the individual and their caregivers, are essential. Training typically takes longer in older adults compared to younger individuals,[312] but with adequate education and support, older adults can use these tools effectively, improve glycaemic levels, and feel safer.

Alarm settings should be personalized to meet the needs and preferences of the individual, and data sharing with a supportive caregiver can be especially helpful as health declines.[313] When selecting new devices, factors such as usability (affected by dexterity, vision, hearing, and cognition) and cost should be considered.

Similar to CGM, AID systems reduce hypoglycaemia and improve TIR in older adults who are healthy or have mild cognitive impairment.[314-317] A personalized approach is often needed during both initial training and ongoing use. The potential role of a caregiver should be evaluated, as they may also require training, though the autonomy of the older adult should be preserved as much as possible.

Other technologies, such as mobile apps for reminders and activity tracking, or digital home assistants, have not been extensively studied in this population but may support independence in those with specific impairments. Given the diversity and evolving health status of older adults with type 1 diabetes, and the growing availability of advanced technologies, treatment strategies including the use of newer devices should be regularly re-evaluated as health, living situations, support systems, and device usability change.

<H1>Section 15: Pregnancy including preconception and post-natal care

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Key Messages:

- Healthcare professionals should discuss pregnancy prior to conception to include the effects of pregnancy on diabetes and vice versa, glycaemic targets, and review of medications
- All pregnant individuals with type 1 diabetes should be referred to a clinic with expertise in the management of diabetes in pregnancy if available
- Glycaemic targets are more stringent during pregnancy to avoid adverse pregnancy outcomes. These goals should be discussed and reviewed with the pregnant individual
- Insulin requirements fluctuate significantly during pregnancy, postpartum, and with breastfeeding. Frequent glucose monitoring for dose adjustments is required
- AID systems should be made available prior to, during and after pregnancy but healthcare professionals should be aware that not all AID systems are approved for use in pregnancy

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<H2>Preconception Planning:

Effective pregnancy management begins before conception, as planned pregnancies are associated with better outcomes for both the mother and the child. Glycaemic levels should be optimised before conception, as this reduces the risk of congenital anomalies, miscarriage, and other adverse pregnancy outcomes.[318,319] Ideally, women should achieve a near-normal HbA_{1c}, preferably below 48 mmol/mol (6.5%) at least three months prior to conception, since this lowers the risk of adverse pregnancy outcomes related to hyperglycaemia during embryogenesis.

All medications should be reviewed to remove any medications associated with fetal harm. For example, statin use should be ascertained as statins are commonly taken by people with diabetes but should not be used during pregnancy. Education should be offered about the need for more intensive blood glucose monitoring, insulin adjustments, and the importance of maintaining a balanced diet. Folic acid supplementation (typically 5 mg daily) is strongly recommended before conception and during early pregnancy to reduce the risk of neural tube defects, which is elevated in women with diabetes.

Managing diabetes-related complications prior to pregnancy, such as hypertension, nephropathy, and retinopathy, is essential. Optimizing blood pressure and kidney function, along with comprehensive eye examinations, can help prevent the progression of these conditions during pregnancy. Until optimal glucose levels are achieved and comorbidities are well-managed, effective contraception should be used. The choice of contraceptive method should be both safe and reliable, tailored to the individual's medical history and personal preferences.[320]

<H2>During Pregnancy

When possible, individuals should be referred early to a clinic with expertise in the management of diabetes in pregnancy. Pregnant individuals with type 1 diabetes require more intensive and frequent monitoring than what is typically available in standard diabetes care and so additional multidisciplinary support is essential throughout pregnancy. Diabetes in pregnancy is best managed by a multidisciplinary team, including a diabetologist or endocrinologist, obstetrician, dietitian, diabetes nurse or educator, and diabetes midwife.[320] A detailed discussion of pregnancy management in individuals with type 1 diabetes is beyond the scope of this report and so only a brief description is given here.[320]

Hyperglycaemia during pregnancy increases the risk of complications for both the pregnant individual and the developing fetus, and may also impact long-term child development.[318,319] Therefore, individuals with type 1 diabetes should be supported in achieving optimal glycaemic levels.

CGM use has been approved for use in pregnancy in both the U.S. and Europe, depending on the device. The CONCEPTT trial demonstrated that CGM use during pregnancy was associated with improved outcomes.[321] As such, CGM should be encouraged during pregnancy, with the understanding that BGM remains necessary in situations where CGM accuracy may be compromised. Importantly, CGM target glucose ranges during pregnancy differ from standard recommendations, with time in range defined as 3.5–7.8 mmol/L (63–140 mg/dL) (fig. 4).[144,322] Consequently, CGM reports should be interpreted using these adjusted thresholds, and alarm settings may need to be

modified to alert users earlier to hyperglycaemia while avoiding unnecessary alarms for appropriately lower glucose levels. Where CGM is unavailable capillary BGM targets are shown in Table 4.

Hypoglycaemia remains the primary barrier to optimising glycaemic levels during pregnancy. It is particularly common in the first half of pregnancy, partly due to impaired hypoglycaemia awareness and pregnancy-related nausea and vomiting.[323] Conversely, pregnant individuals with type 1 diabetes are at risk for DKA at lower blood glucose levels than in the nonpregnant state and should receive education on DKA prevention and detection.[324]

AID systems are emerging as standard of care for managing type 1 diabetes during pregnancy. Randomized clinical trials have shown that AID systems can improve glycaemic levels and quality of life during pregnancy.[325-331] However, these studies have not demonstrated significant improvements in fetal outcomes, such as neonatal birth weight, hypoglycaemia rates, or perinatal mortality. Despite this, their use is recommended whenever available, provided there is local expertise to support their implementation and management.[332]

Not all AID systems are approved for use in pregnancy, and approval varies by country. Further research is needed to evaluate the efficacy and safety of the various AID systems currently on the market during pregnancy.

<H2>Postpartum Care

Postpartum care for individuals with type 1 diabetes is a critical aspect of long-term health management and preparation for future pregnancies. Following delivery, hormonal shifts and physiological changes often lead to enhanced insulin sensitivity, resulting in a marked reduction in insulin requirements. During this period, factors such as breastfeeding, irregular sleep, and inconsistent eating patterns can further elevate the risk of hypoglycaemia, making careful insulin dose adjustments essential.[333,334] Close monitoring of glucose levels is vital to prevent hypoglycaemic episodes and maintain stable glycaemic levels.

Breastfeeding is strongly encouraged due to its benefits for both mother and child. However, it can influence insulin needs, often leading to reduced requirements.[333] Individuals should receive guidance on balancing insulin therapy with breastfeeding and the importance of maintaining optimal glycaemic levels to support effective lactation. Continued education on nutrition, and medication taking is essential to support stable glucose levels during the postpartum period.

Finally, this phase offers an opportunity to revisit long-term diabetes management goals and prepare for future pregnancies if desired. Counselling on contraceptive options and timing of subsequent

pregnancies should be provided, emphasizing the importance of preconception care to achieve optimal glycaemic levels prior to conception.

<H1>Section 16: In-hospital management

Key points

- People with type 1 diabetes are at increased risk of developing diabetic ketoacidosis in hospital
- The target glucose ranges of 7.8–10.0 mmol/l (140–180 mg/dl) should be used for most non-critically and critically ill patients. A glucose goal of 5.6-10.0 mmol/L (100-180 mg/dL) may be used in noncritically ill individuals if this can be attained without hypoglycaemia
- Adopting diabetes technology in hospitals may benefit individuals with diabetes by helping overcome the unmet need for better inpatient glycaemic management and alleviating the workload burden of clinical staff. Where feasible, noncritically ill adults with type 1 diabetes should be allowed to use them with appropriate support

It is important that the hospital teams recognise the key differences between type 1 diabetes and type 2 diabetes, because of high risk of diabetic ketoacidosis if insulin is withheld in people with type 1 diabetes.[213] Therefore, inpatients with type 1 diabetes should be clearly identified to avoid common errors, such as omission of mealtime insulin or withholding of basal insulin for procedures or surgery. People with type 1 diabetes, particularly those with concomitant chronic kidney disease, are at higher risk of hypoglycaemia, which should be avoided by careful basal insulin dosing, mealtime insulin bolusing based on carbohydrate matching and correction dosing for hyperglycemia.[220,335]

There have been no large RCTs specifically assessing glycaemic targets for inpatients with type 1 diabetes. Therefore, we recommend following type 2 diabetes guidelines which recommend target glucose ranges of 7.8–10.0 mmol/l (140–180 mg/dl) for the majority of non-critically and critically ill patients.[220] A glucose goal of 5.6-10.0 mmol/L (100-180 mg/dL) may be used in noncritically ill individuals if it can be attained without hypoglycaemia [281], for example in individuals continuing to use their home AID system.[220]

The data on utilisation of diabetes technologies, including CGM and AID, are still limited in the inpatient setting.[336] One of the reasons is lack of formal approval of those devices for inpatient use by the U.S.

FDA.[337] Adopting diabetes technology in hospitals may potentially benefit individuals with diabetes by helping overcome the unmet need for better inpatient glycaemic management while alleviating the workload burden of clinical staff.[336] Reports supporting CGM effectiveness and safety in noncritically ill inpatients is growing, including those on people on haemodialysis, and after abdominal surgery and solid organ transplantation.[338-344] Hospital-wide CGM policies with the electronic health record integration have been used successfully, with good satisfaction with nurses and adults with diabetes.[345] The evidence concerning effective usage of AID systems in hospitalized individuals, however, is quite limited.[346] Although randomized trials are lacking, the benefits of AID utilisation in hospitalized individuals with type 1 diabetes may include improved glycaemic outcomes, reduce staff workload, and increased patient satisfaction.[337] In contrast, the use of AID in people hospitalized for intercurrent illness and/or receiving drugs (e.g., steroids) that significantly impair glucose homeostasis and in people who lose their capacity in managing AID should be withheld unless appropriate staff to manage AID are available.

Noncritically ill adults with type 1 diabetes using diabetes devices (CGM, insulin pumps, AID systems) should be allowed to use them during outpatient procedures or in inpatient settings when proper supervision is available and the patient/caregiver has clear mentation, previous training and education and is capable of managing the device(s).[347-349] Institutions should have clear guidelines and protocols to manage inpatient type 1 diabetes safely, including allowing selected adults who can monitor their glucose and self-administer insulin safely.

Whenever a dedicated inpatient diabetes service is available, they should be consulted for glycaemic management, DSMES and discharge planning.[220]

<H1>Section 17: Conclusion

The original 2021 EASD-ADA consensus report significantly influenced the clinical management of type 1 diabetes in adults, becoming a landmark reference for healthcare professionals and informing national and international diabetes policy.[4,5] It raised awareness of adult-onset type 1 diabetes, endorsed individualised glycaemic targets, and promoted the adoption of CGM and time-in-range metrics. Importantly, it underscored the emotional burden of living with diabetes and the need to embed psychosocial care into routine clinical practice.

This updated report reflects the continued evolution of type 1 diabetes management, incorporating advances in diagnosis, therapy, and technology. Yet, the writing group acknowledges persistent and substantial evidence gaps across prevention, diagnosis, and treatment. People with type 1 diabetes

deserve high-quality research to guide their care. We also recognise the ongoing disparities in access to treatment and advocate strongly for equitable, person-centred services to ensure that all individuals with type 1 diabetes receive the care they need and deserve.

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Appendix 1: General principles to maintain safe glucose levels during and after exercise[76,78]

- Target glucose levels should be between 7-10 mmol/l (126–180 mg/dl) during exercise.
- Consider increasing this range for individuals at increased risk of hypoglycaemia and/or with impaired hypoglycaemia awareness.
- Do not exercise if hyperglycaemic and ketones are >1.5 mmol/lor if there is moderate ketonuria
- Treat hypoglycaemia before and during exercise

- Take regular carbohydrate during exercise
    - 1.0–1.5 g/kg body weight per h of intense physical activity during the peak action of an insulin bolus that has not been reduced
    - 0.2–0.5 g/kg body weight per h of intense physical activity during the peak action of an insulin bolus that has been reduced or that was administered more than 2 h before starting physical activity
- Have the last meal and insulin dose 2-3 h prior to exercise
- For those using multiple daily injections:
    - Reduce the insulin dose of a rapid-acting insulin analogue if administered within 2-3 h of the physical activity and the planned activity is longer than 30 minutes.
    - The bolus reduction ranges from 25–75% and depends on the timing and intensity of the physical activity.
    - Reduce the meal bolus at the next meal by up to 50%
    - A reduction of NPH or long-acting analogue basal insulin should be considered during multi-hour or all-day endurance effort or if exercising in the late afternoon or evening
    - A reduction in the dose of ultra-long-acting insulin analogues should be considered before multi-day activities.
- For those using insulin pumps without automation or cannot adjust any settings within the system:
    - Reduce the basal insulin rate 2-h before the start of physical activity if the planned activity is longer than 30 minutes.
    - The bolus reduction should be made ranges from 20–80% and depends on the timing and intensity of the physical activity.
    - If the insulin pump is detached during physical activity, the pump's operation should be suspended.
    - A reduction in basal rate should be considered after exercising in the late afternoon or evening
- For those using most automated insulin delivery systems
    - Advice depends on the type of device used and should be individualized.
    - Where possible, plan for physical activity when insulin on board is low, such as before meals or in the fasted state
    - For planned physical activity, set a higher glucose target 1–2 h before activity if a decrease in glucose or stable glucose is expected during the activity (aerobic activity) or maintain a regular (or lower) glucose target if a glucose increase is expected (anaerobic exercise)

- If physical activity occurs within 2 h of a carbohydrate-rich meal, reduce the prandial bolus insulin dose by 25–33% if a decrease in glucose is expected during the activity
- For unplanned physical activity, set a higher glucose target immediately at the onset of activity if a decrease in glucose or stable glucose is expected and consume 10–20 g of fast-acting carbohydrate if sensor glucose is <7.0 mmol/l (126 mg/dL)
- If the glucose level is below target at the onset of exercise, consume carbohydrate 5–10 minutes prior to the physical activity. These amounts will usually be smaller when an AID system is being used
- Carbohydrate loading in advance of activity (earlier than 20 min) may result in a rise in glucose and trigger an AID-increase in basal rate or auto-correct bolus dose that may increase the risk of hypoglycaemia during or immediately after the activity.

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2954 **Appendix 2: Selection of validated psychosocial measures for use in people with type 1 diabetes***

Measure Category	Measure	Number of Items	Links
Depression & Depressive Symptoms	Patient Health Questionnaire 9 (PHQ-9)	9	professional.diabetes.org/sites/default/files/media/ada_mental_health_toolkit_questionnaires.pdf
	Patient Health Questionnaire 2 (PHQ-2)	2	https://cde.nida.nih.gov/instrument/fc216f70-be8e-ac44-e040-bb89ad433387
	Center for Epidemiologic Studies-Depression (CES-D)	20	https://nida.nih.gov/sites/default/files/Mental_HealthV.pdf
	Geriatric Depression Scale	15	https://integrationacademy.ahrq.gov/sites/default/files/2020-07/Update_Geriatric_Depression_Scale-15.pdf
Emotional Well-Being	World Health Organization Wellbeing Index (WHO-5)	5	https://www.who.int/publications/m/item/WHO-UCN-MSD-MHE-2024.01
Anxiety	Generalized Anxiety Disorder Seven (GAD-7)	7	professional.diabetes.org/sites/default/files/media/ada_mental_health_toolkit_questionnaires.pdf
Diabetes Distress	Diabetes Distress Scale (T1-DDAS)	28	https://diabetesdistress.org/
	Diabetes Distress Scale (T1-DDAS) Short Form	7	https://diabetesdistress.org/dd-assess-score-1/
	Diabetes Distress Scale	2	https://diabetesdistress.org/dd-assess-score-1/
	Problem Areas in Diabetes (PAID)	20	professional.diabetes.org/sites/default/files/media/ada_mental_health_toolkit_questionnaires.pdf
	Problem Areas in Diabetes (PAID) Short Form	5 or 1	https://www.vumc.com/departments/diabetes-psychology.htm
	Well-being Questionnaire (W-BQ)	12	https://healthpsychologyresearch.com/guidelines/w-bq12-well-being-questionnaire
Hypoglycemia Fear	Hypoglycemia Fear Survey-II (HFS-II W)	33	professional.diabetes.org/sites/default/files/media/ada_mental_health_toolkit_questionnaires.pdf
	Subscale within T1-DDAS	2	https://diabetesdistress.org/dd-assess-score-1/
Disordered Eating	Diabetes Eating Problems Survey-Revised (DEPS-R)	16	https://insideoutinstitute.org.au/assets/deps-r.pdf
Cognition	Montreal Cognitive Assessment (MoCA)	30	https://mocacognition.com/the-moca-test/
	Mini-Cog	3 and clock drawing	https://mini-cog.com/
	Mini-Mental State Examination	11	https://eclass.upatras.gr/modules/document/file.php/SLT184/mmse.pdf
	Functional Activities Questionnaire	10	https://www.healthcare.uiowa.edu/familymedicine/fpinfo/docs/functional-activities-assessment-tool.pdf
Social Determinants of Health (Social Drivers of Health	PRAPARE: Protocol for Responding to and Assessing Patients' Assets, Risks and Experiences	21	https://prapare.org/the-prapare-screening-tool/

& Health-Related Social Needs			
	Centers for Medicare and Medicaid Services (CMS; USA)	5 domains	Required domains are food insecurity, interpersonal safety, housing insecurity, transportation insecurity, and utilities.
	World Health Organization (WHO)	5 domains	https://www.who.int/health-topics/social-determinants-of-health#tab=tab_1

* Most of the tools listed here are freely available for clinical use. Clinicians are advised to check for licenses and validated linguistic versions. MAPI Trust offers an overview of diabetes specific measures. https://eprovide.mapi-trust.org/advanced-search?search=type%201%20diabetes