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Glycemic control targets and glucose monitoring for children and adolescents with type 1 diabetes

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What’s New?
- Emphasis on individualizing targets
- Target of <7.0% for children in certain groups
- Increase in CGM use/utility
- Discussion of intermittent CGM technology

Executive Summary and Recommendations:
Glycemic control of children and adolescents with type 1 diabetes must be assessed by both quarterly HbA1c and regular home glucose assessments to enable achieving optimal individual health by:

- determining with accuracy and precision the degree of glycemic control achieved by individuals (A),
- reducing the risks of acute and chronic disease complications (A), and
- minimizing effects of hypoglycemia (A) and hyperglycemia (B) on brain development, cognitive function, mood and
- optimizing quality of life

These assessments also enable evaluating:

- each individual’s glycemic determinants,
- health care center care, and
- compliance with stated standards to improve therapies and delivery of pediatric diabetes care (B).

Recommendations:
- For children, adolescents and young adults <25 years we recommend individualized targets, aiming for the lowest achievable HbA1c without undue exposure to severe hypoglycaemia balanced with quality of life and burden of care (E).
- For children, adolescents and young adults <25 years who have access to comprehensive care a target of HbA1c of 53 mmol/mol (7.0%) is recommended (E).
  - A higher HbA1c goal (in most cases <58 mmol/mol (7.5%)) is appropriate in the following contexts:
    - inability to articulate hypoglycemia
    - hypoglycemia unawareness/history of severe hypoglycemia
- lack of access to analog insulins, advanced insulin delivery technology, ability to regularly check blood glucose, and CGM (E), and
- individuals who are high glycators, in whom this A1c would reflect a significantly lower mean glucose than 8.6 mmol/l (155 mg/dl)
  - A lower goal may be appropriate if achieved without excessive hypoglycemia, impairment of quality of life, and undue burden of care (E).
  - A lower goal may be appropriate during the honeymoon phase of T1D (E).
  - For patients who have elevated HbA1c, a step-wise approach to achieve better glycemic control is advised including individualized attention to:
    - personal factors limiting achievement of the target (E).
    - assessment of psychological effect of goal setting on the individual
    - incorporating available technology to improve glucose monitoring and insulin delivery modalities

- HbA1c measurement should be available in all centers caring for persons with diabetes (B).
  - HbA1c measurements should be performed at least four times per year (B).

- Regular self-monitoring of glucose (SMG) (using accurate finger stick blood glucose measures, with or without continuous glucose monitoring (CGM) or intermittently viewed CGM (iCGM) using flash technology) is essential for diabetes management for all children and adolescents with diabetes (A).
  - SMG must be accessible for the testing frequency needed to optimize each child's care (B/C).
  - All diabetes centers should urge nations, states, and health care to ensure that children and adolescents with diabetes have adequate glucose monitoring supplies (E).
  - When finger stick BG are used, testing may need to be performed 6-10 times per day for intensive control (B).
  - Real-time CGM data particularly benefit children who cannot articulate signs of hypo- or hyperglycemia and those with hypoglycemic unawareness (A).
  - iCGM can complement finger stick blood glucose assessments. Although iCGM provides some similar benefits to CGM it does not alert users to hypo- or hyperglycemia in real time, nor does it currently permit calibration. Without robust pediatric use efficacy data, it cannot fully replace other monitoring.
**General principles determining glycemic targets**

Hemoglobin A1c (HbA1c) reflects mean BG over the prior three to four months and is currently the only long-term glycemic control measure with robust outcome data. Multiple studies in diverse populations have shown that elevated HbA1c values are associated with diabetes chronic complications. Intensive management, resulting in better glycemic control and lower HbA1c concentrations, is associated with fewer and delayed microvascular and macrovascular chronic complications (1-5), see chapter XXX (ref to complications chapter). Additionally, better control earlier in the time course of the disease is associated with better outcomes (6, 7). Follow-up data from the DCCT indicate that 5 – 7 years of improved glycemic control, including during adolescence and young adulthood, decreased the risk for microvascular and macrovascular complications (8-11) and mortality (12) in subsequent years.

Chronic hyperglycemia has adverse effects on neurocognitive function and development for children with diabetes (13-17). Hypoglycemia is also a significant risk for children and adolescents with diabetes. (For a comprehensive review of effects of hypoglycemia, see Chapter 12, Hypoglycemia [add ref]). Severe hypoglycemia, particularly in young children, is associated with adverse neurocognitive effects (18). Historically, lower HbA1c values were associated with greater acute episodes of severe hypoglycemia (1, 2), but more recent observational studies in the era of multiple daily injections, pumps, and more intensive glucose monitoring suggest this is not as significant a risk (19-25). Importantly, recent data suggest that lowering A1c targets is associated with a decreased mean HbA1c on a population and individual level, but that this decrease is not associated with increased frequency of severe hypoglycemia, even in children who achieve A1cs <7.0%(26) [add Swedish ref].

HbA1c measurements are useful both for assessing long-term complications risk and as a real-time tool for optimizing glycemic control. HbA1c is routinely integrated clinically into decision making about medical regimens, together with data on documented hypo- and hyperglycemia and other person-specific variables such as age, caregiver knowledge, carbohydrate intake, illness/stress, and exercise patterns. Overall, certainly, prolonged periods of significant hyperglycemia and episodes of diabetic ketoacidosis (DKA) should be avoided (16, 27, 28).

Although HbA1c remains the best measure of long-term glycemia within and between
populations, several studies have shown that HbA1c has significant limitations when used in isolation to assess an individual’s glycemic control. Although for a population, mean glucose is highly correlated to HbA1c (29), when examining individual-level data there are often significant differences between measured glucose values (whether by fingerstick BG or CGM) and observed HbA1c values (30). Sometimes these differences are due to conditions that alter the life span of red blood cells or changes hemoglobin glycosylation, such as sickle cell disease. Racial and ethnic differences in hemoglobin glycosylation are also present (31). In a recent report that identified individuals as “black” and “white” from the US based upon self-report, blacks had mean HbA1c values 4.4 mmol/mol (0.4%) higher than whites for the same mean glucose concentration determined using CGM (30).

Additionally, several studies have now shown significant differences between HbA1c and observed self-monitored glucose (SMG) values between individuals without obvious medical or racial biologic differences (32, 33). Data comparing 13 weeks of Dexcom G4 Platinum CGM measurements with HbA1c measured using nonporous ion exchange high-performance chromatography show wide ranges of HbA1c for the same mean glucose concentration. As an example, for a HbA1c of 64 mmol/mol (8.0%) the 95% confidence interval for mean glucose ranged from 8.6 mmol/l (155 mg/dl) to 12.1 mmol/l (218 mg/dl)((32)). These data suggest estimating average glucose concentrations for individuals from measured HbA1c values should be done cautiously.

It is not yet known whether, for an individual, the HbA1c or overall glycemic exposure is a better marker for risk of complications. Moreover, for people with an HbA1c at or near 53 mmol/l (7%) who have a mean glucose in the lower range of normal consideration should be given to additional glucose metrics such as measures of hypoglycemia.

**Monitoring of glycemic control**

Home self-monitoring of glucose:

- tracks immediate and daily levels of glucose control (34-37);
- helps to determine immediate and ongoing basal and bolus insulin requirements;
- detects hypoglycemia and assists in its management;
- assists in the appropriate management of hyperglycemia; and
Finger stick blood glucose measurements

Greater fingerstick glucose monitoring frequency is associated with lower HbA1c in persons with type 1 diabetes (23, 34-37). HbA1c improvements with more frequent and robust glucose measurements are due to both better insulin dosing for carbohydrate consumed and an improved ability to quickly correct out-of-target glucose values. In addition, early detection of lower glucose values prior to symptomatic hypoglycemia permits correction with a decreased risk of overcorrection and resultant hyperglycemia. SMG around exercise also allows improved insulin management and a decreased risk for hypoglycemia during and following exercise (38).

Equipment. There are many types of monitors; however, significant inaccuracy may arise from operator-related errors (39, 40). Health care professionals should choose and advise on types that are robust, precise, accurate, and familiar to them as well as affordable to the person with diabetes. Devices that do not require calibration/coding may be easier to use. Low quality devices, offered sometimes to reduce cost, may compromise safety. High industry standards, including accuracy, precision and ability to download and analyze data should be upheld by the regulatory agencies. Industry standards state that 95% of readings should be within ±15% of the reference value (41). ISPAD recommends routine use of glucose monitors achieving this standard.

Timing of SMG.

BG is best measured:

- during the day, prior to meals and snacks;
- at other times (e.g. 2-3h after food intake) to help determine meal insulin doses and show levels of BG in response to the action profiles of insulin (at anticipated peaks and troughs of insulin action);
- in association with vigorous exercise (prior to, during and several hours after) so that changes may be made in glycemic management (38, 42);
- at bedtime, during the night and on awakening to detect and prevent nocturnal hypoglycemia and hyperglycemia as well as optimize basal insulin;
- prior to driving a car or operating similar machinery;
• to confirm hypoglycemia and to monitor recovery;
• during intercurrent illness to prevent hyperglycemic crises; and

The number and regularity of finger stick blood glucose measurements should be individualized depending on:
• availability of equipment;
• type of insulin regimen; and
• ability of the child to identify hypoglycemia;

Note: successful intensive diabetes management requires SMG at least six to ten times a day and regular, frequent review of the results to identify patterns requiring adjustment to the diabetes treatment plan (37, 43). This includes review by the person with diabetes and their families in addition to consultation with the diabetes care team.

Glucose targets throughout the day should correspond with individualized HbA1c target. The American Diabetes Association guidelines suggest achieving a goal of 58 mmol/mol (7.5%) requires the following targets (44):

- Pre-meal glucose 5.0-7.2 mmol/l (90-130 mg/dl)
- Pre-bed glucose 5.0-8.3 mmol/L (90-150 mg/dl)

NICE targets to achieve a goal of 48 mmol/mol (6.5%) are 4.0-7.0 mmol/L (70-126 mg/dl) fasting, pre-meals, and other times (e.g. pre-bed, overnight), and 5.0-9.0 mmol/L (90-162 mg/dl) post-meals (45).

Continuous glucose monitoring (CGM) (See also Technology Chapter)

CGM uses minimally invasive devices that measure subcutaneous interstitial fluid glucose every 1 – 5 minutes, i.e., ‘continuously’. All devices permit blood glucose targets to be set so that an alarm will alert the wearer to a glucose value projected to fall below or be above the target in 10 – 30 min, based on the rate of change of the interstitial glucose (46, 47). Newer devices have a mean average relative difference (MARD) of <10%, and therefore a similar accuracy to that of capillary BG meters (48).

CGM presents a much more sophisticated approach than home fingerstick BG monitoring as
it can also identify times of consistent hyperglycemia and times of increased risk for hypoglycemia. Days with outlier glucose values can also be more readily identified. CGM may particularly benefit those with hypoglycemic unawareness, as the devices will alarm when glucose is below a specified range or with rapid rate of fall of glucose (49, 50). With short-term use of sensors, mean glucose values decrease, and time spent in a hypoglycemic range also decreases (51, 52). Use of CGM has been associated with lower HbA1c compared to fingerstick BG measurements alone, with greater improvements with increasing CGM device wear (46, 53, 54).

CGM can be used in “blinded” or “real time” modes. Blinded CGM provides retrospective data and is generally only useful for clinical research or for insulin adjustment by a health care provider (55). Real-time CGM use with immediate corrections to keep glucoses in range has been shown to more effectively improve glycemic control than ‘blinded’ collection of data analyzed by a health provider at a later time (56). Appropriately calibrated CGM devices and an iCGM device are now approved for real-time non-adjunctive (replacement of finger stick monitoring) use in some settings, although some CGM values must still be confirmed by standard fingerstick (57). However, periodic downloads allow the person with diabetes and/or their caregiver and health care provider to review a larger amount of data and make more comprehensive adjustments. The review of the CGM data is a very helpful teaching tool for the effects of food, insulin timing, and exercise on glucose levels. The intermittent, delayed readout, often using blinded modes, has been helpful as a diagnostic tool and for management of hyperglycemia in special groups, e.g., those with pre-type 1 diabetes (58), monogenic diabetes (59) or CFRD (60, 61). Information gained from CGM studies has provided information to inform recommendations for insulin management for all individuals with diabetes including those not using continuous sensing devices (62, 63).

Current limitations of real-time CGM include economic and behavioral barriers and the still imperfect accuracy and difficulty with wear ability of some sensors that may discourage routine use. Currently, these devices, while approved for pediatric use, are expensive and may not be available in many countries. Insurance coverage may be limited. Over time, these devices will continue to become more widely available with better coverage by both national and private insurance.
While real-time CGM is beneficial in both persons using multiple daily injections and insulin pumps, the latter combination is generally more effective (64), particularly when the CGM is integrated into a sensor-augmented pump (65). Early studies of longer-term CGM use (6 months) found that, despite benefiting from similar reduction in HbA1c, children and adolescents may not be willing to wear a device as often, or for as prolonged a period of time as needed to consistently improve glucose metabolism (66). Not surprisingly, the frequency of sensor use predicts the HbA1c lowering effect of the sensor (54, 67). These results indicate additional work is needed to develop technology that is less intrusive in teenagers’ lives and to identify ways to help adolescents adapt to healthcare tasks required to maintain optimal near-normal glucose levels. Early experience, with sensors of less than perfect accuracy, devices that were not easy to wear, and high costs, may have discouraged some users from long-term use (68, 69); this appears to now be changing due to rapid improvement in sensor technology and user re-training(70). With more widespread use of real-time CGM, decreased BG targets can be safely achieved, improving outlook for children with diabetes. (Note: see Chapter 22 for additional discussion of Diabetes Technology.)

Other glycemic metrics that can be assessed include % of time in various target glucose ranges, mean glucose, measures of hypoglycemia and glucose variability. It is possible that time in target may represent the future metric that is used as an overall goal for glycemic control. Glucose variability may also contribute to the risk for complications independently of HbA1c (71-73). Standardized metrics for analysis and reporting of these data have been proposed including an ambulatory glucose profile (AGP) showing data as a modal day (72). Few data are yet available as to how these metrics relate to long term outcomes for persons with diabetes, particularly for children.

**Intermittently-viewed CGM**

In many settings real-time CGM may not be used or available for children. Intermittently-viewed CGM (iCGM) is another way to assess glucose that has been used successfully in children (74). Current systems provide for sensor wear for up to 14 days and require no user calibration.

iCGM has similarities with CGM but is a simpler and more economical technology(72). Currently commercially available iCGM technology has two versions, a personal and a
professional format. The former uses a sensor inserted in the back of the forearm and a separated touchscreen reader device. When the reader device is swiped close to the sensor, the sensor transmits both an instantaneous interstitial glucose level and the eight-hour graph. The system is denominated “flash” technology because the reader must be swiped (“flashed”) over the sensor. The sensor should be changed every 14 days and does not need calibration.

Once the reader is swiped closed to the sensor, information of the real-time interstitial glucose level, trends of the last 15 minutes and a graph of the prior eight hours of data is given on the display. However, if the system is not flashed (swiped) for more than eight hours, the information about that period is lost, and no data can be obtained. Ambulatory glucose profile for the last ninety days is stored in the reader and can be easily downloaded. When analyzed in real-time or retrospectively, the data generated by the iCGM system is like that of real-time CGM. The main differences are that the flash technology does not provide high- or low-glucose alarms, permit calibration, or control insulin infusion rates when used with a pump.

The “professional” format uses the same sensor technology like the personal version. Interstitial blood glucose is recorded every 15 minutes for 14 days. The data are blinded from the user. A health professional needs to wave the reader over the sensor to retrieve the information for download. The professional format is used to aid in understanding disparities in HbA1c levels and blood glucose assessments and for retrospective assessment of glycemic control.

The system has acceptable accuracy compared with capillary (75-78) measurements, which has led to approval of both versions in more than 30 countries (79). These agencies have accepted the use of iCGM as an aid for deciding insulin dose, except in the following situations: rapid changes of glucose levels, symptoms of hypoglycemia or the reader shows a low glucose level, symptoms do not match the system reading or previous to driving (80). Emerging data suggest that use of iCGM can reduce time spent in hypoglycemia in adults with well-controlled T1D (76).

Technological advances in CSII and CGM have led to the development of pumps that adjust insulin delivery based on ambient CGM glucose using computerized algorithms. These are important steps toward “closing the loop” and an eventual true artificial pancreas system. Such devices reduce the risk of severe and moderate hypoglycemia, particularly overnight and hold promise to reduce the burden of care and improve glucose control (50, 81). Further details are available in the Chapter Diabetes Technologies [ref].
Record Keeping

- It is common practice for a monitoring diary, logbook, spreadsheet, smart meter, app, or cloud-based program to be used to record patterns of glycemic control, insulin and carbohydrate doses and adjustments to treatment. This glucose information along with insulin doses should be reviewed by person with diabetes and families regularly (82, 83).
- The record book or data from the electronic device/cloud is useful at the time of consultation and should contain time and date of
  - glucose levels;
  - carbohydrate intake
  - insulin dosage;
  - note of special events affecting glycemic control (e.g., illness, exercise, menses, alcohol intake, etc.);
  - hypoglycemic episodes, description of severity, and potential alterations in the usual routine to help explain the cause for the event; and
  - episodes of hyperglycemia, ketonuria/ketonemia
- Glucose monitoring records should not be used judgmentally but as a vehicle for discussing the causes of variability and strategies for improving glycemic control (E).
- Frequent home review of records to identify glycemic patterns and guide subsequent medical diabetes management is required for successful intensified diabetes management (E).

Hemoglobin A1c (HbA1c)

Glycated hemoglobin

- Glucose is irreversibly attached to hemoglobin while the red blood cells circulate (with a life span of approximately 120 days) forming glycated hemoglobin (HbA1 or HbA1c).
- HbA1c reflects glycemia over the preceding 4 – 12 weeks, weighted toward the most recent 4 weeks. However, the most recent week is not included because the most recent glycation is reversible (84).

The HbA1c assay provides an objective, long-term measure of glycemia and revolutionized diabetes management. There is a strong correlation between HbA1c and BG (29). The
International Federation of Clinical Chemistry (IFCC) has developed a reference method that precisely measures glycated HbA1c only (85, 86). The reference measurement procedure has been defined as bN1-deoxyfructosyl-hemoglobin, and the recommended SI measurement units are mmol/mol (87). IFFC/ADA/EASD/IDF has issued a consensus statement regarding this standardization process (87). A calculator for conversion between the DCCT/NGSP % units and the IFCC/SI mmol/mol units can be found at http://www.ngsp.org/convert1.asp

*Equipment and facilities.*
- Facilities for the measurement of HbA1c should be available to all centers caring for young people with diabetes.
- Every child should have a minimum of four measurements per year (88, 89).
- Capillary blood collection is preferable. It is also preferable that the HbA1c result is available at the time of the medical visit so that immediate adjustments in management can be based on the HbA1c level.
- A normal reference range for non-diabetic children should be available.
- There should be regular quality control comparisons with national and DCCT or IFCC standards. It is recommended that scientific papers provide HbA1c in both DCCT/NGSP and IFCC/SI numbers.

*Fructosamine and other glycated products.*
Fructosamine measures the glycation of serum proteins such as albumin and reflects glycemia over the preceding 3 – 4 weeks. It is therefore used for the assessment of shorter periods of control than HbA1c. Fructosamine or glycated albumin may be useful in monitoring glucose control over time in individuals with abnormal red cell survival time. Fructosamine and other glycated products have been recently evaluated in terms predicting development of vascular complications. In DCCT/EDIC, glycated albumin and HbA1c had similar associations with retinopathy and nephropathy, which were strengthened when both measures were considered together. Only HbA1c was significantly associated with development of cardiovascular disease (90). In the Atherosclerosis Risk in Communities (ARIC) study that included adults with type 1 and 2 diabetes, fructosamine and glycated albumin were associated with microvascular complications, with prognostic value comparable to HbA1c (91).
HbA1c targets.

Goals for children, adolescent, and young adults with type 1 diabetes should be individualized. A target of 53 mmol/mol (<7.0%) is recommended for persons who have access to analog insulins, advanced insulin delivery technology, and an ability to regularly check blood glucose (including potential use of CGM). Higher A1c goals (for most persons 58 mmol/mol (<7.5%) are appropriate in the following contexts: inability to articulate hypoglycemia, hypoglycemia awareness, history of severe hypoglycemia, and more resource-limited environments.

This value is chosen with the aim of avoiding long-term microvascular and macrovascular complications of diabetes while also avoiding severe hypoglycemia and the CNS changes associated with both hypoglycemia and hyperglycemia. Evidence from the DCCT is available for adolescents, and recommendations for younger children are derived using these data and expert opinion. It is important here to note that the intensively treated adolescent cohort of the DCCT achieved a mean HbA1c of 65 mmol/mol (8.1%), while subjects in the corresponding adult cohort achieved a mean HbA1c of 54 mmol/mol (7.1%) (1). Subjects in the follow-up observational study, Epidemiology of Diabetes Interventions and Complications (EDIC), maintained an average HbA1c of 62-66 mmol/mol (7.8 – 8.2%) regardless of DCCT randomization, during 30 years of follow-up (92).

This target is intended as an aspirational goal, with recognition that vast majority of children and adolescents currently do not meet it. For instance, in the U.S., based on 2015 T1D Exchange clinic registry data only 22-23% of children under 12; 17% of children 13-17 years of age with type 1 diabetes cared for by endocrinologists met the prior target of 58 mmol/mol (<7.5%) target (70). Recent data from young adults in Norway also show peak HbA1cs of 9.3% (78 mol/mol) for girls at age 17 and 9.1% (76 mmol/mol) at age 19 in males (93).

Aspirational goals are important, as adolescents who target lower goals tend to have lower HbA1cs (94, 95). Similarly, several registries and individual clinics report reduction in mean HbA1c over time highlighting the importance of benchmarking, quality improvement, and a team approach to improving glucose control(23). The most recent mean HbA1c is 7.8% (62 mmol/mol) in the well-educated EDIC adult cohort that has excellent access to the newest diabetes technology and a mean age of 45±7 years (92, 96). Acute and chronic complication
rates are also decreasing with improvements in care (25, 97).

Of all age-groups, adolescents are currently the farthest from achieving a HbA1c goal of <7.0% (6, 70), reflecting the sub-optimal diabetes management that frequently accompanies the increased independence in diabetes care during the adolescent years, as well as the effects of the psychological and hormonal milieu of adolescence. However, given that results from DCCT/EDIC document that poor control for 5 – 7 years, which is similar to the duration of puberty, may have prolonged adverse effects (8, 10, 98, 99) caregivers should not be complacent with the care of these youth, but work to improve glycemic control as much as possible. While better insulins, glucose monitoring, and insulin delivery decides are available today, compared with the DCCT era, adolescents in general may still be unable to achieve a lower HbA1c levels than the DCCT adolescent average without novel approaches to care in this age-group. Sometimes, particularly for adolescents, “aiming for better” is needed rather than optimal to reduce burnout and loss-to-follow up with caregivers. Too ambitious goals may lead to an unwarranted sense of failure and alienation for many teens. Striking a balance between the increasing autonomy of the adolescent, successful transition of care from parents to child, maintaining a healthy psychological outlook [ref Psychology chapter] and maintaining an optimal HbA1c are the main challenges of caring for the adolescent [Adolescent chapter].

The aspirational HbA1c goal of <53 mmol/mol (<7%) is most appropriate in resource-intensive settings where access to analog insulins, advanced insulin delivery systems, and state-of-the-art glucose monitoring technology are available. Goals even lower than 53 mmol/mol (7.0%) may also be appropriate for those children with significant residual beta cell function who achieve an HbA1c within the non-diabetic reference range at some time in the first year after clinical diagnosis (during the partial remission or “honeymoon” phase), generally between 1 and 6 months after diagnosis.

Other organizations (such as the National Institute for Health and Care Excellence and the Swedish National guidelines) have recommended uniformly lower goals for children and adolescents with type 1 diabetes (45, 100). However, these guidelines admit that there is “no evidence” for this decrease (45). We do not know that these lower goals can be achieved safely, or that they do not result in significant reductions in quality of life and in increased stress/distress. It is also still not yet known precisely how a HbA1c of 48 mmol/l (6.5%) compared to 53 mmol/l (7%) particularly in the years prior to puberty will be associated with
subsequent reductions in micro- or macro-vascular disease as data on the relationship of A1c in the pre-pubertal years to future vascular complications are mixed (101, 102).

Careful attention must be taken to avoid severe hypoglycemia. Although older studies suggested an increased risk for hypoglycemia with HbA1c decreases (1, 2, 103, 104), in recent years this has not been the case, in part due to increased use of insulin analogs, CSII, and pump technologies (19, 21, 22, 26, 70, 105, 106). Because severe hypoglycemia is more common when hypoglycemia unawareness is present, HbA1c targets must be increased when hypoglycemia unawareness occurs. CGM devices, especially when coupled with low glucose suspend, may also particularly benefit those with hypoglycemic unawareness, as the devices will alarm when glucose is below a specified range or with rapid rate of fall of glucose (49, 50, 107). Hypoglycemia unawareness is more common in those who maintain generally lower BG levels (108, 109).

**Health care priorities and future directions:**
Care providers and persons with type 1 diabetes should be aware that achieving an HbA1c consistently at or below the target range without extensive personal and national health care resources and outside of a clinical trial structure may be very difficult. Additional work in quality improvement with deanonymized center- and region-specific data is needed given the observed differences in HbA1c and other metrics across centers and countries, with attention to best practices in care (110-112). (Reference EDUCATION Chapter)

Each child should have their targets individually determined with the goal of achieving a value as close to normal as possible while avoiding severe hypoglycemia as well as frequent mild to moderate hypoglycemia and optimizing quality of life. As diabetes technology improves, especially CGM, recommended target indicators for glycemic control will likely decrease to reflect a new balance of benefits and risks.
Reference List

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