

# The Role of the Diabetes Care and Education Specialist in Pediatric Diabetes Regardless of Etiology

Using projection studies based on the SEARCH for Diabetes in Youth study (SEARCH) and the US Census Bureau population demographic projections, Imperatore et al projected the incidence of youth with type 1 diabetes (T1D) will triple by 2050 to 203,382 persons and youth with type 2 diabetes (T2D) will quadruple to 84,131 persons with diabetes (PWD). Diabetes is one of the most common and costly chronic conditions in the pediatric population.<sup>1</sup> Diabetes care and education specialists (DCES) play a vital role in the education process for children and families with all types of diabetes, including but not limited to T1D, T2D, maturity-onset diabetes of youth (MODY), and secondary diabetes related to cystic fibrosis, steroid utilization, and pancreatectomy. DCES must understand the unique requirements of working with children with diabetes and their parents/caregivers. Even though the mechanisms for developing the diseases are similar within each diagnosis category, the educational approach differs based on the child's developmental stages, family dynamics, and health literacy levels.

This paper independently addresses each form of diabetes rather than approaching them as one disease. Some educational strategies may be the same, but these are different diseases with the common manifestation of elevation in glucose levels. At times, differentiating between T1D and T2D in children may be challenging.<sup>2</sup> The requirements and diligence needed to care for the condition will vary considerably from one form to another.

## Type 1 Diabetes

The incidence of T1D has been steadily rising. The Centers for Disease Control and Prevention (CDC) data revealed a 1.9% annual increase in the incidence of diabetes from 2002 to 2016 with the greatest increase in Hispanics, Pacific Islanders, and

non-Hispanic Blacks.<sup>3</sup> Over 50% of youth are hospitalized at diabetes onset and approximately 30% of newly diagnosed children present in diabetes-related ketoacidosis (DKA).<sup>4</sup> The prevalence of DKA at T1D diagnosis has increased over the past 3 years (41.4%, 51.9%, and 57.7%,  $p = 0.003$ ) during the COVID-19 pandemic.<sup>5</sup> Assessing pancreatic autoantibodies and C-peptide values allows the health care team to help diagnose T1D versus T2D. However, there is a potential for false-positive and false-negative results.<sup>5</sup> Few environmental risk factors have been identified in T1D with genetics playing the major role.<sup>6</sup>

Type 1 diabetes requires vigilance to keep BG and/or interstitial glucose levels within a safe and healthy range. While multiple options for prediction equations are available, T1D glucose values are not always predictable and result in frequent episodes of glucose variability requiring on-the-go insulin adjustments. This balancing act can result in frustration for all involved in diabetes care and adds additional burden to T1D management rarely seen in any other medical condition.

Based on data from the T1D exchange registry collected from 2016 to 2018,<sup>7</sup> managing diabetes in children and adolescents has proven challenging with less than 17% of this age group achieving an A1C of  $<7.5\%$ . Of note, as of 2018, the International Society for Pediatric and Adolescent Diabetes (ISPAD) recommends an A1C target of  $<7\%$  for children and youth aged  $>5$  years with a target of  $<6.5\%$  deemed optimal.<sup>8</sup>

## Treatment

One key factor in treating children diagnosed with T1D is their need for exogenous insulin at the onset. However, matching insulin to activity, food intake, growth, illness, and stress, varies throughout the PWD's lifetime, requiring frequent adjustments.

Even with careful glucose monitoring and fine-tuning of insulin doses, there remains a considerable amount of glucose variability with risks of both hyperglycemia and hypoglycemia. Celiac disease occurs in approximately 1.4% to 24.5% of children with T1D with a wide range in different population groups.<sup>9</sup> If a child with T1D is also diagnosed with celiac disease, it can further impact glucose variability and must also be considered in the treatment strategy.

### The Initial Diagnosis

Approximately 30% of individuals diagnosed with T1D are hospitalized to resolve the DKA, and the DCES is called upon to start educating and training the family about managing T1D at home.<sup>10</sup> Generally, the parents/caregivers will be present during the hospital stay, and then the education process can begin. Families are often overwhelmed by the new diagnosis. Diabetes care and education specialists can provide reassurance and support to help the PWD achieve their diabetes management goals and therefore be able to live fuller lives. Diabetes care and education specialists should inform families that continued support through their diabetes care team is available as needed when questions and concerns arise beyond the hospital stay. This includes providing the care team's contact information to the PWD and their parents/caregivers as most questions and problems arise during after-hours and during the weekends.

The initial education usually covers what is called *survival skills*.

Survival skills typically cover:

- » Understanding the action of insulins
- » Using an insulin pen or syringe
- » Using devices that differ from the hospital equipment
- » How to follow the insulin plan provided
- » Reducing the risk of, recognizing, and treating low glucose
- » Knowing when to call health care providers/professionals (HCPs)/DCES for adjustments
- » Understanding the initial glucose goals during the transition to home
- » Demonstrating how to use the BG meter they can take home from the hospital
- » Acquiring a continuous glucose monitor, if appropriate
- » Working with HCPs and school staff to set up a school-based diabetes medical management plan: 504 Plan or Individualized Education Plan to ensure proper diabetes care while the child is in school.

The Teach-back method of learning evaluation is encouraged to ensure the PWD understands how the BG meter operates. Due to the reliance on insulin and the potential danger of DKA, instruction on ketone monitoring via urine or blood ketone

meter is also provided. The DCES must provide the PWD and their parents/caregivers with clear instructions on how to interpret the results when to check, and what action to take. All trained DCES members of an interdisciplinary care team can also be called upon to help with the education process.<sup>11,12</sup>

Another area of learning needed is *safety training* involving the treatment of hypoglycemia and the management of hyperglycemia. This includes how to use glucagon in case of a severe hypoglycemic event. The PWD and their parents/caregivers are encouraged to call when questions arise, which fosters open communication between the family and the diabetes care team (HCPs, DCES, nursing staff, social worker, and endocrinologist). This helps to establish a trusting and reliable relationship and the safety of the PWD.

Diabetes care and education specialists may initiate carbohydrate counting depending on the individual and parent/caregiver and their ability to grasp this information. The use of carbohydrate counting requires ongoing support and education to fully understand the importance of evaluating carbohydrate intake and the potential role of other macronutrients.<sup>13,14</sup> Fats and protein, although they play a minor role, can impact glucose outcomes whether eaten alone or with carbohydrate.

For a child diagnosed with T1D who is medically stable, hospital admission is generally not needed, and the child and family can be successfully educated in an outpatient clinical setting.<sup>15</sup>

### Transition to Home

As the child and the parents/caregivers prepare for discharge, or in the event of a new diagnosis and treatment without hospitalization, these tools needed to help manage diabetes must be made available:

- » Insulin pens/vials and pen needles/syringes
- » Blood glucose monitoring (BGM) kit with a prescription for sufficient monitoring strips (6 to 8 strips per day: before each meal, bedtime, periodically in the middle of the night, before sports, and any time the child does not feel well)
- » Information on obtaining a continuous glucose monitor
- » Glucose tablets or suggestions for other alternatives for hypoglycemia treatment
- » Carbohydrate counting sheets and online resources or menu plans (to help start the process of understanding the role of nutrition in diabetes management)
- » Prescription for glucagon (injectable or inhaled) and ketone strips
- » Contact numbers of persons to contact for clarification/questions/emergencies

It is essential to ensure parents/caregivers have access to the supplies previously listed. Consider insurance and the use of a

local community clinic if needed. In addition, DCES should alert the social worker to the child and family's needs for obtaining financial assistance if required for ongoing care and supplies. A social worker can help ease the transition back to school and provide psychological support to the family as needed.

Frequent initial visits and/or close phone and email communication with the DCES can reassure the family as they learn how to incorporate the tasks of diabetes management into their daily routine. Communication should include reviewing the timing of glucose checks, adding ketone checks/sick day guidelines as needed, and how and when to use glucagon. In addition, DCES can spend more time discussing the etiology of T1D and the overall management goals to reduce the risk of any acute or long-term complications.

Depending on the individual/family, introducing the concept of insulin pump therapy can also be included in the initial education sessions. The option of a continuous glucose monitoring (CGM) system should be discussed and encouraged when emotionally and financially feasible. When the child, DCES, and parents/caregivers choose to utilize an insulin pump and/or CGM, the education on how to use these devices needs to come from a DCES who is skilled in insulin pump and CGM therapy. It is important to match the lesson pace and topic to the learning style of the child and parents/caregivers. The National Institute for Health and Care Excellence (NICE) guidelines provide a great review of areas of educational need to cover with PWD and parents/caregivers over time.<sup>16</sup>

A practical framework for providing education throughout the individual's lifespan includes components of the Association of Diabetes Care & Education Specialists' (ADCES) ADCES7 Self-Care Behaviors™:

1. Healthy eating (a well-balanced approach)
2. Being active (all children should be physically active)
3. Monitoring of BG or ketone checks (including frequent monitoring)
4. Taking medication (adjustments and/or potentially using insulins with different time action profiles)
5. Reducing risks (focusing on acute complications during the early diagnosis phase)
6. Problem-solving (adjusting for extracurricular activities)
7. Healthy coping with diabetes (how to manage social situations)<sup>17</sup>

### Toddlers and Preschoolers

Recent data reflect the most significant annual increase in T1D diagnosis is in children aged <5 years relative to all children diagnosed.<sup>18,19</sup> Quality education is critically important for young children and families, especially for a child with a history

of significant hyperglycemia and hypoglycemia. In addition, a history of severe high and low glucose levels increases the child's risk for problems related to working memory and attention later in life.<sup>20</sup> The ISPAD Clinical Practice Consensus Guidelines in 2018 recommend that structured education be available to all young people with diabetes.<sup>11</sup> Many young children are cared for outside of the home. All childcare facilities receiving federal funds must comply with Section 504 laws. Diabetes is considered a disability of the endocrine system. Under Section 504, a legal document should be written to clearly define accommodations for children living with diabetes to keep them safe and ensure their best learning potential. Diabetes care and education specialists should encourage and support the parents/caregivers and school to develop the 504 plans (aged 3 years and older). Diabetes care and education specialists play a critical role in providing continuing support for the family and helping them educate other caregivers (daycare staff, babysitters, grandparents) regarding safe diabetes management.<sup>21,22</sup>

### Grade School and Middle School

When youth with diabetes enter school right after diagnosis and at the beginning of each school year thereafter, DCES can be the primary contact between the school personnel, parents/caregivers, and the diabetes care team. Diabetes care and education specialists can facilitate the development of a medical management plan from HCPs and educate school personnel about the child's needs.<sup>22</sup>

3 federal laws address a school's responsibility to provide care to students with diabetes:

- » Section 504 of the Rehabilitation Act of 1973 (also known as Section 504)
- » Americans with Disabilities Act of 1990 (ADA) and the ADA Amendments Act of 2008
- » Individuals with Disabilities Education Act

Any school that receives federal funding must comply with Section 504 laws. Initiating a 504 plan involves executing a legally written document specifying what reasonable accommodations the school must provide. Examples include but are not limited to, access to water, bathrooms, a glucose meter and/or continuous glucose monitor readings, and time for checking BG.

School and extracurricular activities can impact BG levels. Diabetes care and education specialists can teach the child and family about insulin adjustments for activities based on collaborative agreements or recommendations by HCPs. Diabetes care and education specialists can contribute to the education of relevant school personnel such as sports coaches, and others involved with the child's extracurricular activities, to help enhance the child's safety while under their care. A recent study demonstrated many youths are not adjusting insulin for

exercise despite the frequency of hypoglycemia during and after exercise, indicating the need for further education.<sup>23</sup>

Although some parents/caregivers prefer simple language broken down into key points and hands-on teaching,<sup>24</sup> other methods of delivering diabetes education such as mobile technology,<sup>25</sup> tablet-based apps, and online professional and peer support have also been successfully incorporated.<sup>25,26</sup>

### High School

As the adolescent with diabetes continues through the lifecycle, physiological and social changes can create new challenges. The DCES has the knowledge and training to help problem solve. As the teenager spends more time with friends and less time with parents/caregivers, this increased autonomy may lead to challenges with glucose management. Frequent eating out may necessitate more awareness of carbohydrate in foods and guidance on becoming comfortable monitoring glucose levels and taking insulin at mealtime with peers.

Traveling with sports teams, debate teams, and the high school band or orchestra can enrich as well as challenge a teenager living with diabetes. Helping to educate the coaches, music teachers, and peers can be part of the role of DCES.

Students may be challenged with managing diabetes around school and work schedules, with many taking on part-time jobs while in high school. Work shifts can vary from day to day, increasing the need for adapting to maintain glucose within the target range. This may include not only watching glucose trends but modifying food choices and exercise schedules.

Puberty and diabetes have their own unique needs and challenges that need addressing. For example, females starting their menstrual cycle may find variations in BG levels that require a cyclic change in insulin dosing,<sup>27</sup> with insulin needs increasing before the onset of menses and decreasing after. For those on insulin pumps, DCES can help determine if a second basal rate pattern would be beneficial.

Educating young women about A1C goals before pregnancy should be part of the education sessions during the teenage years in addition to strongly encouraging glucose management overall to achieve target ranges and establish a family support system. Teenagers with T1D are considered a high-risk group for poor pregnancy outcomes.<sup>28</sup> Therefore, education about the risks of childbearing, particularly the risks to the infant when glucose values are highly variable and/or consistently elevated, should be included when working with this age group.

Risky behaviors are more common in all teenagers, but these behaviors present unique challenges in teenagers with diabetes. In a recent self-reported assessment of 29,630 teenagers with T1D (median age 17 years), 10.8% reported regular alcohol

consumption.<sup>29</sup> In a recent survey of substance abuse among American adolescents, not specific to diabetes, by 12th grade, 66% had consumed alcohol and 50% had tried marijuana (9th through 12th grade). Diabetes care and education specialists should be an information resource for teenagers with diabetes, providing education about the risks of drinking alcohol and safely managing diabetes as well as nonalcoholic options available to lessen their chances of drinking alcohol.<sup>30</sup>

An evaluation of 2 significant diabetes online forums from 2011 to 2013 suggested that although teenagers expressed concern about their glucose values, other outcomes also mattered to them and need to be addressed in discussions. These outcomes included emotional well-being, grades, family interactions, and interactions with other teenagers.<sup>31</sup> Screening adolescents for potential depression and eating disorders is essential to identify proper care for teenagers affected by these issues. In a study in Denmark, Dybdal et al<sup>32</sup> found an increased risk of eating disorders, anxiety and mood disorders, substance misuse, and personality disorders 5 years or more after a diagnosis of T1D in children.

### Diabetes Camps

Most studies support diabetes camps as having a positive impact on diabetes acceptance and the potential for improved glycemic management.<sup>33</sup> Diabetes care and education specialists can encourage children to attend diabetes camps, help connect families with funding opportunities if needed, and become involved in camps by volunteering. Using the active camping environment as a teaching opportunity is invaluable for children with diabetes to gain skills in managing their disease within the supportive camp community.<sup>34</sup>

### Transition Throughout the Lifecycle

Care and close supervision of diabetes management are shifted from parents/caregivers to the youth with diabetes throughout childhood and adolescence.

During this transition phase, several major concurrent transitions may also be taking place, for example:

- » Moving away from home to attend college
- » Engaging in serious relationships
- » Being sexually active
- » Learning to drive
- » Experimenting with alcohol
- » Smoking cigarettes
- » Smoking marijuana or vaping
- » Taking illegal drugs

Comprehensive and coordinated planning that begins in early adolescence or at least 1 year before the transition of leaving the home environment is necessary to facilitate a seamless transition to adult diabetes care.

New responsibilities in self-management may include the following:

- » Finding a new HCP
- » Making medical appointments
- » Ordering supplies and medications
- » Finding a medical plan suitable for their needs
- » Managing lifestyle including eating plan and physical activity

This shift abruptly occurs as the older teenager enters the next developmental stage, the *emerging adult*.<sup>35</sup>

The years immediately following high school have been associated with many challenges for young adults with diabetes.

Some specific issues:

- » Lapses in health care, including access to medications and supplies
- » Deterioration in glucose targets
- » Increased occurrence of acute complications
- » Psychosocial, emotional, and behavioral challenges
- » Emergence of chronic complications

While in college, it is the student's responsibility to make their diabetes known and request special accommodations if they choose. Working with the resource center to complete any necessary paperwork will be essential to help protect the student with diabetes. Some accommodation requests may include nutritional data from the food service providers, extra time during exams if glucose values are out of acceptable range, and excused absences if needed for medical appointments. Educating key persons on the importance of the use of technology to manage diabetes, including the use of CGM and receivers such as cell phones, may reduce the potential for misunderstandings and conflicts. Diabetes care and education specialists should encourage students with diabetes to inform and *train* resident assistants, roommates, and housing staff about administering glucagon administration for severe hypoglycemia. Having a separate refrigerator for insulin and snacks could also help.

The transition from pediatric to adult-centered care often occurs concurrently with adolescent independence and focuses on developing personal identity. Unfortunately, seeking freedom may take precedence over self-care, making the transition more difficult. Not all individuals move through developmental stages at the same pace thus transition plans need to be individualized.

Contemporary thinking is that young adulthood may not immediately follow adolescence but begins when youth are in their late 20s or early 30s. This phase is referred to as *emerging adulthood*.<sup>36</sup>

Psychiatric issues are more common in emerging adults with T1D like children with other chronic medical conditions. For example, youth in this transition period may experience sleep disturbances, compulsions, and depressive moods.

Anxiety disorders, the most frequently diagnosed psychiatric disorder in the general population, can complicate diabetes self-management. Depression or the presence of depressive symptoms is a well-known comorbidity of diabetes and is a barrier to effective diabetes self-management. Barriers to effective self-management link to deterioration in glycemic outcomes and diabetes complications.<sup>37</sup> Females in this age range are at a 2.4 times greater risk for disordered eating.<sup>38</sup> Diabetes care and education specialists and the young adult's primary HCPs need to address the potential for unplanned pregnancies and sexually transmitted diseases and the need for reproductive planning to optimize the outcomes of the PWD who becomes pregnant. Individuals need to be informed about the maternal and fetal risks of pregnancy and the need for good glycemic management to conceive and give birth to a healthy child.<sup>39</sup>

The rates of clinically apparent diabetes complications are usually low in adolescents, although there is evidence that approximately 10% of persons with T1D<sup>40</sup> and up to 30% with T2D have microalbuminuria.<sup>40,41</sup> Cardiovascular risk factors are more significant in youth with T2D versus those with T1D. In a recent publication, youth with T1D have been noted to have subclinical artery disease.<sup>42</sup> Fatty liver disease and dyslipidemia are more common among children with obesity with insulin resistance and T2D. This data is according to SEARCH, a multicenter study funded by the CDC and the National Institute of Diabetes and Digestive and Kidney Diseases to learn more about T1D and T2D in children and young adults in the United States.

This transition period is considered a high-risk period for PWD during which interruption of care is likely for several reasons. Care disruptions can be due to leaving the comfort of pediatric care, financial stressors, glucose variability, high-risk behaviors such as smoking, drug and/or alcohol abuse, and uncertainty regarding health insurance coverage.

### 8 focus areas from pediatric to adult care differences:

1. Ineffective glucose management
2. Loss of follow-up care
3. Acute complications
4. Psychosocial issues
5. Reproductive health issues

6. Substance use
7. Substance abuse
8. Chronic complications

Resources and guidelines related to the transition period are available, including NDEP (National Diabetes Education Program) transition planning checklist and the American Diabetes Association (ADA) position statement *Diabetes Care for Emerging Adults: Recommendations for Transition from Pediatric to Adult Diabetes Care Systems*.<sup>43</sup>

The ADA recommends that pediatric HCPs work closely with parents and families to provide diabetes self-management care directed to the teenager and emerging adult with a gradual transfer of responsibilities to the teenager from parents/caregivers. In addition, pediatric and adult HCPs should ensure PWD receive ongoing primary and preventive health care separate from their ongoing diabetes specialty care.

### Increased Risk of Suicidal Thoughts and Related Behaviors in Adolescents and Young Adults With Type 1 Diabetes

In a recent review paper,<sup>44</sup> the increased risk of suicidal ideation in adolescents and young adults is presented. Although much of the data is more than 10 years old, a recent paper by Robinson et al<sup>45</sup> addresses the concern of the risk of suicide attempts being greater in adolescents and emerging adults with versus without diabetes. In their study of 3544 individuals with diabetes versus over 1 million without diabetes, the hazard ratio for attempted suicide was 3.25 (1.70-5.88) in those with diabetes.

This data sounds the alarm for the DCES to be aware of the risk and refer to the proper behavioral health specialists if there are signs or symptoms of suicidal ideations. Symptom considerations can include social isolation, depression, anxiety, and a sense of hopelessness. There are screening tools available such as the Columbia Suicide Severity Rating Scale (or C-SSRS) and the Ask Suicide-Screening Questions (ASQ) Toolkit which can be included in the clinic visit.

### Advocacy

Growing up with diabetes provides an individual with the early opportunity to learn about the need for advocacy. The ADA and its Safe at School program assist children with diabetes and the schools they attend to have a safe and equitable learning environment. The Juvenile Diabetes Research Foundation (JDRF) has a Youth Ambassador Program that provides an opportunity for an individual living with T1D aged 5 to 18 years to share their story within the community and support the mission and efforts of JDRF. Training is provided and this platform allows the PWD to positively impact their peers while supporting JDRF.

The Diabetes Link, formerly known as the College Diabetes Network, is a nonprofit organization whose singular mission is to provide young adults with T1D the peer connections they value, and the expert resources they need to successfully manage the challenging transition to independence at college and beyond.

### The Language of Diabetes

How we talk about diabetes can impact how children, adolescents, and families listen to the conversation and therefore influence the treatment outcomes. Using language that is respectful with a person-centered approach is important. The Language Guidelines were published by ADCES and ADA. Visit the ADCES practice tools webpage at [adces.org](https://www.adces.org)

### Technology: Insulin Pumps and Continuous Glucose Monitors

Diabetes technologies such as insulin pumps, CGM, and integrated insulin pumps with CGM have the potential to improve both clinical and psychological outcomes, reducing the burden of diabetes management and improving the quality of life (QOL).<sup>46,47</sup>

Continuous glucose monitors should be the standard of care for children with diabetes, and discussion about the use and acquisition of CGM should start early in the education/training process. Data supports the importance of CGM not only in the optimization of glucose values but for an improved QOL—allowing better sleep for parents/caregivers knowing they will be awakened if significant glucose variability is occurring.<sup>47</sup>

Insulin pump use in the pediatric population with T1D has continued to rise with an estimated 68% of youth aged 6 to 12 years and 62% aged 13 to 17 years using an insulin pump.<sup>48</sup> There is little data supporting the clinical improvement in A1C with pump therapy, however, that has changed with the new automated closed-loop insulin delivery systems.<sup>49</sup>

The connection between continuous glucose monitors and insulin pumps creating an automated insulin delivery system has demonstrated another advantage for children with diabetes. This system lowers the incidence of hypoglycemia and increases time in range reflecting less glucose variability.<sup>50</sup> Parents/caregivers and PWD may embrace diabetes technology early in the education process or they may not be interested until months or even years after the initial diagnosis of diabetes. DCES need to update parents/caregivers regularly on what new products are available to help their children meet their diabetes management goals.

For more information on current diabetes technology in practice, visit [danatech.org](https://www.danatech.org)

### Type 2 Diabetes in Youth

#### Incidence

Type 2 diabetes in youth is a growing clinical and public health concern. Findings from the SEARCH study indicate that the prevalence of T2D in youth is increasing.<sup>51</sup> According to published projections using the SEARCH database, the prevalence of T2D in those under aged 20 years is likely to quadruple in the next 40 years.<sup>51,52</sup>

Type 2 Diabetes in youth occurs in all racial and ethnic groups but disproportionately affects youth of ethnic and racial minorities, as similarly seen in adults. Studies indicate that in minority adolescents, the rate of T2D cases in youth approaches or exceeds 50% of all cases of new-onset diabetes.<sup>51,53</sup> Native American youth have the highest incidence of T2D, followed by non-Hispanic Black, Hispanics, Asian and Pacific Islanders, and non-Hispanic Whites, respectively. Additionally, youth from socioeconomically challenging backgrounds with increased rates of poverty and low parental education attainment have higher rates of T2D than youth with higher socioeconomic status.<sup>54</sup>

A growing body of evidence suggests that T2D in children and adolescents differs from not only T1D but also T2D in adults. Youth with T2D seem to experience a more rapid decline in beta-cell function. Analysis of RISE (Restoring Insulin Secretion) study data showed that the worsening beta-cell function seen in children and teenagers is progressive and does not appear to respond to treatments known to preserve beta-cell function in adults.<sup>55</sup> In addition, youth with T2D also appear to experience the onset of diabetes-related complications earlier than is typically seen in adults with the same diagnosis.<sup>54, 56-58</sup>

#### Etiology

Type 2 diabetes in youth shares the same physiological aspects as T2D in adults including insulin resistance combined with beta-cell dysfunction and relative insulin deficiency due to worsening or decreasing beta-cell function, hyperglucagonemia due to alpha-cell dysfunction as well as impaired incretin effect.<sup>57,59</sup> Unlike T1D, there is not an identified autoimmune process leading to insufficient insulin secretion.<sup>54</sup> Over the past several decades, along with the rising number of children and teenagers with overweight and obesity is the rising number of children and teenagers with T2D.<sup>60</sup>

Risk factors associated with T2D in the pediatric population:

- » Body mass index (BMI) greater than the 85th percentile for age
- » Sedentary health behaviors
- » Onset of puberty
- » Female gender and polycystic ovarian syndrome<sup>61</sup>
- » Race/ ethnicity

- » Family history of T2D
- » Low socioeconomic status<sup>54,60,62</sup>
- » Early life determinants (eg. nutrition, maternal diabetes, and obesity)<sup>63</sup>
- » Nonalcoholic Fatty liver disease<sup>62,64</sup>

Puberty is associated with decreased insulin sensitivity in approximately 50% of lean, healthy children. The onset of puberty is a high-risk time for developing T2D for those already at increased risk.<sup>65</sup> Additionally, adolescent females have a higher prevalence rate of T2D than adolescent males.<sup>57,60,66</sup>

#### Diagnosis

Given the high number of youths with overweight or obesity, differentiating between T1D and T2D in youth can be challenging. However, determining an accurate diagnosis is essential, as treatment, educational needs and methods, nutrition advice, and outcomes differ between the 2 diagnoses.<sup>67</sup> The recommended criteria for diagnosis of T2D in youth are symptoms of hyperglycemia, negative islet cell antibodies, and one of ADA 2023 *Standards of Care* recommended laboratory values.<sup>68-71</sup>

Presentation of youth onset T2D can vary from asymptomatic to DKA or hyperosmolar hyperglycemic state.<sup>72-74</sup>

#### Treatment

Best practice guidelines specific to youth with T2D continue to evolve as more research regarding T2D in youth becomes available.

#### Glycemic Targets

The ADA 2023 *Standards of Care* suggest that a reasonable A1C target for youth with T2D is less than 7% and that more stringent targets may be appropriate in some PWD if they can be achieved without significant hypoglycemia or other adverse effects of treatment. Conversely, less stringent goals may be appropriate where there is an increased risk of hypoglycemia.<sup>74</sup>

Initial treatment should address BG monitoring and comorbidities such as obesity, dyslipidemia, hypertension, and other microvascular complications.<sup>66</sup> Initial and ongoing diabetes education should focus on behavioral changes, including taking medications, medication side effects, and glucose monitoring.

Managing T2D in youth presents a unique challenge to the diabetes care team. Individual-level health behavior interventions are likely insufficient and may not be developmentally appropriate for youth with T2D.<sup>67</sup> Diabetes care and education specialists should be aware that a family-centered approach to education, medical management, and health behavior modification is essential for children with T2D. Persons

with diabetes and their parents/caregivers must work toward recommended health behavior modifications together, and the DCES is a resource for knowledge and ongoing support. Encouraging regular exercise and working with the PWD and their parents/caregivers to develop healthy eating plans that are financially feasible, and include moderate food portion sizes, can effectively reduce medication use to achieve target glucose levels.

### Medications

Currently, management options for youth with T2D include health behavior modifications and 4 medications approved by the US Food and Drug Administration (FDA) for use in youth with T2D under age 18 years. The approved medications are insulin, Metformin, and 2 glucagon-like peptide-1 receptor agonists (GLP-1 RAs) liraglutide and exenatide.<sup>67</sup>

#### Metformin

Recommendations for initial treatment of youth with T2D include Metformin combined with health behavior changes.<sup>67,70</sup> Metformin is taken orally in pill or liquid form, has a low risk of hypoglycemia, requires less BG monitoring, and is associated with weight loss or weight neutrality.<sup>75,76</sup> Because Metformin is a standard, low-cost, and low-maintenance therapy, youth with T2D may have higher persistence rates with Metformin treatment versus insulin therapy.<sup>77</sup> Parents and caregivers should receive education regarding administering the drug, titrating the dose as directed, adverse effects, and minimizing gastrointestinal side effects.

#### Insulin

Insulin is typically required if the individual is not metabolically stable or when glycemic goals are not achieved with Metformin and health behavior changes alone.<sup>67,75</sup>

Educational needs for safe insulin administration in youth with T2D are the same as those for youth with T1D.

Hypoglycemia is uncommon in youth with T2D; however, they should still receive education regarding signs/symptoms and appropriate treatment of hypoglycemia. This education is critical at the beginning of insulin therapy. The potential weight gain with the addition of insulin can be substantial for individuals within this population. Therefore, DCES must emphasize the continued importance of nutrition management and exercise while using insulin therapy.<sup>70,72</sup> The ISPAD Clinical Practice Guidelines outline the use of insulin in this population (Table 1).<sup>75</sup>

**Table 1.** ISPAD 2018 Clinical Practice Guidelines\* for Youth With Type 2 diabetes

Initial Diagnosis	Treatment
A1C <8.5; no symptoms	Lifestyle and Metformin
A1C > 8.5% or Ketosis/ketonuria/ketoacidosis	Lifestyle basal insulin and Metformin (may be able to d/c insulin after 4 to 6 weeks)
Failure to reach A1C<7.0% in 4 months	Add bolus insulin to the plan

Source: Zeitler P, Arslanian S, Junfen F, et al. ISPAD clinical practice consensus guidelines 2018: type 2 diabetes mellitus in youth. *Pediatr Diabetes*. 2018;19(Suppl 27):28-46. doi: 10.1111/peidi.12719

#### Glucagon-like Peptide-1 Receptor Agonists

The ADA 2023 *Standards of Care* recommends that if glycemic targets are no longer met with Metformin—with or without basal insulin—in children at least aged 10 years with T2D, glucagon-like peptide 1 receptor agonist therapy should be considered if they have no past medical history or family history of medullary thyroid carcinoma or multiple endocrine neoplasia type 2.<sup>77</sup>

#### Liraglutide

Liraglutide is a daily, injectable GLP-1 receptor agonist FDA-approved for use in adolescents aged 10 years and older. It is associated with reduced fasting and postprandial BG, reduced A1C, weight loss, and a low risk of hypoglycemia. Liraglutide can be used in combination therapy with diet, exercise, Metformin, and insulin.<sup>78</sup>

#### Exenatide

Exenatide is a once-weekly, extended-release injectable GLP-1 receptor agonist approved for use in adolescents aged 10 years and older. It is associated with reduced fasting and postprandial BG, reduced A1C, weight loss, and a low risk of hypoglycemia. Exenatide can be used in combination therapy with diet, exercise, Metformin, and insulin.

Families need education regarding administering their prescribed drug, escalating the dose as prescribed, adverse effects, and how to recognize and treat hypoglycemia. The risk of hypoglycemia is increased when GLP-1 RAs are used in combination with insulin therapy.

#### Other Agents

There are many different drugs used to manage T2D in adults. However, the use of agents other than Metformin, insulin, Liraglutide, and Exenatide is currently not recommended for youth with T2D outside of clinical trials.



### Bariatric surgery

Studies on weight-loss surgery in adolescents with obesity have found improvements in body weight, cardiometabolic risk factors, T2D management, or remission of T2D following

Roux-en-Y gastric bypass and sleeve gastrectomy.<sup>79-81</sup> Weight-loss surgery is a treatment option for youth with T2D and obesity. However, at the time of writing, there have been no randomized trials that have compared the effectiveness and safety of surgery to conventional diabetes treatment options in adolescents.<sup>83</sup> Parents and caregivers of youth with T2D who meet the criteria for bariatric surgery need access to information on the availability, risks, and benefits of surgical weight loss so they are aware of all treatment options available. This education allows them to make informed decisions about their care.

### Health Behavior Changes

Health behavior habits are the foundation of the treatment of T2D. However, studies have shown that health behavior interventions alone are generally not sufficient to achieve glucose targets in youth with T2D.<sup>83-87</sup> Type 2 diabetes in youth most often occurs in complex psychosocial and cultural contexts that can make implementing and achieving lasting health behavior changes difficult.

Social determinants of health (SDOH) are increasingly recognized for the impact they can have on the onset, prognosis, and course of T2D.<sup>88</sup> To achieve the best possible outcomes, the DCES should be sensitive to potential barriers and adverse effects of SDOH. Identifying barriers such as food insecurity, housing or financial instability, and health literacy is vital to providing effective education and assisting PWD and their families to establish realistic and attainable self-management, health behavior goals.

Because many youths with T2D also have overweight and/or obesity, improved dietary habits and increased physical activity to reduce BMI and improve glucose levels are recommended.<sup>66</sup>

A developmentally appropriate, comprehensive health behavior education program integrated with diabetes management will help youth with overweight and/or obesity as well as their parents/caregivers. Providing this information to the PWD and parents/caregivers can help them achieve a 7% to 10% decrease in excess weight.<sup>66</sup> Success in making health behavior changes and achieving treatment goals requires initial and ongoing education of the individual, their parents/caregivers, and support systems.<sup>76</sup>

### Dietary Management

Nutritional advice given to the youth with T2D and parents/caregivers should be adapted to cultural, ethnic, and family traditions, as well as any relevant cognitive and psychosocial circumstances.<sup>89</sup>

A single best meal plan for adults or youth with T2D has not been established. However, numerous studies have been conducted regarding effective weight management strategies for children and adolescents with overweight. Nutrition recommendations for youth with T2D are based on healthy eating principles recommended for all children as well as age-appropriate, evidenced-based strategies for weight management.<sup>67,75,90,91</sup> Nutrition education for youth with T2D should focus on healthy eating principles and emphasize increasing the intake of quality, nutrient-dense foods while decreasing the intake of calorically dense, nutrient-poor foods, especially sugar-sweetened beverages. The ADA recommends referring PWD and their parents/caregivers to a registered dietitian (RD) with experience and expertise in the needs of youth with T2D for medical nutrition therapy and other nutrition-related diabetes self-management education and support (DSMES).<sup>68,75</sup>

Common dietary recommendations to reduce calorie intake and promote weight loss in children and adolescents<sup>70,75,76</sup>:

- » Eliminate sugar/calorie-containing beverages with the exception of low-fat milk
- » Limit fruit juice to no more than 1 cup per day
- » Eat regular meals on a schedule
- » Promote family meals when possible
- » Limit the frequency of snacks
- » Increase fruit and vegetable intake
- » Consume 2 to 3 servings of fat-free or low-fat dairy per day
- » Reduce intake of processed, prepackaged convenience foods
- » Reduce intake of foods high in refined sugar
- » Reduce the intake of high-fat foods
- » Portion size management
- » Reduce the number of meals eaten away from home
- » Substitute whole grains for refined grains as much as possible
- » Change family diet behaviors to those that promote and support healthy eating such as parental modeling of healthy eating, positive reinforcement, and avoid blame for failure
- » Education regarding how to read and interpret nutrition facts labels

In addition to dietary strategies to promote glucose management and weight management, education regarding carbohydrate counting or a scheduled meal plan may be necessary for youth with T2D using bolus or split-mixed insulin as part of their diabetes management plan.

### Physical Activity

Youth with diabetes, like all children, should be encouraged to decrease sedentary behavior and participate in at least 60 minutes of moderate to vigorous physical activity per day and strength training at least 3 days per week.<sup>67</sup> Activities may be completed in shorter segments throughout the day. Children and adolescents with T2D should be encouraged to meet these recommendations to reduce BMI and improve glucose levels. In addition to increasing daily physical activity, youth should limit nonacademic screen time to no more than 2 hours per day to help reduce sedentary time.<sup>67,75</sup>

Diabetes care and education specialists should educate youth with T2D and their families about the positive impact of regular physical activity on weight management, BG regulation, and improved insulin resistance. Discussing exercise safety is critical, especially if insulin therapy is required. In addition, families may need guidance and support in starting an exercise routine and tips for incorporating more physical activity into their daily lives.

### Monitoring

Studies evaluating the value of frequent finger-stick BG monitoring or regular CGM use have not been conducted in children and adolescents with T2D and the benefits versus costs remain unclear. However, glucose monitoring can provide insight to understand the impact of eating, exercise, stress, and illness on glucose levels when integrated into the broader self-management plan.

The 2018 ISPAD Clinical Practice Consensus Guidelines for T2D in youth advise that BGM be regularly performed. The frequency should be individualized based on medication use, and the degree of glycemic variability, and include a combination of fasting and postprandial glucose measurements.<sup>75</sup>

The ADA *Standards of Care* recommendations for BGM apply to youth with T2D using an intensive insulin plan. For these individuals, it is recommended that glucose levels be assessed using BGM or reviewing CGM data at the following times<sup>77</sup>:

- » Fasting
- » Before meals and snacks
- » At bedtime
- » Occasionally postprandially
- » Before exercise
- » When they suspect low BG
- » After treating low BG until they are normoglycemic
- » Before critical tasks such as driving

For individuals using an insulin plan with less frequent injections, other noninsulin agents, or health behavior interventions alone, BGM or CGM may be a helpful guide to food and physical activity choices and the overall success of therapy.

The A1C concentration measurements are recommended every 3 months or twice yearly at a minimum.<sup>67,75</sup>

### The Role of the Diabetes Care and Education Specialists

All youth with T2D, their parents/caregivers, and HCPs should receive comprehensive, culturally sensitive DSMES specific to the youth with T2D. Diabetes self-management education and support should be provided by a multidisciplinary team that includes a physician, DCES, RD, psychologist or social worker, and other members of the health care team who are knowledgeable about T2D in youth and the continually changing needs of the pediatric population.<sup>67,75</sup>

Diabetes self-management education and support should occur at diagnosis, annually for assessment of education, nutrition, and emotional needs, when new, complicating factors arise that impact self-management, and when transitions in care occur. Initial and ongoing DSMES for T2D needs to focus on food intake and physical activity changes, the administration of prescribed glucose-lowering agents, signs/symptoms and treatment of hypoglycemia, and BG monitoring as needed.<sup>77</sup> Not only do PWD need to know the correct technique when monitoring, but they also need to understand how to evaluate glucose data and identify when an adjustment in therapy may be needed.

Because youth with T2D typically do not present in DKA at diagnosis, initial diabetes education will most likely occur in the outpatient setting. Limited finances, transportation issues, and difficulty taking time off from work are common barriers to appointment attendance and should be considered when designing T2D classes or educational programs if the initial assessment suggests these obstacles may continue to be a challenge. The COVID-19 pandemic expanded the use of virtual platforms for diabetes care and education. Telehealth diabetes education where available may be considered as an alternative to in-person education for some PWD and their families. At the time of writing, no published studies were available that evaluated the outcomes of telehealth diabetes education in youth with T2D.

Youth with T2D often have a family history of T2D and may already know how other family members manage their diabetes. In addition, youth with T2D from underserved communities are at increased risk for suboptimal outcomes and are sometimes familiar with the long-term complications of ineffective glucose management.<sup>92</sup> As part of the initial DSMES, DCES must reassure parents/caregivers that with proper management, children, and teenagers with T2D should be able to live healthy lives.

The onset of T2D in youth before puberty is rare; most youths with T2D are in middle school and high school. Age-specific education considerations and concerns for youth with T2D in these age groups are similar to that for their same-age peers with

## The Role of the Diabetes Care and Education Specialist in Pediatric Diabetes Regardless of Etiology

T1D. Working with the school, as with T1D, and developing a 504 plan will help provide support for the child's needs within the school setting.<sup>18</sup>

Throughout the education process and through various stages of the child's life, the DCES should be sensitive to the everyday challenges of youth with T2D. Diabetes care and education specialists should tailor DSMES to help individuals and parents/

caregivers better meet these challenges and overcome barriers to their medical care, helping to ensure the best possible outcomes.<sup>67,74</sup>

Diabetes care and education specialists can help facilitate participation in a camp program to help children and parents/caregivers at risk. Some day camps are now being organized specifically for T2D for children at risk.

**Table 2.** Recommendations for Screening of Diabetes-Related Complications, Comorbidities, High-Risk Behaviors, and Social Determinants of Health for Pediatric Individuals with T1D and T2D

Comorbidity or Complication	Screening	Recommended Interval for Type 1 Diabetes	Recommended Interval for Type 2 Diabetes
Hypertension	BP monitoring using appropriately sized cuff <sup>63,68</sup>	At diagnosis and every diabetes-related clinical encounter <sup>11,68</sup>	At diagnosis and every diabetes-related clinical encounter <sup>63,68</sup>
Dyslipidemia	Fasting lipids <sup>11,63,68</sup>	Soon after diagnosis; ideally, after glucose levels have stabilized and aged $\geq 2$ yrs. If LDL $< 100$ mg/dl repeat at aged 9 to 11 years, then if $< 100$ mg/dl repeat every 3 years. <sup>68</sup>	Yearly starting at diagnosis; ideally, after glycemic outcome is achieved or within 3 months of diagnosis. <sup>63,68</sup>
Nephropathy	Urine screening for albumin to creatinine ratio <sup>63,68</sup>	$> 5$ years after diagnosis and onset of puberty or aged $\geq 10$ years (whichever comes first); repeat every 1 to 2 years <sup>11,68</sup>	Yearly starting at diagnosis <sup>63,68</sup>
Neuropathy	Symptoms: numbness, pain, cramps and paresthesia and comprehensive foot exam with foot pulses, pinprick, 10-g monofilament sensation tests, vibration, and ankle reflexes <sup>63,68</sup>	$> 5$ years after diagnosis and onset of puberty or aged $\geq 10$ years (whichever comes first); repeat every 1 to 2 years <sup>63,68</sup>	Yearly starting at diagnosis <sup>63,68</sup>
Retinopathy	Comprehensive eye examination with dilated pupils or retinal photography <sup>63,68</sup>	$> 3$ to 5 years after diagnosis and onset of puberty or aged $\geq 11$ years (whichever comes first); repeat every 1 to 2 years <sup>11,68</sup>	Yearly starting at diagnosis <sup>63,68</sup>
Psychosocial Health	Symptoms: Distress, depression, and or disordered eating using validated screening questionnaires or referral for further evaluation <sup>11,68</sup>	Begin shortly after diagnosis; repeat annually at minimum <sup>11</sup>	Starting at diagnosis and then every diabetes-related clinical encounter <sup>63</sup>
Social Determinants of Health	Assess food security, financial concerns, social/school, and community support <sup>63</sup>	At the time of writing, no published recommendation or standard	Start at diagnosis and then every diabetes-related clinical encounter <sup>63</sup>
Smoking, Vaping, Recreational Drug, and Alcohol Use	Clinical assessment on history <sup>63</sup>	Every diabetes-related clinical encounter <sup>11</sup>	Start at diagnosis and then every diabetes-related clinical encounter <sup>63</sup>
Preconception Counseling	Sexual history <sup>11,63</sup>	Begin in early adolescence and revisit at least annually <sup>11</sup>	Start at diagnosis and then every diabetes-related clinical encounter <sup>63</sup>
Autoimmune Screening	Thyroid function screening labs <sup>68</sup>  Celiac screening labs <sup>68</sup>	At or near diagnosis; then every 1 to 2 years or if symptoms arise <sup>11,68</sup>  At or near diagnosis; repeat within 2 years and thereafter every 5 years; sooner if symptomatic <sup>11,63</sup>	N/A <sup>11</sup>
Nonalcoholic Fatty Liver Disease	Liver function screening labs <sup>63,68</sup>	At the time of writing, no published recommendation or standard	Yearly starting at diagnosis <sup>63,68</sup>

Comorbidity or Complication	Screening	Recommended Interval for Type 1 Diabetes	Recommended Interval for Type 2 Diabetes
Obstructive Sleep Apnea	Symptoms: snoring, sleep quality, apnea, morning headaches, daytime sleepiness <sup>63,68</sup>	At the time of writing, no published recommendation or standard	Yearly starting at diagnosis <sup>63,68</sup>
Polycystic Ovary Syndrome	Symptoms: Menstrual cycle history, evidence of hyperandrogenism physical exam for acne and/or hirsutism and/or total testosterone measurement <sup>63,68</sup>	At time of writing, no published recommendation or standard	Yearly unless there is menstrual irregularity. Start at diabetes onset in pubertal females <sup>63</sup>  Every diabetes-related clinical encounter <sup>68</sup>

Sources: Pihoko C et al. ISPAD Clinical Consensus Guidelines 2018: The delivery of ambulatory diabetes care to children and adolescents with diabetes. *Pediatr Diabetes*. 2018;19(Suppl 27):84-104; Shah A, et al. ISPAD Clinical Consensus Guidelines 2022: Type 2 diabetes in children and adolescents. *Pediatr Diabetes*. 2022;1-31; American Diabetes Association. Children and adolescents: *Standards of Medical Care in Diabetes—2002*. *Diabetes Care*. 2022;45(Suppl 1):S208-S231.

### Mature-Onset Diabetes of the Young

Mature-onset diabetes of the young (MODY) accounts for at least 1% of all cases of diabetes. This heterogeneous metabolic disorder is due to monogenic mutations in 1 of at least 14 different genes. The onset of hyperglycemia most often presents at an early age (classically before aged 25 years in lean individuals), although diagnosis may occur at an older age. Mature-onset diabetes of the young is most often characterized by impaired insulin secretion with minimal or no defects in insulin action (in the absence of coexistent obesity). It is inherited in an autosomal dominant pattern and usually has no associated islet autoimmunity. These mutations lead to pancreatic beta-cell dysfunction and elevated glucose levels.<sup>93</sup>

### Presentation of Maturity Onset Diabetes of the Young

Clinically, individuals with GCK- (glucokinase) MODY exhibit mild, stable, fasting hyperglycemia. This form of fasting hyperglycemia does not require treatment with glucose-lowering medications. These individuals might present with symptoms such as polyuria, polydipsia, and weight loss, though they rarely present with DKA.

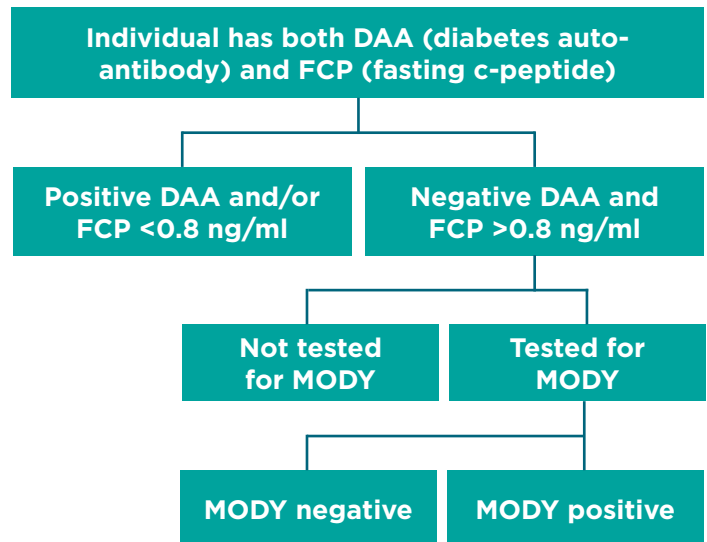
There are multiple causes of MODY, and many of them are genetic. Persons with HNF1A- (hepatocyte nuclear factor 1A) or HNF4A- (hepatocyte nuclear factor alpha) gene mutations develop MODY that typically responds well to low doses of sulfonylureas, which are considered first-line therapy. Mutations or deletions in the HNF1B- (hepatocyte nuclear factor 1β) gene are associated with renal cysts and uterine malformations, known as renal cysts and diabetes (RCAD) syndrome. Researchers identified other sporadic forms of MODY involving other transcription factor genes, including PDX1 (pancreatic and duodenal homeobox 1 [also known as IPF1]) and NEUROD1- (neurogenic differentiation 1).<sup>93,95</sup>

### Clinical Diagnosis

Although clinicians often note an overlap between T1D and T2D, the clinical diagnosis for MODY is based upon the following (Figure 1): family history of diabetes, insulin independence, and onset by aged 25 years. Researchers on this subject generally agree that a correct diagnosis needs to be established in affected individuals because treatment options may vary widely. Some estimate that 95% of MODY cases in the United States are misdiagnosed.<sup>95</sup>

The ADA 2023 *Standards of Care* suggest that practitioners consider a diagnosis of monogenic diabetes in children with the following characteristics<sup>94</sup>:

**Figure 1.** MODY diagnosis criteria The researchers for the SEARCH study recommend the following algorithm to ensure that a proper diabetes diagnosis is obtained:



For individuals with an FCP level of >0.8 ng/mL and negative results for selected DAA, test for the 3 most common forms of MODY: HNF1A, HNF4A, and CGK.<sup>93</sup>

Source: Pihoker C, Gilliam LK, Ellard S, et al; SEARCH for Diabetes in Youth Study Group. Prevalence, characteristics and clinical diagnosis of maturity onset diabetes of the young due to mutations in HNF1A, HNF4A, and glucokinase: results from the SEARCH for Diabetes in Youth. *J Clin Endocrinol Metab*. 2013;98(10):4055-4062. doi: 10.1210/jc.2013-1279

Figure 1. MODY diagnosis criteria:

- » Diabetes diagnosed in the first 6 months of life
- » Family history of diabetes without T2D risk factors (without signs of obesity, low-risk ethnicity)
- » Mild fasting hyperglycemia in young and nonobese
- » Diabetes with negative autoantibodies and without signs of obesity or insulin resistance

The researchers for the SEARCH study recommend the following algorithm to ensure obtaining a proper diabetes diagnosis: For individuals with a fasting C-peptide level of  $\geq 0.8$  ng/mL and negative results for selected diabetes autoantibodies, monitor for the 3 most common forms of MODY: HNF1A, HNF4A, and GCK.<sup>95</sup>

### Medication Treatment Options

Treatment is chosen based on the form of MODY. In HNF1A and HNF4A, considering the initiation of insulin and oral antidiabetes-related medication are most common; individuals with GCK may not require any treatment.<sup>94</sup> No matter the treatment, it is advisable that all individuals diagnosed with MODY be closely monitored to track disease progression, the need for medication change, or the overall change in the disease state.

### Health Behavior Modification: The Role of the Diabetes Care and Education Specialists

As with other forms of diabetes, the role of DCES is to help empower the individual to maximize their self-management skills. Healthy eating, maintaining an appropriate weight, regular exercise, taking medications as prescribed, maintaining proper medication administration, and discussing possible side effects are the cornerstones of treatment. In addition, parents/caregivers and nonmedical staff need to review the frequency of monitoring as directed by the medical staff. Monitoring techniques, avoiding long-term complications, effective coping skills, and problem-solving can present challenges that may contribute to more difficult management. These topics should be incorporated into the diabetes education sessions with the individual and supporting family members.

### Secondary Forms of Diabetes

#### Cystic Fibrosis Related Diabetes

##### Introduction

Cystic fibrosis-related diabetes (CFRD) is the most common comorbidity in persons with cystic fibrosis (CF). The prevalence of CFRD increases with age, and CFRD is reported in 20% of adolescents. Risk factors associated with CFRD are female sex, pancreatic insufficiency,<sup>96</sup> liver disease, need for tube feedings, history of bronchopulmonary aspergillosis, and negative pulmonary outcomes.<sup>97</sup>

Advances in clinical care are helping people with CF live longer and healthier lives. There is a likelihood of seeing an increase in the prevalence of CFRD.<sup>94</sup> The mean predicated survival age of children with CFRD born in 2019 is 48.4 years, compared to 36.6 years of individuals born in 2009.<sup>98</sup>

##### Complications

Early detection of CFRD and aggressive insulin therapy have narrowed the gap between mortality in individuals with and without diabetes and have eliminated the gender-based differences in mortality. High glucose levels may promote thickened secretions and subsequent bacterial colonization, leading to infection and further compromising lung function. Nutritional status may impact ongoing weight loss leading to loss of strength and lung health.

##### Pathophysiology of Cystic Fibrosis-Related Diabetes

Cystic fibrosis-related diabetes is a unique type of diabetes with the primary defect being decreased insulin secretion. There is debate whether CFRD is due to progressive pancreatic beta-cells destruction from mucous, or if it is due to the genetic changes in the cells of individuals with CF.<sup>99</sup> These genetic changes in pancreatic cells have been reported to impair insulin secretion and augment glucagon secretion.

##### Diagnosis

Early diagnosis of CFRD is characterized by normal fasting glucose levels, with a gradual increase over time leading to elevations in fasting hyperglycemia. Individuals with CFRD may not be present with classic symptoms of diabetes such as polyuria and polydipsia. Instead, they may show declines in pulmonary function tests and unexplained weight loss.<sup>100</sup> The progressive deterioration of glucose tolerance can occur at any age, starting with intermittent post-prandial glucose elevations, followed by indeterminate hyperglycemia on oral glucose tolerance test (OGTT), then by impaired glucose tolerance, and finally the presence of CF-related diabetes. The individual may move back and forth between the categories, although once diagnosed with CFRD, the diagnosis remains even if the hyperglycemia is not always evident.<sup>100</sup> The need for insulin may also vary during these times, making management of blood sugar and insulin therapy challenging for the clinician as well as the individual.

The use of the 2-hour OGTT is considered the Gold Standard for CFRD diagnosis, with cut-off points established by the ADA.<sup>71</sup>

Hypoglycemia during an OGTT may indicate dysregulation of insulin secretion and could represent a stage preceding the onset of CFRD.<sup>102</sup>

##### Screening and Monitoring

Recommended screening is outlined in the ISPAD Clinical Practice Consensus Guidelines 2018. Screening for CFRD

should start annually in all persons with CF aged 10 years via 2-hour 75 g (1.75 g/kg) OGTT or earlier if there is a decline in lung function or unexplained weight loss. Hemoglobin A1C (HgbA1C) is not an accurate measure for screening but is recommended quarterly for all individuals with CFRD.<sup>101</sup> Additional screening includes annual monitoring for microvascular disease starting 5 years after diagnosis, blood pressure checks at each visit, and lipid profile monitoring annually for individuals with exocrine insufficiency, CFRD, or the presence of any of the following risk factors: obesity, family history, or coronary disease.<sup>101</sup> Persons with CFRD should be monitored quarterly by a CF multidisciplinary team and a diabetes multidisciplinary team.

### Cystic Fibrosis Transmembrane Conductance Regulator Modulators

Newer treatments for CF using a class of drugs for people with CF called CFTR (cystic fibrosis transmembrane conductance regulator) have improved treatment options so people with CF are now healthier and have the potential for a relatively normal life span. The percentage of people with CF who are eligible for modulators has continued to increase up to 90% due to the ongoing development of drugs for different genetic mutations of the CF gene.<sup>103</sup>

Cystic fibrosis transmembrane conductance regulator modulators are a category of drugs that can enhance and/or restore the expression, and function, as well as stabilize the defective CFTR protein. These modulators help increase chloride transport across the cell membranes.<sup>99</sup> Also reported are improved cell function, reduced infection and inflammation, and improvement of exocrine and endocrine pancreatic function.<sup>104</sup>

Studies confirm that the correction of CFTR activity improves insulin secretion in CF with an improvement in cell functioning that may reverse or improve insulin secretion in individuals with CFRD.<sup>105</sup> It is suspected that modulators influence beta-cell function, improving islet function and insulin sensitivity.<sup>106</sup> There has been improvement in CFRD such that insulin is no longer required in one-quarter to one-third of individuals, depending upon the CFTR mutation.<sup>105</sup> People with CFRD taking CFTR modulators should be alerted to the potential for hypoglycemia and the possibility of improvement or resolution of CFRD even months after starting the medication.<sup>105</sup>

### Nutrition Therapy for Cystic Fibrosis-Related Diabetes

Since the early 1990s, the emphasis of the CF diet has been high calorie, high fat, and high sodium (the *CF Legacy diet*), which was designed to promote weight gain. The goal was to achieve a specific body mass index (BMI; calculated as kg/m<sup>2</sup>).<sup>107</sup> The CF Foundation recommended that children and adolescents maintain a BMI at or above the 50th percentile as it was correlated with

improved lung function and longevity.<sup>108</sup> Achieving these weight gain goals placed the focus on caloric intake, with less emphasis on the nutritional quality of the diet. The high-calorie diet recommendation continued with a diagnosis of CFRD. However, it was recommended to restrict liquids with high amounts of sugar to reduce wide excursions of BG.

Over the past several years, the nutritional management of people with CF has continued to evolve. As new therapies, including CFTR modulators, are improving the outcomes for people with CF, a trend of overweight and obesity has been noted in individuals with CFRD. These trends may be due to improved exocrine and endocrine pancreatic function.<sup>104</sup> The Academy of Nutrition and Dietetics completed a review of the literature in 2020 with a consensus recommendation for individuals with CF who are have overweight and/or obesity to consume an age-appropriate diet that emphasizes foods associated with positive health outcomes in the general population including vegetables, fruits, whole grains, seafood, eggs, beans and peas, nuts and seeds, dairy products, and meats and poultry as tolerated and preferred by the individual with CF. For a person with CF and CFRD, the recommendation is to limit high-sugar foods and beverages with low nutrient density due to adverse effects on BG levels.<sup>107</sup> As some individuals with CF are still struggling with weight gain, it is necessary to personalize the nutritional care plan based on the individual's nutritional status, emphasizing appropriately balanced diets and person-specific recommendations.<sup>109</sup>

### Insulin Therapy

The main goal of insulin therapy is to preserve lung function and maximize nutritional status. Insulin deficiency is the primary defect in CFRD. There is also marked glucagon deficiency and variable insulin resistance secondary to illness and medications such as glucocorticoids. Diabetes-related ketoacidosis is rare, and for this reason, individuals with CFRD do not routinely need to learn ketone monitoring.

Insulin therapy is the only recommended treatment of CFRD to achieve glucose targets recommended by the ADA.<sup>108</sup> Insulin therapy stabilizes lung function and improves nutritional status in individuals with CFRD. Trials have shown insulin therapy to reverse chronic weight loss and pulmonary decline because of its anabolic effects.<sup>110</sup> Oral diabetes agents are not suggested for CFRD, and agents that reduce insulin resistance are not likely to be effective, as insulin resistance is not the main etiological factor.<sup>110</sup>

The principles of insulin therapy in CFRD are unique and should always be personalized based on the timing and degree of glucose excursions, the type of insulin available and the individual's abilities and health behavior choices.

When individuals are in a baseline status of health, insulin needs can be moderate due to the persistence of exogenous insulin. An insulin plan that promotes optimal glucose levels and fits the individual's health behaviors should be the choice for managing CFRD. Individuals with CFRD who have fasting hyperglycemia are best treated with a basal-bolus plan using long-acting basal insulin with rapid-acting insulin to cover carbohydrate and correct hyperglycemia. The determination of units of insulin needed is based on the number of carbohydrate consumed at the upcoming meal or snack (carbohydrate counting). The dose can be adjusted based on post-prandial glucose levels. An insulin pump is also an option to manage CFRD and allows for easier administration of insulin.<sup>109</sup>

Individuals with CFRD without fasting hyperglycemia may be treated with a pre-meal dose of insulin alone or with a longer-acting basal dose alone. Research has shown that in these individuals without fasting hyperglycemia, pre-meal rapid-acting insulin can reverse chronic weight loss and is now considered standard care.<sup>109</sup>

People with night drip tube feedings may be treated with a single dose of regular + neutral protamine Hagedorn (NPH) with a mixed dose to cover both halves of the feeding hours. Glucose checks 4 hours into the feedings can be monitored to adjust the NPH dose. Persons with diabetes should be taught that this is only to be given nights they are receiving tube feedings.<sup>110</sup> As with all insulin therapy glucose monitoring should be done consistently throughout the day, based on insulin type and dose, carbohydrate intake, and other medical factors.

### Continuous Glucose Monitoring Devices in CFRD Management

The CGM devices are closer to becoming a part of the standard management for T1D and have been validated in children and adolescents with CFRD. In 2021, a longitudinal prospective cohort study was done using 3 days of data from CGM, which were compared to results from OGTT with the objective to compare OGTT with CGM and the effectiveness of predicting the onset of CFRD.<sup>102</sup> The results from this study showed that CGM can identify glucose abnormalities not detected by OGTT, and may be more sensitive for the early detection of decreases in BMI. This may indicate that CGM could be used in instances where a person is unable to complete an OGTT, or for those with normal glucose tolerance on an OGTT but experiencing ineffective clinical outcomes.<sup>100</sup>

### Summary

The diagnosis of CFRD places an additional treatment burden upon an already cumbersome daily plan for people with CF. Limited data is available on how individuals with CF cope with the diagnosis of a second chronic illness, how CFRD affects their QOL, or how the care team can facilitate the acceptance of the diagnosis and its interventions.<sup>110</sup>

The availability of a clinical team with expertise in CFRD, a CFRD-specific educational program, and educational materials (like those available through the Cystic Fibrosis Foundation) may also facilitate adapting to the diagnosis of CFRD. Collaboration between the cystic fibrosis team and the diabetes team is imperative to design DSMES for the best outcomes for people with CFRD.

Diabetes care and education specialists are a vital member of PWD's health care team. Initial education will focus on diabetes self-care skills related to the initiation of insulin therapy. Then, provide comprehensive DSMES to the PWD and parents/caregivers based on an individualized needs assessment.

### Steroid-Induced Diabetes During Hospitalization

Steroid-induced diabetes is defined as hyperglycemia occurring in an individual without a diagnosis of diabetes prior to the start of steroid therapy. In the hospital setting, steroid-induced hyperglycemia often generates a referral to the DCES.

Glucocorticoid therapy may be prescribed for conditions including but not limited to asthma, post-transplant, rheumatological conditions, and hematological malignancies. Glucocorticoids alter glucose metabolism by causing a reduction in insulin production and secretion (dose-related), a decrease in insulin sensitivity, and an increase in glucose production.<sup>111</sup> Glucocorticoids can cause new-onset hyperglycemia or worsen insulin resistance in someone with established diabetes.<sup>112</sup>

There is limited documentation in the literature regarding the frequency of hyperglycemia secondary to steroids in the pediatric population, however the majority of cases reported in children are related to glucocorticoid therapy.<sup>113,114</sup>

### Treatment

There is limited research available on the effects, reduction or delay, and treatment for steroid-induced diabetes.<sup>112-115</sup> No national or international guidelines exist for managing steroid-induced hyperglycemia in children.<sup>116</sup> Although there are no standards for when to screen for steroid-induced diabetes, monitoring should be considered in individuals receiving medium to high doses of glucocorticoids.<sup>116-118</sup>

The ADA's *Standards of Care* recommends<sup>117</sup>:

- » Insulin therapy be initiated for the treatment of persistent hyperglycemia starting at a threshold  $\geq 180$  mg/dL (checked on 2 occasions).
- » Once insulin therapy is initiated, a target glucose range of 140 to 180 mg/dL is recommended for the majority of critically ill and noncritically ill
- » More stringent goals, such as 110 to 140 mg/dL may be appropriate for selected individuals if they can be achieved without significant hypoglycemia.

The 2022 Endocrine Society clinical practice guidelines for the management of hyperglycemia in hospitalized adults in noncritical care settings addresses hyperglycemia secondary to glucocorticoids<sup>116,117</sup> and recommends:

- » Neutral protamine Hagedorn or basal bolus insulin plan
- » Ongoing BG monitoring with adjustment of insulin dosing
- » Taking precautionary measures to avoid hypoglycemia when steroid therapy is tapered or suddenly discontinued

The insulin plan is directed at achieving glycemic targets in response to glucocorticoid dosing through BGM and titration of insulin therapy.<sup>118</sup>

The role of CGM during hospitalization to supplement point-of-care BGM continues to be highlighted as early data has shown improvements in glycemic management and clinical outcomes.<sup>117,119</sup> Research is needed to determine whether CGM could be beneficial in managing steroid-induced diabetes.

### Role of the Diabetes Care and Education Specialists

The role of DCES is to balance the demands of managing BG levels with the physical and emotional demands of the individual's underlying condition. DSMES will be individualized based on needs at discharge.

The DSMES should include the following topics, if applicable to the individual's treatment:

- » Overview of steroid-induced diabetes to help the PWD and their parents/caregivers understand the importance of taking medications and monitoring.
- » Instructions on home glucose monitoring, focusing on how and when to check the BG levels.
- » Hypoglycemia signs, symptoms, causes, and treatment including glucagon administration.
- » Insulin therapy based on the prescribed plan needs to be discussed with the youth and their parents/caregivers.
- » Insulin administration, including dosing, is a critical detail to teach the youth and their parents/caregivers.
- » Instructions on when to call HCPs, including if steroids are being tapered
- » Signs and symptoms of diabetes: these individuals need to be taught the signs, symptoms, and treatment of hyper- and hypoglycemia so they can recognize these issues, properly address the situation, and inform their HCPs if any of those symptoms occur.
- » Importance of follow-up with their HCPs or their DCES if signs and symptoms of hyperglycemia persist after completing steroid treatment.
- » It is essential to provide the family with a plan for insulin

titration that matches the adjustments in glucocorticoid therapy to prevent acute complications such as hypoglycemia and significant hyperglycemia.

### Total Pancreatectomy With Islet Auto-Transplantation

Total pancreatectomy with islet cell auto-transplantation (TPIAT) is a surgical intervention that is used for the treatment of chronic pancreatitis in children when medical management strategies are ineffective, and they have debilitating pain and poor QOL.<sup>120</sup> The surgery has been shown to provide long-term pain relief, reduce dependence on narcotics, and increase QOL.<sup>121-123</sup> After the removal of the pancreas, the islet cells are extracted and isolated from the tissue. The islets are then infused back into the portal vein so that they can engraft in the liver where they may produce endogenous insulin after an initial period of adjustment.<sup>120,122</sup> Islet cell auto-transplantation has been shown to prevent the severe glucose fluctuations that result from total pancreatectomy alone<sup>121</sup> and can lead to total insulin independence in 37% to 55% of children who undergo the procedure,<sup>124-125</sup> with higher rates of insulin independence demonstrated in children under aged 8 years.<sup>125,126</sup> An additional 50% of children have a low exogenous insulin requirement following TPIAT and the remaining 20% are dependent on exogenous insulin.<sup>125</sup> Following TPIAT, achieving glucose targets is critical for islet engraftment with the target glucose range between 80 to 120 mg/dL.<sup>127,128</sup> Education and support from a DCES is critical before surgery, at the time of surgery, and for a period of months to years afterward.

Diabetes care and education specialists provide information to the PWD and their family about the details of diabetes care tasks that will be required postoperatively. At the time of surgery, the amount of education that falls on parents is substantial, and the DCES is a critical partner during this time. Families must learn the survival skills needed by children newly diagnosed with insulin-requiring diabetes, and complete education on the use of insulin via insulin pens/syringes or insulin pumps and CGM before discharge. In addition, families are required to learn about the child's post-surgery medications and the use of a feeding pump. It is beneficial for the families to interact with educational modules and have planned pre-TPIAT education encounters before they are under the added stress of attending to a critically ill child. Starting this education before the TPIAT also allows for more time dedicated to practice with diabetes technology and care tasks before leaving the hospital. Diabetes care and education specialists should facilitate education, both pre, during, and post-surgery to prepare them for success outside the supervised hospital environment.

Pediatric TPIAT individuals often utilize insulin infusion pumps and CGM therapy immediately following surgery to optimize glycemic management, which has been shown to promote



islet cell survival.<sup>125,129,130</sup> Forlenza et al<sup>128</sup> found that the use of closed-loop therapy immediately following surgery produced significantly lower mean glucose values without an increased risk of hypoglycemia when compared to injection therapy.<sup>128</sup> Tellez et al<sup>130</sup> showed that immediate transition to insulin pump therapy from the insulin drip following surgery was associated with a shorter hospital stay and reduced glycemic variability. Both Elder et al<sup>131</sup> and Segev et al<sup>132</sup> found that CGM was an accurate tool that helped individuals achieve excellent glycemic management postoperatively, even in the intensive care unit, and CGM users also experience lower mean glucose without increased risk of hypoglycemia in the outpatient setting following surgery.<sup>129</sup> Important to note, McEachron's group<sup>129</sup> found that 74% of CGM readings were within 20% of a reference value despite the fact that two-thirds of the persons were taking hydroxyurea, which has been shown to impact CGM readings.<sup>129,130</sup> Successful use of these technologies is not possible without support from a DCES. Families require frequent touchpoints from a DCES to help initially learn and subsequently manage the insulin pump and CGM. Diabetes care and education specialists should also provide a plan for BG management in the event of a pump malfunction, including the resources required to administer insulin injections until the pump can be repaired or replaced.

Immediately after discharge, post-TPIAT individuals are followed closely by the diabetes team, and additional education on topics such as physical activity, returning to school, and healthy eating for optimal blood sugar monitoring is provided. Over the course of the person's life, additional education will be needed when transitioning off or back on to insulin, if the youth is experiencing hypoglycemia, or if the individual ultimately remains fully insulin dependent.

Post-TPIAT individuals require lifelong monitoring for diabetes because islet function can wane over time.<sup>121</sup> Long-term data on the durability of insulin independence has been published for adults, but not children, though<sup>125</sup> found at least short-term durability of insulin independence in their cohort.<sup>125</sup> It is recommended that glucose be monitored during periods of stress such as acute illness, use of steroids, and transition through puberty. Individuals who were formerly insulin independent may need to temporarily return to insulin therapy during these times of increased needs.<sup>120</sup>

Hypoglycemia in both insulin-dependent and insulin-independent individuals post-TPIAT has been well described.<sup>133</sup> Researchers found that their study participants, most of whom were insulin-independent, experienced hypoglycemic episodes after meals, exercise, or both. Lin et al<sup>134</sup> also reported fasting hypoglycemia. Bellin's group demonstrated a deficient glucagon response to hypoglycemia in the individuals under their care and found that awareness of hypoglycemic symptoms was often absent, though

they speculated that this may have been related to recurrent hypoglycemia. Improvement or elimination of symptoms has been noted with small, frequent meals containing complex carbohydrate and protein, elimination of intense exercise, pre-exercise snacks, and use of CGM alarms.<sup>134,135</sup> DCES should provide a review of acute hypoglycemia management and offer preventative strategies such as the incorporation of low glycemic index foods to offset a large insulin response to food types.

Individuals who have undergone TPIAT and remain insulin dependent require the same support as other individuals with insulin-dependent diabetes. They should receive education on reducing the risk of diabetes complications and information about the screenings recommended to detect these complications. They will need continued assistance with utilizing the newest technology and may require referral to social work or mental health services if they experience psychosocial challenges.<sup>136</sup> Like others with insulin-dependent diabetes, they will benefit from yearly visits with a DCES to address issues that arise over the lifespan, including the ADCES7 Self-Care Behaviors, and from periodic visits with a registered dietitian to address cardiovascular risk factors, food choices for optimal glycemic outcomes, and general healthy eating.

Though TPIAT has been shown to alleviate pain, lessen narcotic dependence, and improve QOL for individuals who have chronic pancreatitis, these individuals require life-long care and monitoring from the diabetes team, of which DCES are an integral part. Persons with diabetes require a significant amount of education before and at the time of surgery, and education should continue after discharge, with topics tailored to the PWD's individual situation.

### Summary

Diabetes presents in many ways in the pediatric population. As the manifestation of diabetes differs, so does the need for individualized treatment and educational interventions. When a DCES conducts a thorough assessment of the individual and family, understands the requirements for their specific diagnosis, and works with individuals and families to establish goals towards maximal health, all involved will benefit. Those living with or affected by diabetes will be able to enjoy their lives despite challenges. The biggest challenge for the DCES may be recognizing the variations in the reasons for elevated glucose levels during the assessment process. Diabetes care and education specialists should understand the unique modifications required in the overall assessment of how the child and family can apply the ADCES7 Self-Care Behaviors principles in these different manifestations of diabetes.

### Online Resources for Diabetes Care and Education Specialists and Families

<http://www.diabetes.org/living-with-diabetes/parents-and-kids/> [www.jdrf.org/t1d-resources/](http://www.jdrf.org/t1d-resources/)

<https://www.diabetescamps.org/>

<https://childrenwithdiabetes.com/>

<http://www.diabetes.org/living-with-diabetes/parents-and-kids/children-and-type-2/>

<https://www.uptodate.com/contents/cystic-fibrosis-related-diabetes-mellitus#H17626652>

<https://www.cff.org/Life-With-CF/Daily-Life/Cystic-Fibrosis-related-Diabetes/Managing-CFRD.pdf>

<https://www.cdc.gov/diabetes/basics/diabetes-type-1-diagnosis.html>

<https://www.diabetescamps.org/>

[https://diabetesjournals.org/care/article/45/Supplement\\_1/S208/138922/14-Children-and-Adolescents-Standards-of-Medical](https://diabetesjournals.org/care/article/45/Supplement_1/S208/138922/14-Children-and-Adolescents-Standards-of-Medical)

### Additional Resources:

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