Journal of Multidisciplinary Healthcare

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SHORT REPORT

Development and Implementation of a Multidisciplinary Clinic Focused on the Care of Adolescents with Youth-Onset Type 2 Diabetes

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Introduction: Diabetes self-management education and lifestyle interventions are the cornerstones of type 2 diabetes (T2D) care; however, the higher risk of comorbidities among youth with T2D requires a comprehensive care model. Traditionally, sub-specialty care relies on a referral model placing the burden on patients/families. In response, we developed a pediatric T2D multidisciplinary clinic (MDC)-A single physical location where patients can access various sub-specialists. The goals of the MDC are to aid with lifestyle modifications and provide referral/access to sub-specialists within the MDC, as determined through screening labs and assessment tools.

Methods: We conducted a retrospective chart review of youth seen in the T2D MDC clinic at Cincinnati Children's Hospital from 1/2020 to 12/2021. We evaluated the frequency that youth met with each specialist and completion rates of annual screening labs.

Results: The cohort consisted of 227 youth with T2D (mean age 17.6 years, mean BMI 40.9kg/m2, 64% female, 50% Black or African American, 65% public insurance). All patients met with a diabetes provider and 81.2% met with a registered dietitian/certified diabetes education specialist. Exercise physiology met with 51.5% of patients, gastroenterology met with 34.8% of patients, social work met with 44.1% of patients, clinical psychology met with 27.3% of patients, and bariatric surgery met with 9.7% of patients. Percent completion of annual labs were: 98.2% for HbA1c, 84.6% for urine microalbumin, 83.7% for lipids, 90% for liver function, 59.5% for retinopathy, and 45.4% for the Patient Health Questionnaire-9.

Conclusion: The majority of patients received diabetes and nutrition education and annual screening labs. Exercise counseling and sub-specialty care remain below 60% in part due to services not being available at every MDC. Our goals are to increase access to subspecialty care within the MDC's and consider additional care delivery methods to provide comprehensive care to youth with T2D.

Keywords: pediatrics, type 2 diabetes, multidisciplinary, adolescent, comorbidities

Introduction

Type 2 diabetes mellitus (T2D) is a chronic condition driven by both environmental and genetic factors. An increase in hepatic glucose production coupled with insulin resistance and impaired insulin secretion results in a relative insulin deficiency. Historically, T2D has been a disease of adulthood, but over the past twenty years the onset and prevalence of T2D among youth has dramatically increased. The Center for Disease Control and Prevention (CDC) projects the prevalence of T2D in those under 20 years of age will quadruple in the next 40 years.[1]

Received: 16 June 2023
Accepted: 7 September 2023
Published: 20 September 2023

Pediatric onset T2D appears to be a more aggressive condition as compared to adult onset T2D. The Restoring Insulin Secretion (RISE) study showed that pediatric T2D is characterized by greater insulin resistance and a faster rate of beta cell decline, emphasizing the need for aggressive and timely interventions in the pediatric population.[2] The SEARCH for Diabetes in Youth (SEARCH) and Treatment Options for Type 2 Diabetes in Adolescents and Youth (TODAY) studies also showed diabetes-related comorbidities (nephropathy, retinopathy, neuropathy, arterial stiffness, and hypertension) occur at higher rates among the pediatric T2D population as compared to the pediatric type 1 diabetes (T1D) population.[3,4] The TODAY study also highlighted the socioeconomic disparities that exist among youth with T2D (participants were majority persons of color and were more likely to be from single parent and low-income households) which can influence access to health insurance and reliable transportation and in turn medical care.[4,5]

Feelings of shame and blame are often reported among youth with T2D. This is thought to be in part due to the intergenerational burden of T2D within families and thus a strong understanding of potential long-term complications.[6] As compared to youth with T1D, the SEARCH study found that youth with T2D reported 50% higher depression scores and 10% lower quality of life scores.[6] Though depression has not been directly linked to blood glucose levels and A1C values, it is thought the association with health-related behaviors plays a large role in impacting diabetes outcomes. Higher rates of depression have been linked to inconsistent medication administration, lower readiness to adopt self-help behaviors, and higher rates of complications and co-morbidities.[6]

Given the increasing prevalence, specifically among youth from lower socioeconomic backgrounds, coupled with the more rapid disease progression and high prevalence of comorbidities in the face of economic and social barriers and higher rates of depression, it is imperative to develop a comprehensive model of care for patients with youth-onset T2D. Our traditional health care delivery model poses challenges to providing comprehensive care as it requires initial contact with a provider, assessment of co-morbidities, followed by multiple referrals for management of diabetes-related co-morbidities. This results in additional communication with the family, more time off work and school, and transportation to additional appointments, placing the burden of accessing care on the patient and family. Multidisciplinary clinics, on the other hand, integrate clinical care, treatments, and sub-specialty consultations into existing appointments.[7] Additionally, multidisciplinary care models have been shown to have positive clinical and economic outcomes in adults with T2D when compared to traditional health care delivery models.[7]

To address the comprehensive needs unique to pediatric T2D, Cincinnati Children's Hospital Medical Center (CCHMC) developed a pediatric T2D multidisciplinary clinic (MDC). The goal of the MDC is to provide access to a diabetes provider, registered dietitian, exercise physiologist and sub-specialists, if needed, in the same physical location. This paper serves to describe the current MDC model, report on demographics of the patient population, quantify co-morbidity screening through laboratory values, screening questionnaires and visit counts, quantify multi-disciplinary efforts, and discuss learnings and limitations to the current clinic model along with areas for growth. Our goal is that our model can be adapted, modified, and replicated by other pediatric institutions planning to start their own pediatric T2D MDC.

Materials and Methods

Design

The pediatric T2D MDC at CCHMC is held at the main campus location and one of the satellite locations (20 miles north of the main hospital campus). As shown in Table 1, the team is comprised of pediatric endocrine providers (medical doctors (MD) or certified nurse practitioners (CNP)), registered dietitians (RD) who are also certified diabetes care and education specialists (CDCES), an exercise physiologist, gastroenterologists (GI), a bariatric surgery team (MD, CNP, a specialized bariatric RD), a pediatric psychologist, and social workers. All providers' salaries are paid by their respective divisions.

Our team offers thirteen half-day multidisciplinary clinics per month. Every clinic consists of a diabetes provider (MD, NP), RD/CDCES, and social worker (Table 2). Then, a combination of exercise physiologist, gastroenterologist, psychologist, and bariatric surgery team are also present depending upon the day. This clinical design was intentional as every patient does not require every subspecialist, nor is every sub-specialist available to attend every MDC. Patients are recommended to obtain annual screening labs including a lipid panel, liver enzymes, microalbuminuria and referral for retinopathy screening, consistent with the American Diabetes Association Standards of Care Guidelines.[8]

Table 1 Sub-Specialty Providers and Their Roles

Diabetes Provider (MD or CNP)	Medically manage diabetes and diabetes related co-morbidities including medication adjustments; assess laboratory data; review psycho-social and ongoing health concerns
Bariatric Surgery Team	Meet with patients interested in or already pursuing bariatric surgery. Discuss risks and benefits. All patients require 6–9 treatment visits (in person or via telehealth, deemed by insurance) prior to obtaining clearance for bariatric surgery.
Gastroenterologist	Meet with patients who have elevated liver enzymes (ALT >40) x 2; evaluate for causes other than fatty liver by performing exclusionary work up (infections, genetics); pursue further investigation with imaging or liver biopsy if needed; provide management if non-alcoholic fatty liver disease is diagnosed
Psychologist	Provide brief evidence-based interventions for psychosocial concerns; promote adherence to medication management and lifestyle changes; identify psychosocial barriers to care and refer for mental health assessment and/or treatment
Exercise Physiologist	Obtain and discuss results of InBody scan; review physical activity and screen time guidelines; create an exercise prescription; set goals around physical activity
Certified Diabetes Care and Education Specialist/Registered Dietitian	Provide patients and families with complete diabetes self-management education in accordance with ADA curriculum requirements; teach how to properly use/administer medications; place and educate about continuous glucose monitors; provide nutrition education and coaching for lifestyle goals
Social Work	Complete psychosocial assessment of patients and refer to supports; mood screenings including same day assessment following elevated PHQ-9 screening and/or suicidal ideation; linking to resources; self-management education including college and safety planning; abuse screenings.

Table 2 Multidisciplinary Clinic Combinations

Combination #1 (5 of 13 clinics)	**Combination #2 (4 of 13 clinics)**	**Combination #3 (2 of 13 clinics)**
• Diabetes provider • RD/CDCES • Social Worker • *Exercise Physiologist*	• Diabetes provider • RD/CDCES • Social Worker • *Exercise Physiologist* • *Gastroenterologist**	• Diabetes Provider • RD/CDCES • Social Worker • *Gastroenterologist* • *Psychologist*
Combination #4 (1 of 13 clinics)		**Combination #5 (1 of 13 clinics)**
• Diabetes Provider • RD/CDCES • Social Worker • *Gastroenterologist* • *Bariatric Surgery Team*		• Diabetes provider • RD/CDCES • Social Worker • *Exercise Physiologist* • *Psychologist*

Notes: *By referral and in the GI clinic. Italicized text indicates unique providers available at each specific clinic.

Patients are also asked to complete the Patient Health Questionnaire 9 (PHQ-9) at least once annually. The PHQ-9 is a validated nine question depression assessment regarding feelings over the previous two weeks.[9] A total score is obtained by adding the score for each response. A total score of 1–4 indicates no to minimal risk of depression, a score of 5–9 indicates mild risk of depression, a score of 10–14 indicates moderate risk of depression, a score of 15–19 indicates moderately severe risk of depression and a score of 20+ indicates severe risk of depression.[9] If a patient scores ≥5 or indicates positive suicidal ideation (SI) regardless of score, they are referred to same day social worker for further assessment as per our clinical protocol for treatment of youth with diabetes.

Screening lab results, questionnaires, and discussions with the patient/family help guide which sub-specialists' patients may be strongly recommended to meet with. The team, patient, and family work to prioritize sub-specialist meetings while keeping in mind the number of providers a patient is recommended to meet with and length of the overall appointment.

Methods

This is a retrospective chart review of all youth with T2D who had at least one visit at the pediatric T2D MDC at CCHMC between January 2020 and December 2021. Data abstracted from the electronic medical record included patient age, sex, diabetes provider appointment, sub-specialist appointment, systolic and diastolic blood pressure, height in cm and weight in kg to calculate body mass index (BMI), date of retinal eye exam (if available), PHQ-9 screener completion rate and score, and the following laboratory data: total cholesterol, low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), triglycerides, hemoglobin A1c, alanine aminotransferase (ALT), and aspartate aminotransferase (AST). If a patient saw a sub-specialist more than once during the defined time period, only the first visit was counted. For referral to GI, elevated liver enzymes were defined as ALT or AST of greater than 40 units/L. This study was reviewed by Cincinnati Children's Hospital Medical Center Institutional Review Board and a waiver of exemption was granted. The data set was de-identified. Data are reported as numbers, percentages, and counts.

Results

There were 227 patients with T2D who had at least one clinic visit from January 2020 to December 2021 in the MDC. During this time frame 659 visits occurred, 103 of which were conducted via telehealth, for an average of 2.9 visits per patient. As shown in Table 3, the mean age of our patients was 17.6 ± 2.6 years (age range 11–26 years) with 90% of the

Table 3 Characteristics of Patients with Type 2 Diabetes in the MDC Clinic

Variable	Mean ± SD or n (%)
Age (years)	17.7 ± 2.6
Race/ethnicity	
Hispanic	19 (8.4%)
White	11 (4.8%)
Preferred category not available/Unknown/Other	8 (3.5%)
Non-Hispanic	206 (90.7%)
White	83 (36.6%)
Black or African American	115 (50.7%)
Asian	5 (2.2%)
Native Hawaiian and Other Pacific Islander	1 (0.4%)
Unknown/Other	4 (1.8%)
Sex	
Female	145 (63.9%)
Male	82 (36.1%)
Insurance	
Public	65%
Private	28.3%
Unknown	6.7%

patients being <21 years of age. Fifty percent of the patients self-identified as Black or African American, 36.6% identified as non-Hispanic white, and 8.4% identified as Hispanic. Sixty-three percent were female and 65% had public insurance. The clinical laboratory values of the patient population are shown in Table 4. The mean hemoglobin A1C was 8.0 ± 2.6%. Patients had a mean BMI of 40.9 ± 9.7 kg/m^2. Mean triglycerides, liver enzymes and urine microalbumin levels were all elevated compared to desired levels for pediatric patients.[5]

The goal of the MDC is to provide access to a diabetes provider, registered dietitian, and exercise physiologist in the same physical location, to assist with goal setting around lifestyle interventions, and access to sub-specialists as needed. As shown in Figure 1, 100% of patients met with a diabetes provider (MD or CNP), 81.2% had at least one CDCES/RD visit, and 51.5% of the population had at least one exercise physiologist visit during the defined time frame. Figure 1 also shows 44.1% of patients met with social work at least once, 34.8% met with gastroenterology, 27.3% met with clinical psychology, and 9.7% met with the bariatric surgery team at least once.

We aimed to identify which patients needed sub-specialist care through screening labs and questionnaires and then offer that care in the same physical location to reduce the healthcare access burden. Of the 227 patients seen in the T2D MDC, 84.6% had microalbuminuria screening, 87.7% had cholesterol screening, 89.9% had liver function tests and 59.5% completed retinopathy screening performed at an outside clinic. Of the 89.9% of the patients that had their liver enzymes drawn, 51% were found to have elevated liver enzymes. Of the 51% of patients with elevated liver enzymes,

Table 4 Laboratory Values + Questionnaire Responses of Pediatric Patients in the MDC Clinic

Variable	Mean ± SD (n=227)	Ideal Target*
Hemoglobin A1c (%)	8.0 ± 2.6	< 7.0
Body Mass Index (kg/m^2)	40.9 ± 9.7	
Blood Pressure (mmHg)		
Systolic	119 ± 11	<120
Diastolic	74 ± 10	<80
Cholesterol (mg/dL)		
Total Cholesterol	177 ± 38	<200
HDL-Cholesterol	38 ± 10	>35
LDL-Cholesterol	102 ± 28	<100
Triglycerides	214 ± 231	<150
Liver Enzymes (unit/L)		
ALT	67 ± 99	<40
AST	42 ± 49	<40
Microalbumin to Creatinine Ratio (mg/g)	45 ± 204	<30
Patient Health Questionnaire – 9 (PHQ-9)	103 (45.4%)	
None or Minimal risk of depression	49/103 (47.6%)	
Mild risk of depression	29/103 (28.2%)	
Moderate risk of depression	12/103 (11.7%)	
Moderately severe risk of depression	12/103 (11.7%)	
Severe risk of depression	1/103 (1%)	

Note: *Ideal targets are based on American Diabetes Association Standards of Care.[8]

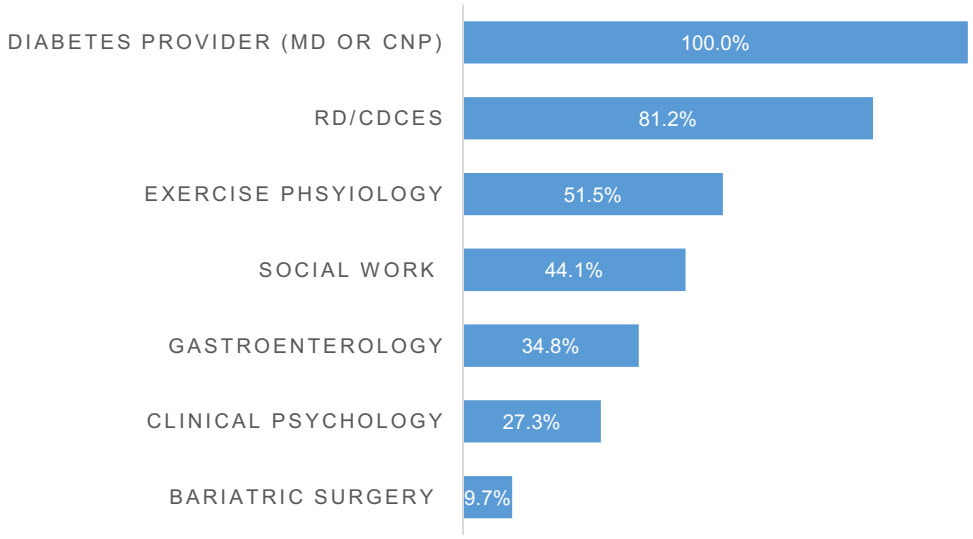

Figure 1 Percentage of patients who accessed sub-specialty care at least once within the MDC.

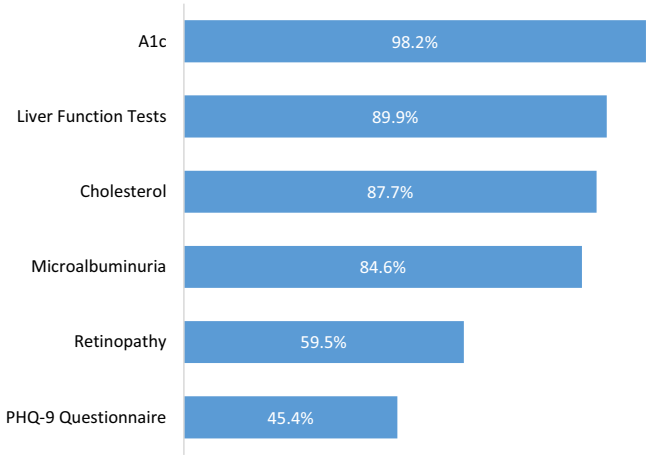

Figure 2 Percentage of patients who completed annual screening labs + questionnaire.

55.8% of them saw a gastroenterologist within the MDC. Of the 227 patients seen at least once in the MDC during the defined time frame, 45.4% of them took the PHQ-9 (Figure 2). Of those, 47.6% had scores consistent with no to low risk of depression, 28.2% had scores consistent with mild risk for depression, 11.7% had scores consistent with moderate risk for depression, 11.7% had scores consistent with moderately severe risk for depression, and 1% had scores consistent with severe risk for depression. Of the 52.4% of patients who scored a 5 or higher or who reported positive suicidal ideation, 96.3% saw a social worker on the same day as indicated by our clinical algorithm. An additional 48% of patients met with social work independent of their PHQ-9 score.

Discussion

By establishing a pediatric T2D MDC at CCHMC we have been able to reinforce the cornerstone of T2D treatment by providing access to both RD/CDCES and an exercise physiologist. RD/CDCES are available at every MDC and 81% of the population chose to utilize them at least once during the defined time frame. Exercise physiology is available at 75% of the clinics (Table 2) and 53% of the population chose to meet with them at least once. Lower rates of exercise physiology utilization suggest not all patients take advantages of these services and may be explained by prioritization of medical or social needs, developmental delays limiting one's ability to be physically active, or time constraints from the

family. Keeping lifestyle modifications at the forefront of youth-onset type 2 diabetes care, we intend to have an exercise physiologist at every clinic so that they are embedded in every visit.

Non-alcoholic fatty liver disease is a silent but serious co-morbidity of type 2 diabetes. Fifty one percent of the pediatric patients with type 2 diabetes at CCHMC were found to have elevated liver enzymes, yet only 55.8% of those with elevated liver enzymes accessed care from a gastroenterologist within the MDC. This is likely because gastroenterologists are only in the same physical space as the diabetes provider 23% of the time (Table 2). Thirty percent of the time a GI provider is available at the same time, but in an adjacent building at the medical center, thus patients must move physical spaces for access to the gastroenterologist. It is also possible that patients saw GI outside of the MDC (traditional referral with separate encounter) and we were unable to account for these. These data suggest a greater need for additional access to gastroenterology within the MDC and consideration for novel models of care in the future including telemedicine visits with the GI provider from the diabetes clinic.

Pediatric bariatric surgery in the MDC is a unique offering at CCHMC. Despite the option for weight loss surgery being available and discussed with all qualifying patients (BMI $\geq$ 35 kg/m^2), which was 65.6% of the population, only 9.7% of youth with T2D chose to meet with the bariatric surgery team. This may reflect apprehension to weight loss surgery in this age group and suggests lifestyle and medical management remains mainstay of care at this time. This also highlights the need for additional research in this area to better understand reasons for patient's declining referrals.

Depression exists among our pediatric patients with T2D. A large focus of our social workers role is to assess PHQ-9 questionnaire scores $\geq$5 and/or positive SI and ensure patients have a plan (safety plan, referral to outpatient clinical psychology/therapy, or referral to the emergency department) prior to leaving clinic. Of the patients that completed the PHQ-9, 52.4% had scores suggestive of mild risk of depression or higher ($\geq$5+), and of those, almost all met with a social worker (96.3%). However, the true risk of depression in this population may be underestimated because only 45.4% of the population completed the PHQ-9. Incompleteness of PHQ-9 scores may be because this data is pulled from a flowsheet that the provider must fill out. If the flowsheet was not completed, the data was not captured, a limitation of this study. Additionally, the PHQ-9 is an automatic questionnaire administered via a tablet at the time of registration. Unanswered questionnaires are another possibility for incomplete data.

Given the psychosocial complexity of many of our patients, we have a clinical psychologist as part of the MDC that uses evidence-based practices to help assess and mitigate the psychosocial barriers (eg, depression, anxiety, attention deficit disorder and social stressors) to implementing medication and lifestyle recommendations. Currently, our clinical psychologist is only available at 23% of MDC's and thus utilization rates are low (27.3%). Increasing psychology availability within the MDC is one goal and utilizing other hospital and community resources is another possibility to increase psychology services to our patients.

Traditional pediatric T2D care relies on a referral model and places the burden of access on the patient and family. The MDC at CCHMC offers care with multiple different sub-specialists in one location in an effort to reduce this burden. Utilizing the MDC reduces the need for multiple appointments on different days, simplifies transportation scheduling, decreases the days the parent/caregiver must be away from work and time the child is away from school. While the MDC model is an ideal intervention for any family; it is especially important for our pediatric T2D population who are traditionally from a lower socioeconomic status and single parent households.[4]

On the contrary, patients can only absorb so much information at one visit, so prioritization is key for helping the MDC run smoothly and keeping patients engaged. We utilize screening labs, questionnaires, and conversation with the patient and family to help prioritize which sub-specialist's patients would prefer to meet with at the appointment. Social situations are also part of the prioritization process. Food insecurity, transportation barriers, housing, pharmacy/medication access barriers are all common social issues we see in the MDC. To reduce visit time, we often pair providers to go in the room with the patient together (this often happens with diabetes provider + RD most often). We also try to anticipate the needs of patients to ensure patients receive correct follow up. For example, if a patient has elevated liver enzymes, we scheduled them for follow-up into the multidisciplinary clinics where GI will be present. Ultimately, the need for prioritization and family desires are strong contributors as to why sub-specialist visits are below 100% even if medically indicated.

During the peak of the COVID-19 pandemic, our clinic moved to a model that readily incorporated telehealth visits. Telemedicine allowed diabetes providers to ensure patients were receiving medications and provided a space to address health care needs during a time when in-person care was not able to be delivered or there was apprehension. Over 17% of the MDC visits from January 2020 – December 2021 were conducted via telehealth. While this was an important accommodation during the peak of COVID-19, the use of telehealth likely resulted in lower diabetes-related co-morbidity screening since A1C and microalbumin screening are done as point of care (POC) testing in our clinics. Telemedicine visits also likely contributed to lower rates of sub-specialist visits given sub-specialists were not available during telemedicine visits. While telemedicine paired with laboratory testing is an option to ensure glycemic management is assessed and screening labs are completed, technology and connectivity have been limitations of its widespread use.

Though it was not examined within this study, the MDC also experiences a high rate of missed appointments. The average patient visit count was 2.9 over a 24-month time frame while ideal, per the ADA guidelines, should be 6–8 visits, indicating an appointment every 3 to 4 months. To maximally utilize the provider's time and expertise, appointments are often double booked or overbooked in anticipation of cancellations or missed appointments. We have started to schedule follow-up visits in the room (instead of asking the family to stop by the front desk to schedule on their way out) in an attempt to improve no-show rates. Lastly, we are in the process of creating a care team model in which each provider would be paired with a clinic RN who would be able to contact families prior to their visit to address barriers to attendance and intervene prior to the visit.

Lessons Learned/Path Forward

While screening questionnaires can help illuminate patient needs that may not come up in conversation, we have found not all diabetes-related questionnaires are helpful in advancing clinical care. For example, the Pediatric Quality of Life Inventory (PEDS-QL) has many questions related to insulin management and blood glucose monitoring which do not always relate to the pediatric T2D population. Instead, we are in the process of adding questionnaires that may be more relevant including social determinants of health to assess social and economic barriers, the University of Michigan Pediatric Sleep Questionnaire (PSQ) to assess for obstructive sleep apnea, an adapted version of the Eating Disorder Diagnostic Scale (EDDS-5) that focuses on identifying disordered eating and body image, and the Type 2 Diabetes Distress Assessment System (T2-DDAS) that focuses on understanding how much overall emotional distress due to diabetes a patient is experiencing.[10] Ongoing assessment of the utility of these questionnaires by providers are balanced with the burden to patients and families. Another enhancement to our clinic includes the addition of a retinal camera (added in 2022 and currently under research protocol) so annual retinal screening can be performed annually during clinic visits, without the need for dilation. Lastly, due to the complex nature of T2D care, a hope is to get a T2D clinic coordinator that can assist with scheduling, lab follow-up and to aid with prior authorization requests for medications.

For programs desiring to design a MDC clinic, we advise identifying providers that have a specific interest in pediatric T2D care. The core team should consist of medical providers, an RD, a CDCES, and a social worker who are available at the same time. Assess the needs of your patients to determine which sub-specialists are most needed within your MDC. Identify a physical space that includes appropriate resources (eg, POC hemoglobin A1C machine). Advertise the clinic within your center and to local pediatricians. We highly recommend creating a system where patient visits can be captured for data analyses and quality improvement efforts. Lastly, meet with the team at regular intervals to develop standard protocols for treatment and management of co-morbidities.

Conclusion

Creation and implementation of a pediatric T2D MDC allows for targeted lifestyle interventions and access to sub-specialty care to occur within the same physical space. We believe this is a comprehensive care model designed to meet the multiple needs of this patient population despite the time constraints of families and patients. Our hope is that other centers hoping to start or refine their own pediatric T2D MDC can utilize and/or replicate our design and take into account our learnings.

Abbreviations

T2D, Type 2 diabetes; MDC, multidisciplinary clinic; CDC, Center for Disease Control and Prevention; TODAY, Treatment Options for Type 2 Diabetes in Adolescents and Youth; RISE, Restoring Insulin Secretion; SEARCH, The Search for Diabetes in Youth; T1D, type 1 diabetes; CCHMC, Cincinnati Children's Hospital Medical Center; MD, medical doctor; CNP, certified nurse practitioner; RD, registered dietitian; CDCES, certified diabetes care and education specialist; GI, gastroenterologist; PHQ-9, patient health questionnaire-9; LDL-C, low density lipoprotein cholesterol; HDL-C, high density lipoprotein cholesterol; ALT, alanine aminotransferase; AST, aspartate aminotransferase; PEDS-QL, Pediatric Quality of Life Inventory; PSQ, University of Michigan Pediatric Sleep Questionnaire; EDDS-5, Eating Disorder Diagnostic Scale; T2-DDAS, Type 2 Diabetes Distress Assessment System.

Acknowledgments

We would like to thank the patients and families who have allowed us to care for them in the T2D MDC at CCHMC. We would also like to thank the Junior Cooperative Society at CCHMC for providing funding to purchase the retinal camera for the clinic. Finally, we would like to thank CCHMC for supporting the development of this program.

Disclosure

The authors report no conflicts of interest in this work.

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