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Factors that Impact Glycemic Control in Adolescents with Type 1 Diabetes

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Abstract:

The incidence of Type 1 Diabetes (T1D) is increasing worldwide and is diagnosed disproportionately in adolescent populations[1,2,3]. Additionally, studies show that adolescents with T1D experience worse glycemic control during this developmental period[6,13,15,18]. Maintaining glycemic control in patients with T1D decreases the risk of developing future diabetic-related complications[3,6,14]. Factors such as race, ethnicity, gender identity, sexual orientation, socioeconomic status, and medical comorbidities influence disparities in maintaining glycemic control in adolescents[6,11,12,13,15, 17]. The recognition of these factors on the management of T1D through an integrative team approach leads to increased glycemic control and decreased diabetic-related complications[6,15,19,20,21]. This paper explores the effects of psychosocial factors and addresses recommendations for effective interventions through multidisciplinary care. The literature reviewed in this paper indicates that improving healthcare access, implementing behavioral interventions, and increasing the use of diabetic technologies in adolescent populations have improved glycemic control and decrease disparities in healthcare outcomes. A multidisciplinary team increases patient education and aids in managing and screening for comorbidities. Team-based management of T1D also provides behavioral specialists that can implement strategies that improve self-management skills and familial involvement[15, 21,30,35,43]. Modern diabetic technology has given patients the tools to increase their healthcare access. It has been shown to improve their self-management skills and has allowed providers to individualize treatment plans further using data analytic software[48,49,50]. Improving glycemic control in adolescence relies on physical and emotional support from healthcare providers and caregivers.

Introduction:

The incidence of Type 1 Diabetes Mellitus (T1D) has been increasing at a rate of 3-4% globally since the 1950s [1]. This increase is of particular concern to individuals younger than 18 years of age as this population has seen the highest increase in incidence, and the majority of diagnoses made are between 10-14 years of age[1]. The U.S. has one of the highest incidences of T1D worldwide and is one of the most common endocrine disorders in children and adolescents, currently affecting 200,000 people under the age of 20[5]. T1D impacts those diagnosed and their caregivers financially, physically, and emotionally[2,6]. In order to maintain a physiologically normal blood glucose level, patients make an additional 180 decisions per day by evaluating glycemic levels using self-monitored blood glucose checks (SMBG) and adjusting insulin doses based on food intake and activity level[1,6]. To assess glycemic control in a patient, providers monitor hemoglobin A1c values (HbA1c), which indicate the average blood glucose levels throughout three months[6]. To avoid future diabetic-related complications, the American Diabetes Association recommends that HbA1c goals be between 7.0-7.5% for patients with T1D between 13-19 years old[6].

The ability to maintain adequate glycemic control within the individualized parameters determined by the healthcare provider is well-established as the chief influence in preventing complications related to T1D[2,3]. Complications of T1D are typically microvascular and macrovascular complications requiring rigorous lifelong management and countless medical supplies. Patients with T1D are immunocompromised and at higher risk for additional autoimmune disorders and mental health disorders, which can compromise glycemic control and add to the difficulty of treatment management[11,12,13,28]. Overall, patients with diabetes have a younger age for mortality than the general population[14]. According to a retrospective cohort study from 2015, the mortality rate for patients with T1D in the U.S. is 5-7 times higher than the mortality rate in other developed countries[14]. Adolescent patients with T1D are of particular concern because studies have shown that glycemic control is likely to deteriorate during this developmental period and can contribute to further complications in the future[3,13,14,16,17]. Older adult populations are typically diagnosed with T1D-related complications. This pattern is attributed to the direct relationship between the duration of the disease and the development of diabetic-related pathologies, suggesting that avoiding complications of T1D relies on the implementation of prevention strategies in younger age groups[7]. In addition to the increase in the prevalence of T1D in adolescent populations, studies show that patients in this age group experience a decline in glycemic control, indicating that adolescence is a "high-risk developmental period" for patients with T1D[5,6,15,18]. Therefore, improving care in this population may reduce future morbidity and mortality rates for all patients with T1D.

Although the term "adolescent" is commonly used and indicates a period of development between childhood and adulthood, specific age-based definitions vary depending on sources. Therefore, this paper bases adolescence on the World Health Organization (WHO) definition of 10-19 years[10]. The American Diabetes Association (ADA) recognizes that the management of T1D in adolescents has unique considerations and should be thought of independently from other age groups [6]. This consideration is necessary because adolescents are experiencing biological maturation through puberty, cognitive maturation through improvements in critical thinking and reasoning skills, and becoming more independent, self-aware, and more attached to peer groups[6]. This transition period is vulnerable to influences that impair the management of T1D because glycemic control commonly deteriorates through adolescence, and patients appear to have difficulties achieving glycemic control when transitioning from pediatric to adult care[5,18]. These findings imply that psychosocial factors partially influence the ability to achieve glycemic control, and adolescents require additional care and support from their providers to accomplish their treatment goals[6,11,12].

Psychosocial factors are imperative to acknowledge and understand because of their impact on the management of T1D[6,11,12,13,15, 17]. T1D is a systemic disease requiring daily and intensive treatment. The constant intensity of T1D allows many elements to influence patients' ability to maintain glycemic control through physiological changes, comorbidities, healthcare access, and intersectional factors like socioeconomic status (SES), race, gender identity, and sexual orientation[11,12,13,15,19,22,23]. The relationship between glycemic control and psychosocial experiences is difficult to determine because it is complicated. However, increasing provider understanding and awareness of these impacts can lead to improved glycemic control through targeted interventions[13,15,22,54]. Moreover, it is not just the adolescent stage that impacts glycemic control in patients with T1D; there are many social influences on morbidity and mortality in patients with T1D. Across all age groups and socioeconomic strata of patients with T1D, non-White, female patients have a mortality rate approximately three times higher than their white male counter parts[14,16]. Adolescents maintain this pattern, which makes psychosocial influences imperative to study to fully understand how glycemic control is affected in this age group.

The recognition of health disparities and the influences of psychosocial factors on the management of T1D through an integrative team approach leads to increased glycemic control and decreased diabetic-related complications[6,11,12,13,15, 17]. This paper will explore the psychosocial factors that impact blood glucose control of T1D in adolescents, the interventions that most successfully address these elements, and recommendations to primary care providers on how to address these issues through multidisciplinary care.

Background: (Literature Review)

Adolescent Development and Behavioral Interventions

Adolescence is a period of biological, social, and psychological maturation. This unique developmental stage is vulnerable to psychosocial influences that affect the morbidity and mortality of adolescents with T1D diabetes. During this period of development, adolescents are attempting to forge autonomy financially and socially, all while battling a chronic illness that takes up a considerable amount of their time[6]. Considering the effects of psychosocial factors is especially important in adolescents with T1D because it is a chronic disease requiring intensive daily treatment. This population is navigating through quickly changing social, academic, and professional landscapes and are evolving physically, mentally, and socially. These changes have effects on the pathology of T1D forcing patients in this age group to reevaluate how to maintain glycemic control[6]. For example, puberty causes an increase in insulin resistance and hormonal changes that necessitates the adjustment of insulin dosages[6]. Refining treatments to account for these changes also appears to be especially challenging in this population because adjustments to insulin regimens have harmful side effects for adolescents[6]. The ADA has published protocols to lower HbA1c levels that are specific to adolescents. These protocols are necessary because this population has an increased risk for hypoglycemia due to physiologic changes unique to this age group[6]. The mixture of biologic and psychosocial changes throughout adolescence makes managing T1D in this population a delicate and unique process because of the impact these factors have on blood glucose levels.

The most apparent change during the psychosocial development of adolescence is the strive to develop autonomy from their parents and to learn skills that allow them to be responsible for themselves. These patients are not only transitioning into adulthood physically but are also maturing mentally. Although learning to manage with less supervision is an essential part of this stage, adolescents with T1D may need more support than has been historically provided. Studies show that during the years of transition to adult care from pediatric care, patients with T1D had an increased risk of poorer glycemic control showing HbA1c values 2.5% higher than their counterparts that remained in pediatric care[17]. This deterioration of glycemic control was independent of previous levels of control while in pediatric care, suggesting that it is some aspect of the transition that is causing poorer control in this population[18]. The cause of the barriers to transition is most likely multifactorial, including lack of standardization of transition protocols for providers, perceived differences in care methods from adult and pediatric providers, and patients feeling uncomfortable or unprepared to leave their pediatric endocrinologist[18,19].

Developing a better understanding of why adolescents seem to struggle with this transition is vital for improving T1D management and reducing future complications. Research that implements behavioral management in adolescent T1D treatments may help answer this question. Studies have shown that adolescents who experience higher self-efficacy and routinely expect positive outcomes achieve improved glycemic control[20]. Improvements in an individual’s ability to control one’s actions, emotions, and thoughts to reach set goals, known as self-regulation, are correlated with improvements in T1D management[20]. These findings suggest that behavioral interventions may be useful in this population[19,20,21,22,23].

Research trials of behavioral management strategies studied the effects of these methods on glycemic control in T1D. One strategy is known as Coping Skills Training (CST). It attempts to improve self-management skills in stressful social situations and deter harmful coping mechanisms through group workshop sessions[20]. Adolescents taught to use CST showed improved glycemic control compared with individuals who did not use CST[20]. Although a more thorough understanding of these results is still required, research does indicate that this population still requires emotional and physical support from caregivers to improve glycemic control[6,18,19,20,21,22].

Adolescence is a time that can cause shifts in family dynamics because of social and developmental changes. It is common for caregivers to assume that adolescent patients can take on managing most of their T1D on their own because this age group can independently accomplish many treatment tasks and have a decent understanding of the disease[6]. However, family involvement throughout adolescence appears to be important for glycemic control as patients with T1D appear to meet treatment goals more often when they experienced greater parental involvement and greater amounts of emotional and physical support[6,20,22]. A randomized control study showed improvements in glycemic control when employing behavioral interventions that focused on familial involvement compared to adolescents with T1D receiving standard care[20]. The two interventions studied are referred to as "Family Teamwork" and "Behavioral Family Systems Therapy" and resulted in improved glycemic control for two years and 18 months, respectively, following each intervention[20]. Furthermore, family conflicts intensify due to the added stress diabetes management has on caregivers, siblings, and patients[6,15,22]. The incorporation of behavioral interventions with T1D treatment plans that provided families with diabetes education, developmental education based on the age of the patient, and training for familial communication and conflict prevention and resolution following routine diabetic care appointments have been shown to improve glycemic control[15,20].

Motivational interviewing (MI) is another behavioral intervention that attempts to help patients decipher what intrinsically motivates their behaviors through collaborative conversations[23]. A randomized control study from 2013 found that youths with T1D provided MI had a 2% decrease in HbA1c levels after three months of MI treatment[25]. MI implementation decreased HbA1c levels more in patients who had higher HbA1c levels before treatment, and all patients saw even greater improvements when caregivers were involved[25]. Behavioral interventions that decrease the impact psychosocial stressors have on human physiology appears to improve glycemic control.

External stressors can have a substantial impact on glucose control because it is a complicated systemic disease. In addition to familial stress, another example of an intense stressor that adolescents experience is peer-related stress. The demands of SMBG, potentially wearing a pump and having to be more conscious of food intake, make this disease visible to people outside of the care team. Patients with T1D report issues with self-esteem, peer pressure, feeling "different," and feeling judged by their peers when caring for their diabetes[25]. In a randomized control clinical trial that aimed to determine the types of stressors adolescents experience, adolescents with T1D responded to interactive questions about "general life stressors" and "diabetes-related stressors." Researchers evaluated these responses and found that adolescents experienced "general life stressors related to their developmental age" most often, but "diabetes-related stressors" were of higher magnitude and influenced their perceptions of "not fitting in" with peers more than their "life stressors"[25]. These findings indicate that adolescents with T1D experience more stressors than the general population in their age group and that peer influences and perceptions may be a very impactful motivator to achieving glycemic control in adolescents.

An increase in dependence on peer relationships and yearning for more independence is common in adolescence[6]. This combination exposes individuals to scenarios that they have not experienced before, such as driving and experimenting with drugs, tobacco, alcohol, and sex[6].

Navigating through these new experiences can be difficult psychosocially and can also affect the management of T1D. The ADA recommends that the provider discuss these topics proactively with their patients with T1D[6]. The intensity of peer influence is also a positive factor within this population as peer-group interventions have shown to improve treatment adherence.

An example of this is the shared medical appointment model (SMA). SMA is a newer strategy that aims to deliver patient education more effectively and enhance patient support through peer interactions and provider feedback[26]. Patients with T1D attend appointments in groups to ask questions and discuss issues that individuals have with provider input and supervision. Although there is little research on how these appointments impact glycemic control in adolescents with T1D, patients and providers have reported perceiving benefits such as increased knowledge of the disease as well as increased support during lifestyle discussions[26].

Effects of Comorbidities

Although biopsychosocial influences impact T1D in all stages of life, adolescents appear to be particularly sensitive to the factors which affect their ability to properly manage diabetes by performing physical tasks such as SMBG and intricate cognitive tasks such as determining insulin dosages and how to remedy abnormal blood glucose levels. Patients with T1D experience comorbid conditions, including endocrine diseases, metabolic disorders, and psychological disorders at a much higher rate than the general population[6]. Studies have shown that if an individual is diagnosed with T1D in early adolescence, they are at increased risk for mental health disorders[26]. According to the ADA, adolescents with T1D are three times as likely to have a psychiatric disorder like major depressive disorder or anxiety than their peers. These patients also have a 30% chance of being diagnosed with a psychiatric disorder within 15-20 years of T1D diagnosis[6,27]. Psychiatric disorders are worrisome in adolescents because this age group commonly struggles with glycemic control, and a decline in mental health can impair cognitive and physical abilities, further inhibiting the management of T1D[27].

The effects of T1D are systemic and fluctuate continuously throughout the day, allowing additional pathologies to influence its management severely. T1D may even contribute to the etiology of some disorders like psychiatric disorders[27,28]. Several studies have indicated a correlation between psychiatric disorders and T1D, although there is no consensus of the origins of this relationship[27,28]. A retrospective cohort study from 2018 shows that patients who had elevated levels of HbA1c (>8.5%) within the first two years of T1D diagnosis were more likely to be diagnosed with a subsequent psychiatric disorder such as depression or anxiety[27]. The same study concluded that 46% of 1,035 patients with T1D were diagnosed with two or more psychiatric disorders, and 22.8% were diagnosed with three or more psychiatric disorders, which are higher rates than the general population experiences[27]. Additionally, suicidal ideation is also found in much higher rates in adolescents recently diagnosed with diabetes than the general population, with 26.4% reporting thoughts of suicide. However, suicide attempt rates of adolescents with T1D reflects similar percentages of the general population[6].

Although the cause of psychiatric disorder development in T1D is unknown, research has found a correlation between glycemic control and mental health disorders. Poor glycemic control correlates with increased risk of developing a psychiatric disorder, and the ability to maintain glycemic control decreases when patients are diagnosed with a comorbid mental illness[27]. A retrospective cohort study in 2018 found that patients who had a preexisting mental health disorder when they were diagnosed with T1D were more likely to have elevated HbA1c levels during the first two years of management compared to patients without a preexisting psychiatric disorder[27]. Depression is also positively correlated with increased rates of DKA in adolescents[6].

The other common mood disorder diagnosed in patients with T1D is generalized anxiety disorder (GAD). Anxiety poses a unique threat to T1D because its symptoms may mimic hypoglycemic episodes, furthering hypoglycemic anxiety, and complicating patients' ability to discern when they are having a hypoglycemic episode[28]. Anxiety surrounding the fear of needles is also a debilitating factor for patients newly diagnosed with diabetes and negatively affects glycemic control[39]. Implementing a multidisciplinary team specializing in T1D management has shown to improve glycemic control, mental health conditions, and health care costs[28].

In addition to mood disorders, eating disorders are of great concern for providers caring for patients with T1D because of the increased morbidity and mortality they can cause in this population. For example, patients with T1D who suffer from anorexia are sixteen times more likely to die than their non-diabetic counterparts[6]. Patients with T1D who are classified as females are twice as likely to develop an eating disorder than the general population[28]. However, the research may be biased to focus on eating disorders in females with T1D[28]. According to the ADA, 31-40% of women ages 15-30 with T1D report disordered eating patterns such as binge-eating, and insulin restriction[28]. In light of this, the ADA recommends screening for eating disorders when patients experience recurrent DKA episodes or refractory poor glycemic control6. Whether there is a difference between the prevalence of eating disorders within adolescent diabetic populations versus the general public is still being debated. However, patients with diabetes are at risk for an eating disorder unique to patients with diabetes, referred to as "insulin omission"[6]. Adolescent females have higher rates of developing this disorder and had worsened glycemic control, microvascular complications, and hospitalizations[28]. Whether eating disorders are more prevalent in patients with diabetes than in the general population, all disordered eating inhibits glycemic control, increased rates of hospitalizations, and diabetic-related complications such as retinopathy, neuropathy, and premature death[28]. Because the rates of mood disorders, eating disorders, and psychiatric disorders in patients with diabetes are high in adolescents, recognizing, appropriately treating and preventing the progression of these conditions will improve T1D management and help prevent future diabetic-related complications.

Another example of psychiatric diseases specific to T1D is Diabetic-related Distress (DRD). DRD is seen in 41% of patients with T1D and is defined as distress related to the self-management of diabetes, including perceptions of support, access to quality health care, and the emotional toll management of chronic disease and requires different treatment strategies than other mental health disorders[29]. Distinguishing this disorder from other psychiatric disorders is essential because DRD is unique to patients who must adhere to diabetes management, is more often chronic, and is closely linked to an individual's glycemic control than other psychological disorders such as depression and anxiety[29]. For example, based on a randomized control trial concluded that "emotion-focused" and "educational/behavioral" interventions in patients with elevated D.D. and HbA1c levels significantly improved the psychologic symptoms and increased glycemic control as compared to those without these treatments[29]. Because the improvements in HbA1c levels were modest compared to the decrease in D.D. symptoms, researchers suggested that continuous screening and implementation of behavioral management may improve HbA1c levels by preventing DD[29]. Patients with T1D have unique considerations when it comes to psychiatric disorders and may require multidisciplinary care to recognize, prevent, and treat these conditions.

Impact of Intellectual Disabilities

Another population that requires special considerations and a collaborative model approach are individuals with intellectual disabilities (I.D.). Research suggests that populations that suffer from I.D. are at a heightened risk of developing T1D due to effects from developmental syndromes[30]. For example, patients who have Down Syndrome are at the highest risk of developing T1D compared to other intellectual disabilities[30]. This patient population is of particular concern because impairments in neurodevelopment are associated with deficiencies in executive functioning and may lead to worsened glycemic control outcomes because of poor adherence to treatments[27]. These patients were also more likely to have comorbidities such as hypertension and hyperlipidemia and worsen glycemic control than their non-disabled, T1D counterparts[30]. Obesity and a propensity for a more sedentary lifestyle have been associated with individuals with I.D. and are known to aggravate diabetic-related complications[39]. Healthcare access is limited among this population leading to worsened preventative healthcare, medical education, and treatment outcomes[30].

Compromised communication between the healthcare and the patient may be a portion of the problem as many people with I.D. communicate differently than the general population and may require extra, focused patient education strategies[30]. Evidence of ineffective communication is apparent when examining rates of routine screening tests for T1D within this population. People with diabetes with I.D. who were 16 years and older were likely to miss their yearly diabetic appointments, and even when they saw a provider, they were still less likely to receive the same screening evaluations as the general population[30]. A 2018 study in Canada showed that 94% of patients with T1D and I.D. saw their primary care provider, but only 52% received blood glucose checks, 44% underwent lipid evaluation, 29% were screened for retinopathy, and only 19% were evaluated for microalbuminuria[30]. Screening for diabetic-related complications and additional comorbidities is a routine part of check-ups for patients with T1D and is especially crucial in patients with I.D. because they are at higher risk for developing comorbidities than the general population.

In addition to the lack of routine screening, patients in this population have also demonstrated poor glycemic control in several studies. A U.K. cohort study of 125 individuals found that 50% of patients with I.D. and T1D did not meet HA1c goals even when they were in contact with their providers[30]. With uncontrolled glycemic levels, an individual is at risk for experiencing symptoms related to hyperglycemia and hypoglycemia, which can both be medical emergencies. Patients with I.D. are more likely to have undiagnosed medical conditions, including these acute complications of T1D due to a phenomenon called "diagnostic overshadowing"[30]. Providers tend to attribute the symptoms an individual is experiencing to their diagnosis of I.D. instead of diabetic-related complications[30]. This false attribution puts these patients at a higher risk of not receiving adequate emergent medical attention. Although studies have not explicitly evaluated how I.D. affects T1D management in the adolescent population, the studies show deteriorating glycemic control starting at age 16, which suggests that this population may also have difficulty transitioning from pediatric to adult care with the added barriers related to their I.D. diagnoses. This research also highlights the importance of screening in this population because poor control can be related to comorbid-related influences, and these patients are at risk for suffering from undiagnosed disorders.

Intersectional Effects on Healthcare Access

Socioeconomic Status, Healthcare Costs and Health Insurance

The inability to access quality healthcare appears to affect specific populations disproportionally and leads to difficulties managing chronic conditions such as T1D [8,11,12,13,22]. The inability to access healthcare is attributed to structural barriers within the healthcare system and affects metabolic control in T1D. Patients of lower SES have worse glycemic control and have higher rates of complications from T1D[8]. Individuals on public insurance and from single-parent households are also more likely to have poor glycemic control[8,21]. Adolescents of lower SES may experience poorer glycemic control due to a lack of resources, decreased ability for caregivers to provide supervision of T1D management, and an increase in social stressors than those of higher SES[8].

The connection between glycemic control and SES is multifactorial with physiological and social roots. A study by Zilioli et al. attempted to determine the cause of this phenomenon by examining the relationship between life stressors, diabetes-related stress, and glycemic control. Researches collected demographic data through questionnaires from 66 participants aged 16-20 years and measured diurnal cortisol levels from saliva samples taken four times a day for two weekdays and two weekend days[8]. The study found that lower SES was associated with higher levels of stress, and researchers hypothesized that class discrimination and insufficient resources were responsible for this relationship[8]. This research team hypothesized that these psychological stressors might impact patients with T1D by disrupting the hypothalamic-pituitary-axis, which assists in regulating blood glucose levels and causes an increase in cortisol levels[8]. Increased cortisol levels result in increased gluconeogenesis, inhibition of insulin sensitivity, and decreased uptake of glucose in the periphery[8]. This study confirmed that individuals of lower SES who reported more stressors had patterns of cortisol release associated with higher levels of HbA1c[8]. These studies imply that patients' ability to feel secure in accessing their medical supplies and treatment needs impacts the care of T1D.

Although medical needs for T1D is individualized to each patient, every patient requires insulin to survive. Patients with T1D also have additional provider visits, hospitalizations, and more medical supplies than the average adolescent. Those services require patients with T1D to pay more for healthcare than the general public, but the price of insulin alone may be the most significant financial burden on patients with T1D[31]. Multiple studies show that this healthcare cost affects T1D management. For example, a study published in 2020 concluded that insulin accounted for 18% of all out-of-pocket medical spending in patients with T1D on private insurance[31].

Additionally, patients of lower SES were less likely to be on insulin pump therapies, and if patients that felt as though they were paying high costs for test strips, they were less likely to perform SBGM sufficiently. Both of those interventions are known to improve glycemic control in T1D[21]. Insecurities about costs can lead patients to apply unhealthy coping strategies. A survey from 2019 determined that 25% of individuals who visited an outpatient diabetes center in Connecticut reported underuse of their insulin due to cost. Of these patients, 37% of them did not discuss this issue with their providers[32]. The cost of lifesaving measures for T1D has caused such a burden on adolescents that there are multiple incidences of fatalities caused by patients purposely giving themselves lower doses or fasting to save more insulin[32,33]. Insecurities in medical payments not only affect long-term management of T1D but also can cause severe acute complications and appear to be an issue that patients do not eagerly bring up with their providers.

Health insurance coverage is another uncertainty that patients with T1D in the U.S. experience disproportionately to the general population. The insecurity of healthcare insurance coverage is a massive burden because the cost of T1D is expensive due to medical supplies, the cost of insulin, and provider appointments. For example, the CDC estimates that adolescents with T1D pay an average of $9,333/year for medical costs than $1,468/y without T1D[34]. These uncertainties related to healthcare coverage can be an intense stressor for patients. A cross-sectional study examined data from national population-based surveys from 1999-2006 and found that glycemic control improved with better health insurance coverage[11]. A more recent cross-sectional study in 2018 determined through analyzing data from surveys from 2010-2016 that although healthcare insurance coverage has improved for all ages since the Affordable Care Act was implemented, adolescents, as well as young adults, are still at a higher risk than other age groups to be uninsured[35]. The issue of adolescent coverage was also independently addressed in the ACA, allowing patients to remain on their parent's health insurance until they are 26 years old[34]. According to this research, insurance coverage is a known threat to receiving adequate healthcare in adolescence, impacting treatment outcomes for T1D.

Structural Barriers

Further social elements such as race, ethnicity, gender identity, and sexual orientation are related to healthcare access and healthcare outcomes[12,13,17, 21,36,37]. A theory called the "minority stress perspective" explains why cultural and ethnic minorities experience poorer health than the majority population[36]. Minority populations experience discrimination and maltreatment daily, which triggers the sympathetic nervous system to deal with the stress[36]. When experienced daily, this heightened physiological response is hypothesized to be a risk factor for many chronic diseases as it has negative systemic effects[36]. The majority of physicians and advanced practice providers identify as non-Hispanic White[37,38]. This homogeneity lends itself to innate cultural and ethnic biases that the provider carries into their practice. This unconscious bias of the provider, coupled with the systemic racism that permeates the healthcare system in the U.S. creates a challenging environment for patients who identify out of this majority.

As the U.S. continues to struggle with racism, a continuous influx of studies shows that the healthcare system is not immune to its effects. In addition to subconscious bias, race-based research data, and systemic racism within the healthcare system, individuals who are Black, Indigenous, or People of Color (BIPOC) are more likely to face financial struggles, poorer health outcomes and have less access to healthcare in general[21,39]. Moreover, a cross-sectional analysis in 2013 evaluated medical data from patients with T1D between 13-20 years old and found that only 14% of Black patients met ADA HbA1c goals compared to 28% of Hispanic patients 34% of non-Hispanic White patients even when researchers controlled for SES factors[17]. BIPOC are also less likely to use diabetic technology, which can improve glycemic control. This technology includes continuous glucose monitors (CGM), insulin pumps, and closed-loop monitoring devices. Additionally, BIPOC are less likely to have intensive insulin therapies and adequate amounts of SMBG checks per day[21,39]. For example, in a 2015 cross-sectional analysis of patients younger than 18 years old, insulin pumps were used by 61% of non-Hispanic White patients, 26% of Black patients, and 39% of Hispanic patients[39].

This same study discovered that disparities are particularly striking when comparing glycemic control in Black and White adolescent populations. Black patients with T1D younger than 25 years of age were found to have increased rates of diabetic ketoacidosis leading to a mortality nine times higher than that of non-Hispanic White patients[39]. Black children of the highest SES had poorer glycemic control (HbA1c of 9.6%) than white children of lower SES (HbA1c of 8.4%)[39]. The fact this disparity occurs across all SES levels appears to be unique to Black patients with T1D because once researchers accounted for SES, there were no differences in glycemic control between non-Hispanic White patients and Hispanic patients[39]. According to a recent publication from the ADA, inequalities in healthcare lead to more diabetic-related complications in the Black population[14]. Black patients experience retinopathy at 46% higher rates than in non-Hispanic White patients[14]. They also suffered increased rates of nephropathy that required dialysis and limb amputations[14]. These studies show that glycemic control is related to ethnicity and race, which puts racial minorities, especially Black patients, at an increased risk for future diabetic-related complications and worsened quality of life[39,14]. These studies indicate that Black patients have added impairments to achieving glycemic control than other racial minorities and White patients with T1D.

The U.S. is comprised of a wide variety of ethnicities and cultures. Cultural perspectives affect how patients perceive their healthcare, adhere to their medical treatments, and receive their patient education. A common barrier for ethnic minorities in the U.S. healthcare system is language. According to the U.S. Census Bureau, 18% of the U.S. population spoke a language other than English, and 11.9 million households did not speak proficient English[40]. The U.S. Census Bureau expects that the number of people who speak languages other than English will continue rising, making it a critical psychosocial-related barrier to healthcare considerations[40]. For example, one study found that patients who did not speak English were less likely to perform self-monitoring blood glucose checks adequately[41]. Another study showed that providing a Spanish-speaking clinic for adolescents with T1D who spoke Spanish as their first language improved their glycemic control[41]. This finding suggests that cultural differences have important implications for the management of T1D and healthcare access overall.

T1D influences most aspects of everyday life for patients. They must continuously monitor this disease while eating and being physically active. Nutrition appears to be an additional factor that creates inequality for patients with T1D because of limited access to a variety of nutritious foods, referred to as "food insecurity." Individuals may experience food insecurity because they live in an area that is physically far from stable sources of nutrition, known as "food deserts," or the inability to afford quality foods. Adolescents with T1D have higher rates of food insecurity than the national population[42]. The majority of people within "food deserts," are of low SES, and because of racial and ethnic disparities between SES classes, this issue disproportionately affects BIPOC and single women[42]. Having inadequate access to proper nutrition leads to unacceptable coping strategies such as skipping meals and consuming large portions of processed foods with a long shelf life but are low in nutritional value[42]. Factors like these may help explain the positive correlation between food insecurity rates and obesity rates[42].

Overall, the rate of obesity in adolescent populations has been increasing dramatically since the 1980s and has detrimental effects on T1D management and future complications[22]. People with T1D who also suffer from obesity are at increased risk for microvascular and macrovascular complications than the general population. Patients who experience food insecurity appear to be at especially high risk for these complications. A Canadian study from 2014 concluded that even when researchers controlled for social, demographic and disease-related factors, food-insecure patients with T1D were at risk for having HbA1c levels higher than 7% and experienced more hypoglycemic episodes, emergency department visits and higher rates of comorbidities such as hypertension, hyperlipidemia, mood disorders, and tobacco use[43]. Employing a team-based approach that allows for a diabetic educator to provide nutritional education for diabetes management and a social service specialist that can help minimize food insecurities may improvements in HbA1c levels[6].

Cultural Influences

Comparing glycemic control in two ethnic and cultural minorities in the U.S. exemplifies the effect cultural differences have on healthcare outcomes. A cross-sectional analysis of adolescent patients with T1D in 2016 found that 50% of patients from Latinx and Asian descent did not meet their glycemic control goals[22]. These outcomes were due to a combination of English proficiency, healthcare access, SES, family dynamics, comorbidities, and acculturation (defined as the number of generations born in the U.S.)[21,22]. For example, Hispanic and Black populations have higher rates of obesity in youths diagnosed with T1D than other ethnicities[22]. Culture also influences how family involvement influences glycemic control. For example, a literature review from 2016 found that Latinx families that more recently immigrated to the U.S. reported higher degrees of family support and, therefore, better treatment adherence and improved glycemic control[22]. In this same study, Latinx populations with more generations born with the U.S. had higher rates of depression, while less acculturated Asian populations experienced higher rates of mental health problems[22]. This research implies that increasing attention to differences in cultures within healthcare systems and shaping diabetic education and care to differences in cultures may decrease diabetic-related complications for adolescents.

In addition to race and ethnicity, gender identity, and sexual orientation of an individual is related to healthcare access and outcomes[36]. LGBTQ+ patients are more likely to avoid healthcare and delay seeking medical attention due to perceptions of discriminatory and unequal treatment from healthcare providers. This population is also twice as likely to be uninsured than their cisgender, heterosexual counterparts[36]. Adolescents in this population face considerable amounts of disparities while moving throughout the world, including increased risk of physical, emotional, and sexual abuse and increased rates of homelessness[42]. They also experience higher rates of mood disorders, substance abuse, and suicidal ideation than the general population[44].

LGBTQ+ adolescents that suffer from T1D are not only constantly aware of their physical and emotional safety because of societal inequalities, but also must consistently maintain adequate glycemic control to function. Comparing the management of T1D in

LGBTQ+ populations with the general public is difficult to do as LGBTQ+ status is often underreported or incorrectly collected[45]. Additionally, information and research on T1D management within these populations is lacking. A cohort study conducted in Belgium in 2017 examined the rates of T1D in transgender populations by analyzing medical records of 1,081 transgender patients and found that T1D was 2.3 times higher within this population than the general population[46]. Defreyene et al. suggest that this relationship may be caused by the additional psychosocial stressors that transgender individuals experience, including stigma, emotional disorders, and the biopsychosocial stresses of electing to undergo gender-affirming hormone therapy[46]. Researchers need to conduct more extensive, diverse studies to decipher the relationship between gender identity and T1D. However, the added daily psychosocial stress that transgender patients experience indicates that this population requires additional support when managing T1D.

Accessibility of Diabetic Specialists

The accessibility of providers that specialize in T1D care has been shown to improve outcomes for patients[47]. Unfortunately, the number of patients diagnosed with T1D is increasing while the number of endocrinologists is decreasing[47]. According to the Endocrine Society, there has been a national shortage of endocrinologists that is continuing to worsen due to longer patient life expectancies, increasing prevalence of endocrine disorders, and insufficient numbers of physicians specializing in endocrine[47]. This trend was noticed in 2000 and has appeared to worsen over time[47,48]. In 2008 pediatric patients with T1D outnumbered endocrinologists 300:1. An Endocrinologist Survey in 2012 showed that this shortage continued, determining that the average wait for an appointment with an endocrinologist in the U.S. was 37 days[47,76]. Although this affects all populations, it is exacerbated based on geographic location as some patients depending on the region they lived experienced appointment waitlists of 3-6 months[48].

Approximately 50% of pediatric endocrinologists work in academic centers within metropolitan areas, which indicates that in addition to being physically distant, patients in medically underserved areas may experience longer waitlists to get an appointment, and providers may have less time per patient[47]. A cross-sectional analysis of patient data from 2015 showed that patients who lived within 50-miles from a pediatric endocrinologist were less likely to access these services than patients who lived 20 miles from specialized medical centers[48]. Furthermore, urban areas that were 50-miles away from these specialty centers had even less access to pediatric endocrinologists due to higher patient to physician ratios than rural areas[48]. These studies show that barriers to healthcare access include limited access to public transportation and longer travel times. Strategies to mitigate these barriers are essential to improving T1D management in adolescents because studies show that frequent communication with diabetes care teams improves patient outcomes with reduced acute and chronic complications and decreased healthcare costs[6].

Methods:

This paper used a database search of Pubmed, National Center for Biotechnology Information, and Google Scholar. The keywords used during this search were "psychosocial effects on glycemic control of adolescents," "psychosocial effects on glycemic control," "glycemic control in type 1 diabetics", "psychosocial effects, glycemic control," "psychosocial, glycemic control," "psychologic disorders, T1D". A filter was set on these searches to include articles published from the years 1999-2020. Further articles were selected from the references used in articles found from the initial search. Articles selected focused on patients with T1D between the ages of 10-19 years old, which was selected to define "adolescent" based on the definition from the WHO[10]. Articles were excluded from selection if unavailable in English translations. A Registered Dietician specialist in diabetes education, Carol Brunzell RD, L.D., CDE, from the University of Minnesota, was interviewed via e-mail about her experience with adolescents with T1D within her practice.

Discussion:

For reasons yet to be discovered, the rising global incidence of T1D disproportionately impacts adolescents[1,2,3]. In addition to the rising number of patients with T1D, this age group has shown a consistent pattern of deteriorating glycemic control[6,8,12,15,19,22]. This combination has the potential to negatively impact patients with T1D, their support systems, and society as a whole due to increased diabetic-related complications and their resultant healthcare costs. Many studies identify adolescence as a vulnerable developmental period for patients with T1D. Much of the literature focuses on discovering which biopsychosocial factors contribute to the difficulty maintaining glycemic control and to what degree, but few studies attempt to discover solutions to these influences [5,6,11,12,15,19,22]. Practitioners are encouraged to recognize that poor glycemic control in adolescence is likely due to an amalgamation of elements. Therefore, treatment is often encouraged to include a multidisciplinary approach with individualized treatment plans tailored to the patient's risk factors for complications, presence of comorbidities, and comfortability with self-management skills[6]. Developing advancements that help adolescents maintain glycemic control will decrease diabetic-related complications in future older adult populations, lessen healthcare costs, and increase the quality of life for millions of people impacted by this disease[5,6,11,12,15,19,22]. Increasing access to quality healthcare, prescribing diabetic technology, and implementing behavioral interventions have been shown to improve glycemic control in adolescents[5,6,11,12,15,19,22].

Improving access to healthcare is an overarching subject that encompasses many aspects of control in T1D. Access to quality healthcare not only includes the ability for patients to physically interact with healthcare teams but also includes the ability to financial access services and receive necessary preventative, therapeutic, and palliative care. Psychosocial barriers can inhibit access to healthcare, such as screening work-ups, comprehensive patient education, a multidisciplinary diabetic care team, and diabetic technologies, all of which improve glycemic control[5,6,11,12,15,19,22]. Difficulty to access healthcare is influenced by psychosocial factors, including socioeconomic status, geographic location, race, ethnicity, gender identity, sexuality, and comorbidities[5,6,11,12,15,19,22]. Screening and evaluating for psychosocial impairments routinely in patients with T1D appear to be influential in preventing diabetic-related complications because of the powerful impact these factors can have on glycemic control[6,11,13,15,17]. Although healthcare providers should improve access to quality healthcare for their patients and decrease psychosocial influences on glycemic control, many systemic barriers exist above the level of provider control.

Healthcare reform policies through all healthcare levels are vital to improve care for patients with T1D and decrease racial, economic, and cultural disparities in the management of the disease. For example, studies have shown that the Affordable Care Act (ACA) has begun decreasing inequality in healthcare by expanding coverage for populations historically uninsured[48]. The populations that most benefited from the ACA were BIPOC, youth, and those of lower SES. These are the same populations that are most likely to experience diabetic-related complications[25,47]. Adolescents benefited from certain aspects of this policy as individuals could remain insured by their caregivers until age 26. This change in policy indicates that the transition from pediatric to adult care may be universally difficult for all adolescents and is not unique to diabetic patients further supports the theory that adolescence is a vulnerable developmental period requiring more healthcare support than has been historically given to this population[6,18,19,25,49]. Despite these improvements, racial, gender, socioeconomic, and cultural disparities in healthcare access of adolescents remain and require improvements in systemic changes such as Medicaid expansion[49].

A strategy that can mitigate systemic influences on glycemic control is to implement an integrated diabetic care team that includes team members who have in-depth knowledge of T1D and specialize in different aspects of its management[13,20,21,23]. This approach increases the quality of diabetic education, which can improve healthcare access by giving patients the tools to advocate for themselves. These tools include increased knowledge of T1D, its treatment, and how to navigate the healthcare system and social services. The diagnosis of T1D drastically alters an individual's life and is a considerable burden for adolescents already experiencing so many life changes. This unique developmental period requires continuous amounts of support and education from the diabetic care team. Integrative healthcare is especially important in populations that require more time and resources to provide adequate care, such as patients with additional comorbidities or intellectual disabilities[27,28,30]. For example, diabetic educators are essential because they increase the amount of time spent on educating patients on the minutiae of particular topics including diet, exercise and lifestyle choices as well as providing assistance with screening for comorbidities such as mental health disorders (Personal communication, Carol Brunzel, May 30, 2020). Increasing patient education in diabetic populations will allow them to not only be able to improve their management of T1D but allow them to become better self-advocates for their care.

The use of a multidisciplinary, educational approach can improve healthcare disparities by providing focused, individualized care based on each patient's psychosocial needs. Nutrition and exercise are topics especially pertinent to managing T1D and requires a lot of education and guidance. Proper nutrition is an aspect that unites socioeconomic status, ethnicity, race, gender, and culture. Because food insecurity unequally impacts adolescents with T1D, females and ethnic minorities, improving nutritional education and providing interventions for patients to have access to quality nutrition could help decrease these discrepancies[42]. Obesity and sedentary lifestyles also have psychosocial-based patterns with higher rates in individuals with I.D. and ethnic minorities[22]. Regular exercise is imperative for adequate glucose control in patients with T1D. The same benefits of exercise seen in adult populations apply to adolescent populations, including decreased adipose tissue and improvements in mental and cardiovascular health[6]. Although cardiovascular fitness may not directly improve HbA1c levels, it may decrease the risk of other comorbidities that impair T1D management[6]. Despite the value of exercise in patients with T1D, there are still risks associated with exercise, such as fluctuations in blood glucose levels[6]. Because patients with T1D have unique considerations when it comes to exercising, it requires extra planning from the caregivers to ensure that complications such as hypoglycemia do not occur. Caregivers must also educate the patient and the authority figure involved in the activity to understand how to manage T1D and avoid acute complications[6]. Understanding how diet and exercise affect glycemic control in T1D is essential for obtaining adequate control of blood glucose levels and is improved when patients receive intensive, integrated diabetic-education[6](Personal communication, Carol Brunzel, May 30, 2020).

This team-based approach can also address factors unique to adolescent development that can negatively impact glycemic control. Adolescents are exposed to many changes through peer interaction and self-discovery during this developmental period that can influence glycemic control. The ADA recommends that providers speak with patients with T1D individually starting at age 12 to proactively discuss how new experiences that are common in this age group can affect the management of T1D as well as provide an accepting, open environment for questions and concerns[6]. Discovering one's sexuality and gender identity is an essential component of adolescent development[38]. Providers should routinely discuss safe sex practices, reproductive health, and provide contraceptive options[6]. Due to the disparities seen between LGBTQ+ population and cisgender heterosexual counterparts related to diabetic complications, providers should do what they can to reduce heteronormative and sexuality-based discrimination within their facilities[38]. Providers could encourage training on cultural sensitivity to help lessen the LGBTQ+ population's stressors and encourage regular communication with the diabetes care team[38]. Providers should be aware that this population may need more support in reducing psychosocial stressors that can worsen glycemic control, as seen in the minority stress model[38]. These aspects distinctive to adolescence require that medical management of this age group be considered independently from other ages, and T1D treatments should fit their specific needs. A team-based approach to the treatment of T1D would allow diabetic teams to more comprehensively screen patients for concerns related to nutrition, exercise, lifestyle, and increase education on these influential factors.

Developing practices specific to improving care in adolescents is especially important when patients are transitioning to adult care because many patients experience deterioration of glycemic control during this period. Patients tend to leave pediatric care towards the very end of adolescence between 18-21 years of age[18]. Studies have shown benefit when pediatric providers implement strategies to improve the transition period at least one year prior to the transfer[6,18,19]. These strategies involve a team-based approach with open communication and shared decision making between the adult provider, pediatric diabetes care team, family, and the patient[6]. In addition to patient education, a study showed that providers that received "transition of care" training experienced shorter transition periods, sufficient transfer of patient records, and reduced return of patients to pediatric care[18]. Despite this, providers who manage T1D report insufficient guidance and protocols to follow during these transfers[18]. Providers state that the two most common reasons for transferring patients are due to their continuous poor glycemic control and are older than 18 years old. However, neither of these reasons fit the recommended criteria for transferring pediatric patients according to the ADA, despite the logistics of transferring patients, providers reported that their primary barrier to transferring pediatric patients to adult care was that the patient felt an emotional attachment to the provider[19]. The struggle to maintain glycemic control during the transition to adult care and the fact these patients admit patient-provider relationships play an influential, emotional role during this stage further indicates how impactful relationships can be in adolescent populations.

The fact that relationships influence adolescents strongly indicates that behavioral interventions may be a beneficial addition to T1D management because they rely on communication, vulnerability, and trust with the provider and group members. Behavioral interventions involve a provider-patient relationship and sometimes use peer-peer relationships to improve self-management skills, develop healthy coping methods, and help manage psychosocial stressors that adolescents experience[20,21]. Behavioral interventions such as motivational interviewing improve self-management skills, which are important aspects of T1D treatment. Self-management of T1D requires that patients regularly perform diabetes-related care such as SMBG, adherence to insulin regimens, and awareness of the impacts of food intake and activities[21,23]. Researchers argue that because the success of MI is rooted in the patient's internal motivation, it may be particularly useful during shifts in development as in adolescence[23]. The effects of MI were improved even more when family members and caregivers were a part of the conversations. The importance of familial support in T1D is further supported by the fact that behavioral family systems therapy decreased family conflict and increased familial involvement in the management of T1D[23]. Strategies such as these may also help decrease disparities seen in cultural minorities such as Latinx and Asian populations because familial influences impact T1D management[22]. Although there is not enough conclusive evidence that behavioral interventions have a direct effect on glycemic control, they appear to be promising additions to T1D treatment in adolescent patients because they allow providers to target aspects specific to this developmental period that increase glycemic control.

Diabetic technology is a recent addition to diabetic care that has improved the management of T1D in adolescents. Increasing availability, decreasing cost, and access to diabetic technology may improve all aspects of diabetes management, including increasing healthcare access, diabetes education, decreasing healthcare disparities, and overall increasing glycemic control[16,50,52]. This population is typically familiar with how the technology operates, and many adolescents rely on its usage for many other aspects of life, which implies that implementing it for T1D management may be a natural and helpful addition to these patients[52].

Recently, Web-based platforms have delivered training and guidance to managing T1D[51]. These platforms teach skills, such as coping mechanisms and problem-solving. Additionally, social media platforms have allowed adolescents to communicate with peers who also suffer from T1D easily[51]. Although these platforms did not affect glycemic control, they were shown to improve self-management behaviors and may reduce negative psychosocial influences on T1D management. Less negative psychosocial influences have been correlated with fewer diabetic-related complications in the future[51]. Technology has also been helpful in this population by developing things, including text-message services and applications that send reminders for self-management tasks, diabetes education, and even text messages of encouragement[51]. Studies have also indicated that specific applications could support safe alcohol consumption in patients with T1D. Although researchers are continuing to evalute if technological interventions can improve glycemic control, adolescents report enjoying using these services, which indicates that this technology could be a beneficial addition to T1D management[51].

In addition to promoting self-management of T1D, developing technology for T1D has also eased burdens of daily management tasks. Devices that can provide patients with continuous glucose monitoring increase the amount of blood glucose checks per day and glycemic control improves with increased SMBG checks[51]. CGM usage has been shown to reduce the number of hypoglycemic episodes and DKA and improves HbA1c levels[51]. Enhancements in insulin delivery devices have improved quality of life and glycemic control by administering insulin through titratable, continuous subcutaneous infusion therapy, and meal boluses instead of multiple daily injections of insulin[51]. A subsequent advancement is the combination of these therapies by using sensor-augmented pumps or closed-loop systems that have also shown improvements in T1D management[51]. This technology has allowed researchers to compile large amounts of data that can be analyzed and evaluated to determine how to provide personalized treatment plans[16]. Studies have shown that the use of these devices improves not only glycemic control but also psychosocial burdens in adolescence[50]. The use of data analytics has been shown to deliver higher-quality, individualized care to patients with T1D and may be especially helpful for adolescents who are experiencing changes to their treatment regimens. However, as of 2015, most patients between the ages of 2-25 years were not using these devices[51]. Although these technologies require additional education and are more expensive for patients than injecting insulin, they have been shown to improve glycemic control in T1D and could be a solution for populations that struggle with T1D management[16,50,51].

Additionally, racial and ethnic disparities provide barriers to accessing diabetic technology as Black patients are the least likely population to be prescribed and use CGM, insulin pumps, or closed-loop systems[39]. Increasing availability and accessibility to this technology could improve T1D management for adolescents and decrease racial disparities in health outcomes[16,50,51]. Studies have shown that racial and ethnic minorities experience worse diabetic complications and perform fewer SMBG checks per day than their non-Hispanic White counterparts[46]. These differences may improve with providers encouraging the usage of close-loops systems, CGMs, and insulin-pumps[50,51].

Technology has improved self-care abilities in patients and has increased their ability to access diabetic care teams. Telemedicine is a growing field and is effective in delivering healthcare to medically underserved populations and delivering comparable quality to in-person visits. Adolescents, in particular, have reported high levels of satisfaction from telehealth visits in one study[51]. Meeting with a provider in a telehealth format decreases travel time and wait time, which leaves both providers and patients with more time[51,52]. Patients from rural areas also reported missing less school and work when using telehealth[51,52]. Telehealth may also help to close the disparities in T1D management seen between socioeconomic classes. In a randomized control trial in 2015, the use of telehealth appointments for T1D was evaluated in patients under

18 years old and concluded that telehealth appointments lessen healthcare-related costs, increase the number of times a patient visited and was as effective as in-person for maintaining HbA1c levels[51].

Telehealth has also increased the availability of diabetic specialists to areas that would have otherwise gone without those services. Projects like Project Extension for Community Health Outcomes (ECHO) train primary care providers to deliver specialized healthcare to areas underserved by endocrinologists through telehealth services[51]. In addition to telehealth, closed-loop systems may help make up for the decreasing number of endocrinologists because analytic data software, as well as the ability to titrate dosages easily, allows providers to more efficiently tailor needs to their patients[47]. This improvement ultimately leaves providers with more time, which allows them to visit with more patients[48]. The programmability of closed-loop systems can also allow patients to send glycemic levels to providers electronically, limiting the amount of in-person appointments patients need and increasing healthcare access to patients who have difficulty traveling to the office.

Diabetic technology also has implications for reducing additional psychosocial barriers to adequate glycemic control by reducing the impact of comorbidities[47,50]. The high prevalence of comorbidities in this population requires providers to be aware of the screening guidelines and evidence-based screening tools. Providers should routinely screen adolescents with T1D for metabolic disorders, including hypertension and hyperlipidemia, other endocrine disorders such as thyroid disease and celiac disease, and mood disorders such as depression, suicidal ideation, anxiety and eating disorders[6]. Studies have shown that early identification of psychiatric disorders may improve diabetic treatment outcomes and improve quality of life[27]. Providers that treat patients with intellectual disabilities should be especially cautious and take care to be providing all necessary screening for these patients to improve preventative medicine rates in this population[30]. Usage of technologies such as tablets has improved the efficiency of screening for comorbid conditions[50]. CMG and insulin pumps also improve care for patients who suffer from psychiatric disorders like anxiety and depression because they simplify care[,50]. These pumps are also programmable and have memory logs that providers can evaluate, which could help avoid harmful behaviors such as insulin omission[50]. CGM improves glycemic control in patients with autism who have trouble with self-management of T1D and have difficulty with frequent in-person visits because of adverse interactions with hospital staff[47]. This improvement in this population suggests that implementation of diabetic technology may have the ability to improve health outcomes for patients with intellectual disabilities and those with comorbid diseases but may be able to help prevent the progression of additional disorders or poor T1D management, thus decreasing the risk for future diabetic-related complications. Efforts are required to lower the cost of diabetic technology, improve insurance coverage, and encourage providers to prescribe it to non-Hispanic White populations.

CONCLUSION:

Individuals of all age groups with T1D have increased morbidity and mortality rates than the general population[1,2,3,6]. Patients diagnosed in childhood or adolescence have an even greater risk for diabetic-related complications because the rates increase proportionally to the length of time a patient has suffered from T1D[1,2,3,6]. Studies have shown that attaining individualized glycemic control goals is correlated with less risk of both acute and chronic complications of T1D[1,2,3,6]. Inadequate management of blood glucose levels can cause hypoglycemic episodes and DKA and eventually leads to microvascular and macrovascular complications[6]. In order to reduce diabetic-related complications in patients with T1D, providers and patients must address the factors that inhibit adequate glycemic control. Many studies have shown that psychosocial factors can influence a patient's ability to accomplish their T1D treatment goals [6,13,15,22,56]. The increasing global incidence of T1D in children and adolescents, along with the decreasing number of endocrinologists, indicates the importance of all providers understating how to manage T1D, including identifying obstacles that impair patients with T1D from achieving glycemic control. T1D is highly prevalent in the U.S. and has deadly consequences for patients. The prevalence and intensity of the disease signify that facilitating the advancement towards sufficiently managed diabetes will decrease healthcare costs to the U.S. economy and, most importantly, allow millions of people to have an increased quality of life.

Glycemic control can improve with additional future research by including underrepresented populations such as patients with T1D from ethnic and racial minorities, those with intellectual disabilities, or those who identify as LGBTQ+. In particular, these studies should examine how providers can improve access to healthcare through expanding Telemedicine and the use of newer technologies, including CGM and insulin pumps, more uniformly across all T1D populations to decrease diabetic-related complications. While there are studies that expose these disparities, relatively few provide solutions to this problem. Technology has the potential to improve glycemic control, so further research should also include strategies to make diabetic technologies more prevalent in all populations, which may rely on reducing costs and increasing awareness. Providers must advocate for more education regarding the benefits of diabetic-technologies in managing T1D in adolescents. These efforts should also include further advancements in the multidisciplinary approach by focusing research on how to utilize varying healthcare providers and specialists T1D care effectively.

Improving the quality of life for patients with diabetes relies heavily on improving glycemic control during adolescence. According to the literature reviewed in this paper, psychosocial factors have profound influences on the ability to attain glycemic control. The mitigation of these factors involves improving healthcare access through systemic reform, increased availability of health insurance, Telemedicine, language barriers, increasing education and availability of diabetic technology, and implementing behavioral interventions to improve self-management skills. Providers and healthcare systems must advocate for healthcare reform that decreases systemic disparities between groups and improves the quality of healthcare for all populations. Furthermore, individual behavioral interventions, familial therapies, and an integrative diabetic care team have improved glycemic control. Technology such as insulin-pumps, CGMs, closed-loops systems, and analytic data software also improves healthcare access and quality of life in patients with T1D. Navigating through these factors to maintain glycemic control in adolescence requires a team effort from the diabetic team, the patient, and their caregivers.

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