

THE INFLUENCES OF SOCIOECONOMIC STATUS ON ACHIEVEMENT AND
NEUROCOGNITION IN CHILDREN WITH TYPE 1 DIABETES MELLITUS

by

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Abstract

Socioeconomic status (SES) refers to an individual's place in society (Hackman et al., 2000), and there has been much research examining looking at the strong influence SES has through the life span. This study aimed to assess the effect SES has on children's neurocognitive and academic abilities with type 1 diabetes mellitus (T1DM).

Structural equation analyses revealed a latent construct of *SES* measured by self-reported income, income by zip code, father's education, respondent's education, and free/reduced lunch to have a direct effect on adolescents with T1DM youth neurocognitive ($\beta = .46, p = < .001$) and academic abilities ($\beta = .35, p = < .001$). Cogstate assessments measuring processing speed, working memory, and visual attention comprised the latent construct *neurocognitive abilities I*. WJ-III-NU Achievement scores on subtest measured the latent construct *academic abilities*: Letter-Word Identification, Passage Comprehension, and Reading Fluency, Calculation and Math Fluency, Spelling and Writing Fluency. Low SES coupled with a chronic medical condition like T1DM, may lead to an even greater vulnerability in school outcomes. The differences in academic and neurocognitive performance urge researchers, school personnel, and health officials to understand the long-lasting effects SES-associated disparities have on children with T1DM.

Chapter 1: Introduction

The American Psychological Association (APA, 2007) has defined socioeconomic status (SES) as the social standing or class of an individual or group. SES is a reliable predictor of many different social, behavioral, and health outcomes. Low SES, for example, has been shown to lead to higher infant mortality rates (Haider, 2014), higher levels of obesity (Levine, 2011), and higher physiological markers of chronic stress in adolescents (Chen & Paterson, 2006). Several research groups have also demonstrated SES can impact parts of the brain, supporting working memory, long-term memory, and spatial processes such as the prefrontal cortex (Hackman & Farah, 2009). Research has supported various indicators of SES, such as lower parental education, lower income, and unstable employment contribute to poorer academic outcomes (Harwell et al., 2017).

The relationship between educational achievement and socioeconomic background is a prominent issue studied for many years in educational research. This chapter introduces the effect of SES in schooling. The focus will be on how SES affects the cognitive and academic performance of children with Type 1 Diabetes Mellitus (T1DM). This chapter concludes with the purpose of this study and the research hypotheses.

SES Effects on Schooling

Academic performance has been reported to vary with SES. Research studies have shown that children from lower SES groups earn lower test scores than children from advantaged homes. Morgan et al. (2009), for example, showed that children from low SES households scored lower on language, memory, and socioemotional processing tests and suggested economic disadvantage may contribute to cognitive and linguistic challenges. Duyme et al. (1999) conducted an intelligence quotient (IQ) study of 5000 adopted children who had experienced early trauma and had moved through various placements before being adopted. The children's

IQs were measured prior to their adoption and several years later as adolescents. The children who were adopted into lower SES families displayed lower IQs than the children placed with higher SES families compared to their IQs before their adoption. IQs of children did not significantly differ but there was a difference in growth between their IQs before and after being adopted. Collectively, these studies demonstrate how access to financial resources may lead to difference in children's academic and cognitive performance. For instance, the financial resources of the adoptive parents play a role in the overall IQs of the children. Nonetheless, these research findings might also be confounded by the fact that IQ tests assess fluid and crystallized intelligence (reasoning and problem-solving abilities; Horn & Cattell, 1967) leading to deflated scores for those who lack exposure to the content rather than capturing their true abilities. Therefore, this study contributes the knowledge to what extent environment can alter the cognitive development of disadvantaged children after early childhood.

Many studies have suggested the major confounding issue is that schools in low SES communities are often under-resourced; they lack materials or the personnel to teach their students adequately. Pribesh et al. (2011), for example, found schools with high poverty rates have less staff and fewer library resources than schools educating children from higher SES backgrounds. Children in low-income schools are also more likely to have less experienced teachers as educators (Clotfleter et al., 2006). Interestingly, a teacher's years of experience and quality of training are correlated with a child's academic achievement (National Council, 2000). Therefore, children in low SES schools may be set up for academic failure due to factors outside of their control. In fact, several researchers have argued that a poor school environment contributes more to SES differences in learning rates than genetic or familial characteristics (Aikens & Barbarin, 2008). Chetty et al. (2011) provided supporting evidence for this concept by

conducting a study in which elementary school students from various SES backgrounds were randomly assigned to a classroom. Regardless of the assignment, the researchers classified classrooms as “higher” quality or to a classroom with a “lower” quality. A proxy for class quality was derived by peer effects (average test scores of classmates at the end of kindergarten), teacher effects (years of experience), and other effects (class sizes) that may affect test scores. Students assigned to a classroom with “higher” quality were more likely to attend college and have higher incomes as adults.

On the other hand, other researchers have argued that gaps in cognitive, language, and academic development exist before formal schooling begins in children from different socioeconomic backgrounds. These researchers have based their argument on increasing evidence showing disparities in children’s achievement by SES before children are enrolled in schools (Hillemeier et al., 2009). Researchers also have noted that children from low SES families are less likely to have experiences promoting the development of skills necessary to succeed academically (Buckingham et al., 2013). A child’s initial reading competency, for example, has been correlated with the number of books and educational material found at home. Low SES households have been shown to have less access to learning materials, including books, computers, stimulating toys, or tutors than higher SES households (Bradley et al., 2001). Several researchers have supported these studies examining whether the amount of cognitive stimulation in different SES groups is directly related to a child’s test performance. Using data from extensive national studies, researchers have reported that the number of children’s books in the home, and the frequency someone in the home reads aloud to the child, are vital mediators between poverty and performance on several cognitive tests (Guo & Harris, 2000).

Independent of when and where the differences in academic and cognitive performance arise, the reality is SES-associated disparities in the education system have dramatic and long-lasting effects. A study conducted with children from low SES families demonstrated children from low-income backgrounds enter high school with average literacy skills five years behind high-income students (Reardon et al., 2013). It has also been shown that students from low-income backgrounds have a worse success rate in academic areas such as science, technology, engineering, and mathematics (Doerschuk et al., 2016). Even more alarming are the dropout statistics from the National Center for Education in 2018, which show high school dropout rates for low-income families to be ten times more likely when compared to high-income families. Furthermore, students from low SES who do graduate and aspire to go to college, unfortunately, have limited access to informational resources about college (Brown et al., 2016), making it more difficult for them to enroll. The 2014 US Census Bureau reported individuals within the top family income are eight times more likely to obtain a bachelor's degree than individuals from the lowest family income percentage.

Collectively, these studies have demonstrated children from low SES families are at a disadvantage when it comes to how they perform academically and cognitively compared to children from high SES families. The SES disparity is valuable information, specifically for schools. Understanding both the impact SES has on students but also on the environment they produce for their students can help school leaders obtain better training for their teachers, produce a more stimulating environment, and teach skills that can be transferred to the household.

Type I Diabetes Mellitus

Type 1 diabetes mellitus (T1DM) is an autoimmune chronic health condition affecting more than 200,000 children and adolescents in the United States (Menke et al., 2013), making it one of the most common disorders among children and young adults. T1DM is characterized by the immune destruction of beta cells in the pancreas. Beta cells produce insulin, a hormone that regulates blood glucose levels. The destruction of beta cells leads to decreased insulin, which results in increased blood glucose levels, a condition also known as hyperglycemia. Most children present to their doctor or the emergency room with markedly elevated glucose levels, increased thirst and hunger, frequent urination, fatigue, and weakness (Kitabchi et al., 2009).

Exposure to environmental factors (polluted air, water, unhealthy diet, vitamin-D deficiency, etc.) and genetics have been associated with the onset of T1DM; however, its exact cause is unknown (Rewers & Ludvigsoon, 2016). The incidence rates of T1DM are increasing; the annual incidence is increasing globally at 2.3% per year (Lawrence et al., 2014). The possibility of T1DM arising in the general population is one in 300 (Redondo & Eisenbarth, 2002) and is one of the top five chronic illnesses supported in the school environment.

Regular maintenance of T1DM requires constant monitoring of blood glucose levels, diet, and the daily administration of insulin. Failure to achieve good glycemic control may lead to serious health consequences and hospitalization. This maintenance represents a significant lifelong cost and time requirement. Tao et al. (2010) compared the annual medical costs of T1DM patients with “healthy” patients. They matched diabetic and non-diabetic patients based on propensity scores generated by controlling for age, gender, ethnicity, and several other factors. They considered the costs of hospital visits, prescription drugs, and ambulatory visits. They found that patients with T1DM spend approximately \$6000 more on medical expenses each year. If the patient had a complication and was admitted to the hospital, the study found the

average medical expenses were substantially higher. Patients with T1DM with at least one complication spent \$25,858 yearly in total medical expenditures, whereas the matched control spent \$2,270. Indirect costs for patients with T1DM were also different between the groups. For example, adults with T1DM miss on average 5.5 more workdays than individuals without diabetes each year, and children with T1DM miss 3.3 more school days. Over their lifetime, a patient with T1DM acquires substantial medical and indirect costs because of their disease. Tao et al. (2010) estimated the cost to be \$130,000 over their lifetime for someone diagnosed with T1DM at the age of 14-years old. This is concerning, not only because of the high cost but also because the individual income for patients with T1DM is more than \$7000 lower than the income of individuals without diabetes. The household income is nearly \$10,000 lower for T1DM patients.

Other sociodemographic factors related to SES, such as ethnicity, family structure, and access to health insurance, have been associated with poor glycemic control in T1DM patients. Harris et al. (1999) demonstrated that African American adolescents from single-caregiver families and/or two-caregiver families had more inadequate glycemic control than their White counterparts. Unfortunately, most low SES families are not able to purchase private health insurance due to its high cost. This leaves most low SES families with few options; while some may be fortunate to qualify for state medical insurance, many are uninsured. Frequent monitoring of their glucose levels is, therefore, cost-prohibitive for many uninsured individuals. These studies collectively demonstrate an association between low SES, poor glycemic control, and poor long-term health outcomes among patients with T1DM.

T1DM Effects on Schooling

There is strong evidence suggesting students with T1DM struggle in school, and factors such as glycemic control (hyperglycemia and hypoglycemia), age of onset, and duration of diabetes impact different areas of cognitive functioning and academic achievement. Thus, not only is the trajectory of disease outcomes influenced by family SES, but difficulties in school may impact future educational attainment and employment. Despite these connections, very little research has examined the role that SES plays in cognitive functioning and academic performance in youth with T1DM. This line of inquiry is essential given that research has also documented that many youths with T1DM do well in school. These youth have similar aspirations as their same-age peers to pursue higher education (Palladino et al., 2013).

Although most studies have found elevated levels of HbA1C correlating positively with poor academic performance, other factors are known to play a role. Hemoglobin is a protein found in red blood cells; it carries oxygen throughout the body. When the glucose (sugar) builds up in your blood, it binds to the hemoglobin in the red blood cells. Therefore, the A1c test measures how much glucose is bound. The target A1c level for people with diabetes is usually less than 7%; the higher the hemoglobin A1c, the higher risk of having complications related to diabetes.

Additional factors implicated in poor academic performance include stress, depression, and other psychosocial factors stemming from chronic disease. Grey et al. (1995) found that children with diabetes were depressed, dependent, and withdrawn at the time of diagnosis, were within the normal range 1-year post-diagnosis, but again, showed some depressive symptoms two years after diagnosis. One theory is that fluctuating blood glucose levels cause increased secretion of stress hormones like cortisol and adrenaline. Similarly, stress has also been shown to augment the secretion of cortisol. Elevated stress hormones prompt the liver to release more

glucose. For people with diabetes, this extra glucose can result in dangerously high blood sugar levels that damage blood vessels are limiting blood flow to some regions of the brain, which may ultimately lead to learning disabilities. Besides the damaging effects of diabetes on the body, studies have shown poor glycemic control may also promote cognitive changes, including changes in memory, executive function, attention, and academic performance (Kodl & Seaquist, 2008). Thus, adequate care and blood glucose monitoring are critical for successful academic outcomes in children and adolescents with T1DM. Definitions of relevant terms are provided in Appendix A.

Purpose of the Study

Although much research has demonstrated that socioeconomic background does influence educational achievement, there are still gaps in our understanding. Much of the research has taken on a broad approach and failed to make discernable conclusions about specific groups or specific variables. For example, many T1DM studies have failed to distinguish the effects of SES on academic versus neurocognitive performance and instead made generalized comments about a child's overall academic performance. Highlighting these differences is crucial in the clinical and academic setting since deficits in academic or neurocognitive performance are addressed very differently in the classroom by teachers, support staff, and psychologists working with the children. Having insight into the difference socioeconomic status creates in a student's achievement is valuable for systematic purposes in schools to better provide support and services for their achievement.

The study sought to provide insight into how SES may play a role in the academic achievement and neurocognitive functioning of adolescents with T1DM. Additionally, this study

helps identify whether there are cognitive and academic differences based on SES in youth with T1DM. The following research questions are examined in the current study:

Research Question 1. What is the relative contribution of SES indicators (parental education level, self-reported income, free/reduced lunch status, etc.) in predicting performance on standardized cognitive (executive functioning, memory, etc.) tasks?

Predictive Hypothesis 1. Socioeconomic status affects neurocognitive abilities.

Hypothesis 1.1 Lower SES status will significantly predict lower neurocognitive abilities.

Research Question 2. What is the relative contribution of indicators of SES (parental education level, self-reported income, free/reduced lunch status, etc.) in predicting performance on standardized achievement (reading, writing, and math) tasks?

Predictive Hypothesis 2. Socioeconomic status affects academic abilities.

Hypothesis 2.1 Lower SES status will significantly predict lower academic abilities.

Chapter 2: Literature Review

This chapter introduces theories and research regarding the effects of SES in academia, considering both historical and novel research that has shaped the way we study and understand the impact of SES on education. The focus will be on how SES affects neurocognitive and academic performance, then look at its effects on children with T1DM.

Socioeconomic Status

SES describes the class standing of an individual or group, which can positively or negatively impact a person's life (Conger et al., 2010). The potential impact SES has on many aspects of a person's life makes it a highly researched topic. Even though there are many forms of reporting/measuring SES, each aspect of SES may have an important influence on how children are affected developmentally.

Family Income

In research, the method of reporting SES through self-reported family income requires families to select an income bracket that best reflects their monthly or annual income. Most researchers have used the official federal poverty line as a reference point to define these income categories (McLaughlin et al., 2012). The official U.S. poverty line in 2018 for a family of four was \$25,100. According to the 2018 U.S. Census Bureau, more than 39.7 million people in the U.S. live below the federal poverty line. Studies have also shown that more than 30% of children (12.8 million children under the age of 18) live below the federal poverty line despite having full-time, year-round employed parents.

Income depicts a stream of economic resources over a period but often does not account for higher error rates due to the sensitivity of self-reporting. There is a high probability that income is not reported accurately or at all. In fact, the 2002 National Survey of America's

Families reported that 20% of questions asking about income had no response. Similarly, the 2002 National Health Interview Survey had a non-response rate of 31.9% (Shavers, 2007).

Another issue using income as the only measure of SES is that family income is usually taken from census data, which is not specific for one family or individual. Rather, it paints an overall estimate of the income across households in different neighborhoods; therefore, researchers only gain a perspective of how many children live in poverty and provide an estimate of the environment the child may be living in.

Zip Code

Many more researchers have been using zip codes to estimate SES (Shavers, 2007). An estimate of median household income is derived based on input of the zip code into the census tract database. An individual's zip code can indirectly provide information about an individual's environment, including the average home values, the proportion of college-educated individuals, percentage of single-parent families, unemployment rates, and estimated income for a specific area. Recently, zip code data has also been shown to provide information about a person's health, functioning, and access to resources (National Center for Education Statistics, 2012; Shavers, 2007). Consequently, it is often used as an indirect measure of SES or a substitute for an individual's or household income, especially when income is not shared or given accurately.

Occupation

Occupation is also frequently used as an indicator of SES because it indirectly provides information about an individual's income and educational achievements (APA, 2007).

Occupation in SES research is often described and ranked in categories. For example, a study might categorize and list occupations from lowest to highest SES in the following manner:

Unemployed, Unskilled Manual Labor, Skilled Manual Labor, and Professional Labor. The

individual's SES is then classified per the specific category and its ranking. Children are then categorized into the occupation category of their parents and household. By using this type of scale, the data show that minoritized groups living in the U.S. are more likely to have jobs that pay less (Rodegers, 2008).

The occupation a parent has can affect the number of working hours, labor, wages, and unstable working opportunities. This may force parents to spend time and energy that would otherwise be directed toward supporting their children's education. This quality time spent on educational activities is positively related to student's achievement (Hill et al., 2004). For example, one study demonstrated math scores increasing for children if parents believe that it is worth studying math because of its usefulness in the labor market (parent had a job relating to math; Giannelli & Rapallani, 2018).

One of the problems with using occupation as an SES measure is that most standard occupational classification systems are based on occupations that more commonly employ men and/or use the salaries earned by men in that profession. More women are joining the workforce, including taking on jobs that were once male dominated. Unfortunately, the salaries earned by men and women are not equal despite similar experience and education (Alkadry & Tower, 2006; Stevenson, 2015). Especially in low SES families, where most families are single-parent or single-mother households, using occupation as an SES measure would lead to discrepancies. Additionally, many of these classification systems do not include homemakers and retirees. They do not account for racial/ethnic and gender differences in benefits arising from employment in the same occupation.

Education Attainment

Education has often been considered a critical indicator of SES because, unlike income and occupation, it provides information regarding earning potential across a person's lifespan (Shavers, 2007). Children with college educated parents are less likely to be considered low-income. In contrast, more than 85% of children whose parents have less than a high school education live in low-income households. A study conducted by Diemer and Ali (2009) showed that children whose parents had gone to college were more likely to want to go to college. Similarly, Diemer and Blustein (2007) showed that children whom complete college end up earning up to eight times more income as adults than children who do not receive college degrees.

Even though data have shown that both parents' educational attainment is an important predictor of a child's performance in school, most studies have reported and focused on the mother's educational level (Hart & Risley, 1992). Maternal education is researched more often because, traditionally, the mother is seen as the caretaker of the family. These studies have shown that maternal education is a predictor of children's vocabulary and language skills when they enter preschool. The quality and quantity of input given by the mother, more so than the father, plays a role in the development of speech, language, and cognition (Hoff, 2003; Huttenlocher et al., 2007). A longitudinal study conducted by Gottfried et al. (2003) found that maternal and paternal education explained 16% of the difference in IQ at eight and twelve years of age and this finding remained stable at age seventeen.

Although the impact a mothers' education has on their child's achievement has been researched more in the past, research has increased the studies looking at a fathers' overall effects on their child's learning. For example, a study found poverty negatively influenced more

fathers' than mothers' parenting and that fathers' engagement was a stronger moderator between poverty and a child's cognitive skills (Baker et al., 2018).

Unfortunately, many SES studies have been designed to capture formal education only. However, many individuals have additional forms of training (apprenticeships and/or vocational training) that can impact SES (Tsui, 2010). Furthermore, SES does not rise consistently with an increase in years of education; therefore, using it as a measure for SES can be problematic.

Free or Reduced Lunch

Free or reduced lunch has often been used as an estimate to measure SES in the field of educational research because it is easily accessible in school records (Harwell & LeBeau, 2010). Free or reduced lunch at schools first became available in 1946 to children from low-income families. Children were eligible if their household income met the eligibility cutoff. Since then, researchers have used free or reduced lunch eligibility to measure income (Domina et al., 2018). Throughout the years, however, there have been many policy changes that have changed the qualification requirements. Students are now eligible for free and reduced lunch if their families qualify for other public health programs. Additionally, when 40% of the student population at a school is eligible for public benefit programs, students may become eligible for free or reduced lunch. With so many policy changes to the program and inconsistencies across who is eligible, there is substantial evidence suggesting free or reduced lunch eligibility is a poor measure of SES (Harwell & LeBeau, 2010).

Title 1 Status

Another measure of SES often used in educational research is the school ranking or title. Title 1 status is determined by the number of low-income students enrolled at the school, which is linked to the number of students receiving free or reduced lunch as well as information from

the federal poverty census information (U.S Department of Education, 2018). Schools with large concentrations of low-income students are classified as Title 1 schools. Title 1 schools receive funds to provide services to support the students who are failing or are at-risk in their academics. The amount of money the school receives is determined by the number of low-income children enrolled. Many schools use these funds to improve curriculum, parental involvement, increase staff and program improvement, and provide supplemental educational services outside the regular school day. The impact of these extra funds/services have been extensively studied (Heinrich et al., 2010; Zimmer et al., 2007). The data have shown that math test scores averaged across seven districts of students participating in these services are higher than math test scores of students that are not receiving services. Another study found similar results when they measured the student's math scores; however, when they measured the students' reading abilities, Springer et al. (2009b) did not find any significant differences between the groups.

In the 2015-2016 school year, more than 50,000 high poverty public schools were receiving Title 1 funds in the U.S. (U.S. Department of Education, 2018). One of the major problems with using the status of the school as a measure of SES is that while many students attend school in the neighborhood in which they live, several students attend schools outside their neighborhoods. Therefore, the school status may not provide an accurate measure of the SES of that neighborhood or community.

Insurance Status

Another contextual measure of SES that is gaining popularity across disciplines is access to health insurance. Studies have shown that more than 60% of uninsured adults belong to low-income families. A study conducted on males by Penson et al. (2001) demonstrated that health insurance status was associated with health-related quality of life (HRQOL) over time and that

patients with lower annual income and limited access to health insurance had a significantly lower HRQOL baseline. In a separate study, researchers found that men with less income, less education, and lower occupational status displayed higher mortality for a variety of death causes, which could have been treated medically (Wood et al., 1999) if these individuals had medical insurance.

Access to health insurance among young children is much more accessible regardless of SES status. Public insurance covers over 70% of low-income children in the U.S. However, research has shown that older children have a higher risk of being uninsured. Furthermore, even though some children may be insured, that does not mean they will use it. Dunlop et al. (2000) found that children from low SES households used primary care more frequently but were less likely to get specialty care.

SES Summary

The impact and significance of SES across many disciplines of educational research have made it one of the most highly researched and measured variables. How SES is measured, however, is often left to the discretion of researchers. They may opt to use only one method (such as family income) or combine multiple (such as income, occupation, and education) to determine the participants' SES. Recently, more and more researchers are viewing SES as a multifactorial variable and are combining several measures to create a composite or index measure that can be applied to determine the SES status of an individual or group. The numerous methods used to measure SES suggest that those reviewing the literature must exercise some caution. The results and conclusions will vary as the research looks at different variables and not necessarily the same ones each time. Discrepancies between research studies may, therefore, be because the variables under consideration are different.

SES and Neurocognitive Performance

There has been substantial evidence suggesting that SES affects the quality of the education system, including curriculum rigor, access to resources, and experienced teachers. A direct relationship is frequently reported among studies; when SES decreases, the quality of the education system also decreases. Concurrently, other studies have shown the quality of education a child receives is related to their school performance.

This section will provide a detailed review of studies looking at the role and impact of SES on children's academic and cognitive development. Both cognitive and academic development are valuable measures of a child's overall performance, ability, and progress in school. A general overview of the impact of SES on the education system and student achievement is included in Chapter 1.

Cognitive Development

Cognitive development considers the mental capacity of an individual to problem solve, plan, think in abstract patterns, and learn from experience (Gottfredson, 1997). Cognitive development is a vast discipline comprised of the following parameters: perception, attention, memory, motor skills, language, visual and special processing, and executive functions.

Intelligence. The general intelligence (IQ) of an individual is used as an indicator of cognitive development. Sternberg (2012) explains intelligence as an individual's overall ability to learn and adapt to their environment. Higher IQ scores suggest the individual has higher intellectual functioning. This measure is useful as a starting point to understand a student's skills and needs. However, it only provides information about a student's general functioning. It does not necessarily explain, for example, why a student may not know how to read even though they are in the fifth grade, or if the student has some special skills in an area such as art, music, or

learning a foreign language. Therefore, it must be used in combination with other measures of cognitive performance.

Of all the measures of cognitive ability, IQ has been the most studied regarding SES. In an adoption study, Capron and Duyme (1989) found that children adopted by parents belonging to high SES (years of schooling and occupation) groups scored 11.6 IQ points higher than children adopted by low-SES parents. They also determined that children born to high-SES parents scored 15.5 IQ points higher than children born to low-SES parents. In another study, Duncan et al. (1994) found that low family income and poverty status were associated with lower IQ levels in children at age five. More specifically, they found that the IQs of children in affluent neighborhoods were higher than in low-income neighborhoods, regardless of family structure and maternal schooling.

A more recent study, looking at the growth of intelligence from infancy through adolescence based on SES, showed that higher SES (parental education, occupation, and income) was related to higher starting IQ in infancy and more significant gains in intelligence over time. Children from low SES families scored on average six IQ points lower at age two than children from high SES backgrounds, and by age 16, the IQ difference had almost tripled (Von Stumm, & Plomin, 2015).

Verbal Abilities. Verbal abilities include the student's skills to understand and use language to communicate their needs and ideas. Children who display low scores on their verbal abilities may display problems in conveying basic knowledge or expressing themselves verbally even though they have adequate memory to recall what they have learned. They may also struggle in basic problem-solving and reasoning skills that require verbal output.

Several studies have found correlations between SES and a child's verbal abilities, suggesting that language is one of the cognitive domains most affected by SES. Researchers found that children from higher SES groups had better language composite scores than children from low SES families (Noble et al., 2005). A study conducted on adolescents in grades 7 through 12 showed that a mother's and father's education, father's and mother's occupation, household income, neighborhood disadvantage were all significantly and independently associated with verbal ability (Guo et al., 2019). Similarly, Huttenlocher et al. (2002) found a correlation between SES and the complexity of sentences uttered by children. Children belonging to high SES groups could form and verbalize more complex sentences than children from low SES families. Parents from higher SES have been found to speak many words to their children, using more extensive and more complex vocabularies than lower SES parents. Anderson et al. (1996), for example, found a significant relationship between maternal SES and verbal IQ in a Swedish cohort of boys and girls. Raviv et al. (2004) conducted a study to identify factors that influence the relationship between SES and language skills; they also found that maternal cognitive stimulation was a significant mediator of verbal comprehension, expressive language, and receptive verbal abilities.

Nonverbal Abilities. Nonverbal abilities are an individual's ability to interpret and solve problems using visual information accurately. Nonverbal intelligence helps with analyzing and solving problems without having to rely on language abilities. This becomes useful in the schools, specifically for students who display limited language abilities. The tests often used to assess nonverbal abilities measure an individual's visual-motor construction, visual-spatial processing, and visual problem-solving. SES has been shown to affect nonverbal intelligence

through a number of factors such as health and nutrition and cognitive stimulation (Black et al., 2017).

Working Memory. Working memory is the ability of an individual to store and retain and manipulate information. It is essential for planning, comprehension, reasoning, and problem-solving. It is also a prerequisite for the long-term storage of information. Several studies have shown that children who cannot follow directions have low working memory ability; they are either not able to remember instructions or not able to stick to the task goal and pay attention continually. Sabol and Pianta (2012) demonstrated that children with low working memory do not do well in school. They found that children at fifty-four months who displayed low working memory showed higher levels of socioemotional problems and low achievement in fifth grade. Working memory has also been shown to be impacted by SES. For example, Farah et al. (2006) found significant deficits in working memory between kindergarten students from low to middle SES income. They also found similar differences between 11-year-old from low to middle-SES. In a study of first-graders, SES was shown to be a significant predictor of working memory. Morgan et al. (2009) showed that children from low SES households scored lower on memory and socioemotional processing tests, suggesting that economic disadvantage may contribute to cognitive challenges.

Executive Function. Executive functioning describes a set of processes that have to do with helping create individual plans and the ability to monitor oneself to achieve a goal. Executive function depends on three types of brain function: working memory, mental flexibility, and self-control. Working memory regulates an individual's ability to retain and manipulate distinct pieces of information over short periods of time. Mental flexibility helps sustain or shift attention in response to different demands. Self-control enables individuals to set

priorities and resist impulsive actions or responses. Studies have consistently found that higher SES is associated with better executive function performance.

SES and Academic Performance

Academic performance has been shown to be affected by SES. In most school districts across the U.S., a child's academic development is assessed by teacher evaluation and their performance on standardized exams. Several groups have shown that economically disadvantaged students average lower scores on achievement tests such as the ACT and SAT (Cooper & Crosnoe, 2007). Academic abilities are also often measured by standardized assessments of achievement. These tests allow for the opportunity to measure reading, writing, and math.

Reading

Reading skills reflect the basic reading skills, reading comprehension, and reading fluency of the child. A parent's education level has been shown to impact their child's literacy level directly. Children benefit from watching their parents read and from reading with their parents. These tasks help support the child's language and literacy development and help prepare them for school. A child's literacy development is impacted when parents are less educated and are of lower SES. Better reading outcomes have been contributed to higher SES (Peterson & Pennington, 2015). SES has been shown to affect the home environment language production and the quality of school instruction (Hoff, 2003; Lee & Burkam, 2002).

Basic Reading Skills. Basic reading skills include phonemic awareness, sight word recognition, and phonics and word analysis. Students need to be able to identify letters, letter sounds and decode written language. Noble et al. (2006) examined the effects of SES on the relationship between phonological awareness, word decoding, brain activation in children. The

study found an increase in brain activation in children with higher-SES when viewing pseudowords, while children of lower-SES displayed less brain activation. In 2015, fourth-grade and eighth-grade students eligible for the school lunch program (indicating low family income) were 2.5 times more likely to read at a below proficient level than students from higher-income families (U.S. Department of Education, 2015).

Reading Comprehension. Reading comprehension is the ability to process text, understand what is being read, and integrate it with prior knowledge. Previous studies have demonstrated that SES is a predictor of children's early reading development (Hart et al., 2013; Kieffer, 2010). This is essential because students from low-SES backgrounds may be at elevated risk for reading difficulties (Kieffer, 2012). Reading comprehension has been noted to rely on vocabulary knowledge (Foorman et al., 2018). Therefore, a lack of vocabulary can cause difficulties in reading comprehension and subsequently affect learning in schools (Johnson et al., 2010).

Reading Fluency. Fluency is defined as the ability to read with speed, accuracy, and proper expression. The passage may be read out silently or aloud and fluently to understand what one is reading. Just like comprehension, few studies are looking at reading fluency and the effects SES has on reading fluency. Weigel (2006) examined mothers' SES status and their view of reading. Mothers of lower SES households found literacy activities laborious, while mothers of higher SES viewed reading as entertaining. Additionally, low SES parents may often work multiple jobs and struggle to dedicate time to engaging in joint book reading.

Mathematics

Mathematical skills are measured through math calculations (the ability to count, group objects, and compute simple math facts and operations), math problem-solving skills (developing

understanding and being able to explain the process used to arrive at solutions), and math fluency (ability to perform mathematical problems accurately and quickly). Students from low-socioeconomic backgrounds often do not get the chance to build verbal and symbolic number knowledge. Jordan et al. (2009) conducted a study that found students from low socioeconomic backgrounds entered kindergarten well behind students from middle-class economic backgrounds in tasks that assess number competence. An earlier study looked at national data that reflected gaps in math performance between Caucasian and African American students. They found a significant gap at both the lowest and highest SES levels. The lowest SES Caucasian students consistently scored equal to or higher than the highest SES African American students across fourth, eighth, and twelfth grade (Lubienski, 2002).

Research has shown that approximately one-third of fourth-grade children from low-income households do not reach basic achievement levels in mathematics (U.S. Department of Education, 2005). This educational gap is seen even in earlier ages; high and low SES kindergartner's math assessments depicted a 1.3 standard deviational difference (Duncan & Magnuson, 2011). Furthermore, early SES disparities in math may have implications for later social mobility (Crosnoe & Cooper, 2010) if low SES children do not attain the math skills needed for the future.

Writing

Writing skills are broken down into spelling (the ability to spell dictated letters and words), sentence composition (the ability to formulate and write sentences), and essay writing (the ability to write an essay). Few studies are looking at how SES affects writing outcomes for students, most studies discussing writing are focusing on reading and through the study look at

print knowledge, written syntax and the impacts it has on linguistic knowledge (Hecht et al., 2000; Purcell-Gates et al., 1995).

Processes Explaining the Effects of SES on Adolescence Performance

Many theories have attempted to explain why SES has such a dramatic effect on a child's cognitive and academic performance in school. Some researchers have focused on biological factors; others have looked at the role of the parent and home and school environment. This section will review some of the most accepted theories and studies assessing a child's academic and cognitive performance across different SES groups.

Biological Factors

As our understanding of biology and genetics increases, so have investigations of how SES affects the levels of hormones or the expression pattern of genes known to play a role in learning and development. Several studies have shown that the stress-response hormones cortisol, and adrenaline, are inversely correlated with SES (Cohen et al., 2006). Changes in the levels of these hormones have also been suggested to impact a child's academic development and performance. A highly studied theory, known as the stress theory, hypothesizes that mothers from low SES backgrounds have chronically elevated levels of stress hormones. These hormones negatively impact the development of different brain areas supporting working and long-term memory, spatial processing, and pattern recognition in utero (Hackman & Farah, 2009). For example, Campbell et al. (2019) identified 258 expecting mothers with elevated cortisol, a stress hormone, and then several years later assessed the cognitive development of their offspring. Specifically, the Wide Range Assessment of Memory and Learning, 2nd Edition was administered to children when they were approximately seven years old. They found that elevated prenatal cortisol negatively affects a child's memory and cognitive development.

Studies have also found that chronic stress impacts learning, behavior, and health in early childhood (McLaughlin & Sheridan, 2016). Mistry et al. (2009) conducted a psychosocial study assessing how a child's perception of family economic stress affects their academic outcomes. They found that children who thought their families had many financial constraints and/or economic stressors were more depressed and performed worse academically than students who were unaware of those stressors in their families.

Parental Involvement

Many studies examining the relationship between academic performance and SES have focused on parental involvement (Duan et al., 2018). Home-based involvement involves the parent asking about their child's day at school and their willingness to supervise and check homework. School-based involvement includes engaging in school-based activities, communicating with teachers, and attending class meetings (Shute et al., 2011). Academic socialization includes parents' expectations and trust about their children's education. Academic achievement and school behavior have been shown to be positively influenced by parent's involvement and expectations of their child's education (Benner et al., 2016; Hill & Tyson, 2009). Parent involvement with their child's school, such as attending parent-teacher meetings and helping with school activities, has demonstrated that those children perform better academically (Pomerantz et al., 2007). In a separate study conducted by Tamis-LeMonda et al. (2004), parents' direct engagement with their children was shown to positively affect their child's linguistic, literacy, and cognitive abilities.

Unfortunately, studies have also shown that parents with low SES typically practice low levels of academic socialization with their children (Carolan & Wasserman, 2015). One study found that only 36% of low-income parents were regularly involved in three or more school

activities, compared to 59% of parents above the poverty line (US Department of Health and Human Services, 2000). Caregivers of low SES status tend to be overworked and overstressed (Evans, 2004), leaving low-SES children to fend for themselves and their younger siblings. Homes of higher SES have been shown to often participate in high-quality activities (Fantuzzo et al., 2004), such as demonstrating better communication with their children (Conger, & Donnellan, 2007).

School Environment

Others have argued that poor school environments and conditions contribute more to SES differences in learning rates than biological factors, parenting style, or cognitive stimulation in the home (Aikens & Barbarin, 2008). Many of these studies have suggested that the major confounding issue is that schools in low SES communities and Title 1 schools are often under-resourced; they lack materials or the personnel to teach their students adequately. Pribesh et al. (2011), for example, found that schools with high poverty rates have less staff and fewer library resources than schools serving children from higher SES backgrounds. Children in low-income schools are also more likely to have less experienced teachers (Clotfelter et al., 2006), which, interestingly, is correlated with a child's academic achievement (National Council, 2000).

Research has demonstrated that SES influences a student's academic and cognitive abilities. When a student struggles with a chronic illness, such as T1DM, research has also supported varying cognitive and academic performances.

Type 1 Diabetes Mellitus

Type 1 diabetes mellitus (T1DM) occurs when the body's immune system destroys the pancreas' insulin-producing cells. This results in a complete deficiency of the insulin hormone. People with type 1 diabetes do not have the ability to move glucose into the cells because insulin

is not available. Glucose, therefore, stays in the blood, which makes the blood sugar level very high.

T1DM often affects younger adolescents. Once diagnosed, adolescents require an individualized care plan with ongoing education, support, and assessment for acute and chronic complications. Proper and frequent monitoring of blood glucose levels is essential because extreme fluctuations in blood glucose levels can lead to fatal complications. In order to control their blood glucose levels, adolescents typically receive insulin therapy either via multiple daily injections or via an insulin pump. Adolescent/family members must learn how to monitor blood glucose levels, and they must remember to make it part of their daily routine.

Research has shown that these daily responsibilities often leave little to no time for parents to worry about the regular developmental tasks of their children. Not only do parents experience psychosocial stressors due to the daily responsibilities of managing their child's condition, but they are also constantly worrying about their child's health. Smaldone and Ritholz (2011) interviewed 14 parents of children diagnosed with T1DM as toddlers. At the time of the interview, the children were approximately 11 years old. Most parents reported feeling fear and worry and doubted their ability to appropriately manage their child's diabetes at the time of diagnosis. They also reported feeling isolated because many of their family members and friends did not understand the demands and worries associated with T1DM (Johnson et al., 2013).

In a study conducted by Herbert et al. (2015), 44% of 134 parents reported that their child's diagnosis impacted their school enrollment decisions. 12% reported removing their child from a school or daycare program because they were concerned about the school's ability to manage their child's T1DM appropriately. The impact of these decisions on a child's academic and social development is profound. Multiple studies have shown that moving while the child is

in elementary school affects both the cognitive and social-emotional functioning of a child. The Early Child Longitudinal Study, for example, followed 19,612 children from kindergarten through eighth grade and found that moving schools during childhood and early adolescence were negatively associated with the child's cognitive skills (Coley, & Kull, 2016).

Unfortunately, parents with lower incomes are at an even greater risk of experiencing the above worries and stressors. As a result, children of these families are also at increased risk of suffering socio-developmental setbacks. Walker et al. (2015) found that youth from lower SES backgrounds with T1DM were under-resourced in social supports; they knew fewer people who also had diabetes, neither parent nor the child engaged in diabetes-specific groups or organizations, fewer participated in any extra-curricular activities and parents often turned for support to family members rather than medical professionals for help regarding diabetes management. The study also demonstrated that children from lower SES households had higher mean HbA1C levels, which put them at risk for poor glycemic control and increased morbidity/mortality. Several studies have corroborated these findings. Gallegos-Macias et al. (2003), for example, found that low familial income is one of the primary factors associated with poor glycemic control among children with T1DM.

Many low-income families have public health insurance and are obligated to pay out-of-pocket for medical expenses. As mentioned before, Tao et al. (2010) determined that patients with T1DM spend approximately \$6000 more on medical expenses each year, with a total of \$130,000 over their lifetime for someone first diagnosed at the age of 14. Low-income families worry about not having enough money to pay for doctor's visits and are consequently more likely to cancel doctor appointments and/or wait until the condition worsens. In a recent study, Cortina et al. (2010) showed that adolescents with private health insurance monitored their blood glucose

levels more frequently and had significantly lower HbA1c values than those with other forms of health insurance. They also shared more responsibility for diabetes management with their families.

As mentioned before, Harris et al. (1998) found that African American children exhibited poorer glycemic control than their White counterparts, suggesting that both ethnicity and family structure are important determinants of glycemic control in T1DM. In a similar study, Willi et al. (2015) investigated the management and glycemic control of more than ten thousand White, African American, and Hispanic children with T1DM. They found that SES and parent education level accounted for some of the discrepancy seen in African American and Hispanic youth compared to White youth. Collectively, these studies highlight the striking impact that SES has on the quality of life of families and children with T1DM and suggest that more research is needed on how to mitigate these adverse effects.

School-aged children and especially adolescents with T1DM often report feeling different from their peers. They often wish they did not have diabetes so that they can be perceived as "normal" by their peers and friends. Diabetes monitoring and treatment can be very public events for young people. Injection sites, finger pricks, and pumps, for example, may all be visible, which can lead to increased questioning that can potentially make the young person feel uncomfortable. As a result, children and adolescents may skip checking their blood glucose levels at school or administering insulin to fit in with others. Non-adherence to treatment may result in hyper or hypoglycemia, both of which may result in severe/fatal consequences. By adolescence, diabetes is often more challenging to control during the teenage years due to hormonal changes. Children with T1DM encounter many stressors in their life due to their chronic health condition. Dealing with stress is important but even more important for children

with T1DM because of the serious effects it can have on their health. The production of adrenaline and cortisol (“stress hormones”) causes the liver to release more glucose for additional energy (Falco et al., 2015). For individuals with diabetes the increase of these hormones can cause high blood sugar levels. Therefore, it even that much more important for children to learn how deal with the stress that their health condition may cause.

T1DM has also been shown to increase the risk for psychiatric disorders in children. In a study evaluating routine behavioral and mental health screening in a pediatric diabetes clinic, researchers found that children between 4-7 years old with T1DM were more likely to score higher on the Strengths and Difficulties Questionnaire. This test helps assess the risk for psychological disorders such as anxiety and depression (Zenlea et al., 2014). Similarly, in a different study looking to determine whether having diabetes as a child affects psychological adjustment, researchers found that both internalized and externalized behavior problems were increased in children (ages 7-13) with T1DM (Castro et al., 2000).

T1DM and the Effects on Neurocognitive Abilities

Considering all of this, it is unsurprising that when interviewed, parents of children with T1DM and children with T1DM described their diagnosis as unrelenting, constant, and tiring. The challenges families and individuals face following a diagnosis impacts all aspects of their lives. For children and adolescents, the biggest impact is on their academics. There has been mounting evidence suggesting that while children with T1DM have the same range of intelligence (IQ) as the general population, students with T1DM struggle in school (Streisand, & Monaghan, 2014). More specifically, factors such as age of onset, duration of diabetes, and glycemic control have been shown to correlate with cognitive and academic performance (Naguib et al., 2009). For example, Cato and Hershey (2016) reported that children who are

diagnosed earlier with T1DM tend to have more difficulty in school and perform worse on academic and cognitive tests. In a longitudinal study of cognitive and academic abilities, Kovacs et al. (1992) reported that at the time of diagnosis, children with T1DM performed within the average range in cognitive abilities and school grades, but that over time, their vocabulary and overall grades tended to decline.

To understand why differences in cognitive performance exist between children with T1DM and children without diabetes, several extensive, national studies have been executed. The DirecNet research group has published several papers comparing brain structure and neuropsychological functioning in a group of children between the ages of 4 and 10 with T1DM to age-matched healthy controls. The results of these studies show that children with T1DM and a history of significant hyper or hypo-glycemia had decreased gray matter volume in areas associated with cognition (medial frontal, lateral frontal, occipital lobe, and cerebellum) compared to healthy participants (Marzelli et al., 2014). Using data from the same participants, Cato et al. (2014) demonstrated an association between hyperglycemia and some measures of cognition: executive function, learning, memory, and processing speed, even as early as two years after the onset of T1DM.

Interestingly, cognitive differences appear to be more pronounced in older children with early diabetes onset (<5 years). The following studies looked at children between 7-18 years old diagnosed with T1DM as toddlers. Lin et al. (2010) compared 106 youth with T1DM 12 years after diagnosis and 75 healthy controls. They tested eight cognitive domains, including verbal abilities, perceptual reasoning, new learning, working memory, non-verbal processing speed, and mental efficiency, divided attention, and sustained attention. Youth with T1DM performed more poorly on working memory than youth in the control group. Children with T1DM who had

experienced at least one hypoglycemic event demonstrated poorer working memory, verbal abilities, and non-verbal processing speeds. If the child had experienced either a hyper or hypoglycemic event, they performed more poorly than controls on verbal abilities, working memory, and mental efficiency. Another study also found significant relationships between cognitive performance and both chronic hyperglycemia and recurrent severe hypoglycemia in children between 7 and 14 years old (Northam et al., 1998). Similarly, Semenkovich et al. (2015) reported a relationship between repeated severe hypoglycemia and spatial memory performance in children ages 7-18. In all these studies, researchers found that after 12 years of disease duration, the effects of poor metabolic control cause additional struggles, particularly for verbal IQ subtests and executive functioning tasks.

T1DM and the Effects on Academic Abilities

A chronic illness may directly affect a student's cognitive abilities but also affect their learning capabilities. Previous studies have discovered a relationship between the academic performance of the student and their glucose levels. A study conducted by Potts et al. (2015), found the inability to maintain glucose control was associated with poorer academic grades. These findings were corroborated by a study measuring the glucose level of students and their academic performance simultaneously. Again, the recommended daily glucose range for a student with T1DM is 80mg/dL to 140 mg/dL (ADA, 2016b). The study's findings suggest that if a student participated in an academic task twelve hours after being in a hypoglycemic episode, their performance on the academic task would be hindered (Knight & Perfect, 2019). Students whose glucose levels were greater than 180 mg/dL had lower scores on reading fluency and writing fluency subtests than those in the target range. Another study found that children who had poor metabolic control and had been hospitalized at least two times for hyperglycemia, had

lower mean scores on an achievement assessment than those who had average metabolic control and hospitalized fewer than two times for hyperglycemia. With this noted interference, the changes in glucose have been found to predict changes in GPAs; the more struggles maintaining glucose levels, the worse a student's grades would be (Winnick et al., 2017).

When comparing children with early-onset T1DM to their healthy counterparts, their counting and arithmetic assessments demonstrated to be lower in those that acquired T1DM at a young age. Another aspect that can contribute to the overall academic abilities of a student with a chronic illness, as mentioned before, is attendance. Their proneness to miss at least 10% more of the school year will affect their opportunity to learn directly from their teacher and participate in instruction. A study conducted by Parent et al. (2009) displayed teachers perceiving their students with chronic illnesses significantly lower academically than their healthy counterparts.

The research on children who have T1DM shows that their cognitive and academic performance is lower compared to healthy youth (Semenkovich et al., 2016). SES has been confirmed to impact different aspects that affect a student's school performance, such as a parent involvement and environmental factors. There is also no question that the health of students aligns with their school performance. However, the research is minimal in its efforts to discover the effects SES may have on the academic abilities of a student who has a chronic illness, such as T1DM.

Overall, most studies have shown low SES negatively affects neurocognitive and academic performance in children. While fewer studies are looking at children with T1DM specifically, the current data suggest that children with T1DM that belong to low SES groups also perform worse on cognitive and academic tests. Further, SES is a consistent and reliable predictor of a vast array of outcomes across the life span. Making SES relevant to researchers,

practitioners, education personnel, and advocates. Thus, this study can serve as a foundation on a conceptualizing framework looking at SES research and how to effect change. Looking at SES in a factor format instead of individual variables can help conceptualize all the extensive intricacies that it holds. Understanding the powerful effects can better organize intervention and prevention strategies to support and target these areas in unison to improve overall neurocognitive and academic performance.

Chapter 3: Methods

Chapter three presents the characteristics of the participants in the study, including the latent, dependent, and independent variables, followed by the research question.

Participants

The participants for this study came from a clinical trial that examined the effect of a sleep intervention on students from the age of 10 to 16 with T1DM (Glucose Regulation and Neurobehavioral Effects of Sleep - GRANES). The participants were recruited from an outpatient specialist clinic within a hospital located in the southwest of Tucson, Arizona. The original study had 111 participants enrolled. The inclusion criteria for participants in this current study were: (1) diagnosis of T1DM; (2) a parent willing to participate; (3) between the ages of 10–16 years old and (4) the child had to participate in the academic and Cogstate assessments.

The number of participants in the study was 111. Participants had a mean age of 13.60 ± 2.11 years, with 53 being female and 58 being male. Approximately half (48.3%) of participants identified as non-white, with 29.5% identifying as Hispanic/Latino/Spanish/Mexican. The other 18.8% of participants selected more than one ethnicity. Approximately a fourth (29.5%) of the participants' parents reported their education to be less than a high school diploma, 31.3 % reported obtaining a high school diploma.

The mean annual household income per zip code based on census tract data was \$52,055. Approximately half of the participants (48.6%) reported an annual household income of less than \$50,000. The average duration of T1DM diagnosis was 4.93 ($SD \pm 3.73$) years prior to the study. Participants' average age when they were diagnosed was 8.58 years old ($SD \pm 3.62$). The average FSIQ of the participants is a standard score of 100. See Table 1 and 2 for participants' characteristics.

Table 1*Description of Participant Demographic Characteristics*

Characteristic	<i>n</i>	%
Gender		
Female	53	47.7
Male	58	52.3
Ethnicity		
White	56	50
Hispanic, Latino, Spanish, or Mexican	33	29.5
More than one selected	21	18.8
Diabetes Characteristic		
		Mean
Years of Age		13.60 ± 2.11
Mean Age at T1DM Diagnosis (Years)		8.58
(Age of Diagnosis Range)		(0.92-15.8)
Mean Duration Since T1DM Diagnosis (Years)		4.93
(Duration Since Diagnosis)		(.10-14.83)
Cognitive Characteristics		
		Mean
Full Scale IQ		100 ± 14.35
Verbal IQ		99.87 ± 13.70
Performance IQ		100 ± 15.62
	<i>n</i>	%
Gifted or Accelerated Program	14	12.5
504 Accommodations	34	30.4
Individualized Education Plan	26	23.2

Table 2*Description of Participant SES Characteristics*

Characteristic	<i>n</i>	%
Respondent's Education		
11 th grade or less	21	18.8
High School Graduate	16	14.3
Partial College or Specialized Training	34	30.4
Bachelor's Degree	22	19.6
Graduate Degree	16	14.3

Father's Education

11 th grade or less	12	10.7
High School Graduate	19	17.0
Partial College or Specialized Training	33	29.5
Bachelor's Degree	23	20.5
Graduate Degree	18	16.1
Household Income		
\$10,000-\$20,000	19	17.1
\$20,000-\$35,000	15	13.5
\$35,000-\$50,000	20	18.0
\$50,000-\$75,000	9	8.1
\$75,000-\$99,000	22	19.8
\$100,000 or more	22	19.8
No Response	4	3.6
Free/Reduced Lunch	48	42.9
		Mean
Mean Household Income by Zip code		\$52,055
(Median Income Range)		(25,811-101,888)

Measures

This section describes the measures collected as part of the larger clinical trial that is relevant to the purpose of the present study.

Wechsler Abbreviated Scale of Intelligence, Second Edition (WASI-II)

The WASI-II is a brief measure of cognitive ability. It is an individually administered assessment instrument used to compare the performance of individuals (Wechsler, 2011). The test was designed for individuals from 6 years of age through 90 years and 11 months of age. The normative sample included 2,300 examinees divided into 23 age groups, and each group had 100 participants.

The WASI-II was used in this study to measure the verbal and nonverbal abilities of the participants. To measure the verbal skills of the subjects, the test consisted of a vocabulary and a similarities test. The Vocabulary subtest is designed to measure an examinee's word knowledge and verbal concept formation. It includes three picture items and twenty-eight verbal items; for

the picture items, the examinee names the object presented visually. For the verbal items, the examinee defines words that are presented visually and orally. The Similarities subtest is designed to measure verbal concept formation and reasoning. It requires the examinee to describe how two common objects or concepts are similar. Taken together, performance on these two subtests makes up the Verbal Comprehension Index. Average reliability coefficients for the WASI-II subtests for participants were: Vocabulary, .91; Similarities, .89. On composites, average reliability coefficients have been reported to be .94 for VCI (Maccow, 2011).

To measure the subject's nonverbal abilities, their perceptual reasoning was looked at. The assessments used were the Block Design and Matrix Reasoning subtests. The block design subtest is designed to measure the ability to analyze and synthesize abstract visual stimuli. On Block Design, the participant manipulates blocks to match a pattern presented to them. Matrix Reasoning asks the participant to identify a pattern and select the missing element from that pattern; this test looks at fluid intelligence, broad visual intelligence, classification, and spatial ability, knowledge of part-whole relationships, simultaneous processing, and perceptual organization. Average reliability coefficients for these particular WASI-II subtests for participants were: Block Design, .89; and Matrix Reasoning, .87. On composites, average reliability coefficients have been reported to be .92 for PRI (Maccow, 2011).

The WAIS-II has been concurrently validated with measures of intelligence such as Wechsler Adult Scale Intelligence, Wechsler Intelligence Scale for Children, Fourth Edition, Wechsler Adult Intelligence Scale, Fourth Edition, and Kaufman Brief Intelligence Test, Second Edition and with the measures of achievement Wechsler Fundamentals: Academic Skills. WAIS-II has been found reliable.

Cogstate Tests

The Cogstate test is a computerized cognitive test designed to measure a specific area of cognition based on the study design and population requirements. The assessment of this study looked at memory, processing, executive functioning, and learning. Researchers have used Cogstate to investigate cognitive functioning in individuals with several chronic illnesses. This study used the following tests: Groton Maze, Detection Test, One Card Learning, One Back. For this study, the results of the assessment were converted to standard scores and used for data analysis.

Groton Maze Learning Test. The Groton Maze Learning Test is used to measure executive functioning. The participant is presented with a 10 x 10 grid and must use a set of rules and, through trial and error, find a path to get from the start to the end. After completing the maze, the participant must do the maze four additional times. The fewer errors the participant commits, the better their performance. Normative data on children between the ages of 10 to 15 yields a mean of 55.56 errors and a standard deviation of 17.81 (Cromer et al., 2015).

Detection Test. The detection test uses reaction time to measure psychomotor functioning and processing speed. The Detection Test requires a participant to click a predetermined key when an image of a face down playing card is turned faced up. Participants repeat this task multiple times; shorter times translate to better performance. The detection test uses reaction time to measure psychomotor functioning and processing speed. Normative data yields a mean Log10 transformed reaction time of 2.53 and a standard deviation of 0.078 (Cromer et al., 2015).

One Card Learning. The One Card Learning test is used to measure visual memory and learning. On this test, the participants are shown a series of playing cards. The participant must determine if it is a card they have seen or not seen before. On this assessment, higher accuracy

scores are associated with better performance. Normative data yields a mean accuracy of .98 and a standard deviation of 0.086 (Cromer et al., 2015)

One Back. The One Back test is used to measure attention and working memory. On the One Back test, the participants are shown a series of playing cards. The participant must determine if it is a card they have seen or not seen before. Normative data yields a Log10 transformed reaction time of 2.87 and a standard deviation of 0.089 (Cromer et al., 2015).

Identification Test. The identification test is used to measure visual attention. Participants are presented with an image of a playing card face down, the playing card is turned face up, and they must determine the color (red or black) of the card. Participants participated in multiple trials, the shorter the completion time, the better the performance. Normative data yields a mean Log10 transformed reaction time of 2.69 and a standard deviation of 0.068 (Cromer et al., 2015).

Woodcock-Johnson, Third Edition Normative Update, Test of Achievement (WJ-III-NU ACH).

The WJ-III-NU ACH was used to determine academic ability in various areas of achievement. The WJ-III-NU is an individually administered assessment instrument used to compare the performance of individuals of the same age or year of formal education completed (Woodcock, McGrew, & Mather, 2001). Subtests scores have a mean of 100 with a standard deviation of 15. The test is normed for individuals from 2 years of age to over 90 years of age.

The WJ-III-NU Achievement assessment is a valid and reliable tool used to measure academic achievement of children and adults (Abu-Hamour et al., 2012). The following subtest was used in this study to measure the participant's overall academic abilities.

Calculation. The calculation subtest requires the participant to solve a series of increasingly difficult mathematics facts. The student is given a worksheet to complete.

Letter-Word Identification. Letter-word identification assesses the ability to identify letters and to read words from an increasingly difficult vocabulary list. This subtest is an oral test, and pronunciation is assessed.

Passage Comprehension. Passage comprehension needs the participant to read passages and answer questions about what they have read. This subtest measures the students' understanding of what was read. The child reads a sentence silently and then decides on a specific word needed in the blank to complete the sentence.

Spelling. Spelling requires the examinee to write and spell words of increasing difficulty. The examiner dictates the word followed by a contextual sentence. The student is to spell only the word provided.

Math Fluency, Reading Fluency, Writing Fluency. The math (3 minutes), reading (3 minutes), and writing fluency (7 minutes) subtests are timed and designed to determine how quickly the examinee can solve problems in the given subject areas. Reliability coefficients for the administered subtests are as follows: calculation, .86; letter-word identification, .94; math fluency, .90; passage comprehension, .88; reading fluency, .90; spelling, .90; and writing fluency, .88 (Schrank et al., 2001).

Subtest was used in the model instead of full composite. If full composites were used, they would be considered latent constructs that would interfere with the ability to complete the study due to the population size, the more latent constructs in the model, the higher the recommended population size.

Demographics and Health Interview Form

The participant's guardian(s) completed a demographics and health interview form during the study. These forms include information regarding the participant's: ethnicity, country of origin, medical diagnoses, and financial status. Through the demographic and health interview form for this study, we confirmed the medical diagnosis of T1DM and obtained a self-reported level of education and income for both parents (mother and father) if available. The questions that will be used from the interview forms for the study are the following: demographic health interview #9–What is the highest level of education you completed?, demographic health interview #10–What is the highest level of education your child's father completed?, demographic health interview #8 – Which annual income best reflects your household's family? And demographic health interview #6 – Free lunch or reduced lunch? Demographic health interview #6 – Does he/she qualify and/or receive free/reduced lunch at school?

Medical Record Review Form

The medical records of the participant were reviewed to gather relevant information, including age or date of diagnosis, health history, zip code, and laboratory results such as their most recent HbA1c.

Procedures

Participants were recruited during regularly scheduled appointments at a pediatric endocrinology clinic at the University of Arizona. Each participant was enrolled in the larger study for approximately two weeks, during which there were three clinic visits, one home visit, and two school visits (Perfect, 2014 for a full description of study procedures for the clinical trial).

Recruitment

Recruitment for the GRANES study followed one of two procedures. Each potentially eligible patient was asked by clinic staff at their regularly scheduled clinic appointment if they would be interested in hearing about a research study being conducted in the clinic. If they were interested, a team member was brought into the room to describe the study and schedule study appointments if they agreed to participate. Alternatively, if a team member was not at the clinic, contact information was collected so a team member could contact them with more details later. These participants were informed of study procedures and scheduled over the phone if they indicated they were interested in participating. Information about recruitment efforts, including the number of individuals who are approached, participated, or declined to participate in the study, has been published previously (Perfect, 2014). For this specific research study only, the pertinent information will be reported and used.

Research Process and Appointments

After obtaining consent, the participant and guardian were asked to fill out some surveys and questionnaires addressing demographics, health, etc. The participant also practiced the Cogstate tests so that lack of familiarity with the software would not artificially deflate the performance. The families remaining appointments for this research study were set, including one more extended assessment meeting.

Evaluations

During this visit, the participant and guardian returned to the clinic to complete several questionnaires as well as academic and cognitive assessments; this meeting was estimated to last approximately 4 hours. At this visit, the participant completed the designated WJ-III-NU Achievement subtests and the Cogstate tests. The examiner reminded the participant and their family about their next appointment, and their study-related supplies were refreshed. The WASI-

II cognitive assessment; was administered at the following scheduled meeting. All data was collected at baseline, therefore no intervention effects from the larger study impacted the results of evaluation.

Data Analysis

This study aimed to investigate the relationship between SES and neurocognitive abilities and examine the effect of SES on academic abilities.

Dependent Measures

The dependent measures consisted of the scores on the assessments administered to the participants at baseline (pre-intervention). The latent construct of neurocognitive abilities represents the Cogstate assessment results. To measure executive functioning, the Groton Maze Learning Cogstate assessment was used. To measure processing speed, the results of the detection assessment from the Cogstate assessment were used. The one card back assessment result was used to measure working memory. Visual memory abilities were measured by One Card Learning assessment. The Identification test results were used to measure attention memory. For the latent construct of academic abilities, the WJ-III-NU Achievement scores were used. To measure reading, the Letter-Word Identification, Passage Comprehension, and Reading Fluency results were used. To measure math, Math Calculation and Math Fluency scores were used. As a result of the large amount of missing data pertaining to the Math Problem Solving subtest, this subtest was not incorporated into the math abilities. To measure writing skills, both the Spelling and Writing Skills subtest results were used. Separating the different measurable variables of academic abilities into separate latent constructs (reading, writing, math) was considered but due to the effects of adding more variables (latent variables) in and having the power to be able to prove the model, were one of the main reasons for keeping them all separate.

Independent Measures

The independent measures consisted of the parent or caregiver responses to the questions asked through the health interview. The respondent had six options that ranged from 10,000 to 100,000 or more dollars. Based on their response, they were placed within the group that best suited their range of income: 10-20 thousand, 21-35 thousand, 36-50 thousand, 51-75 thousand, 76-99 thousand, and 100,000 or more. The participants' zip code was used to enter into the census data tract providing median household income to yield an estimated overall income. Data gathered from the questionnaire to obtain information on the highest education level of the household allowed respondents to choose from less than a high school diploma to a graduate degree. During data analysis, the responses were collapsed to high school or less, high school graduate, partial college/specialized training, bachelor's degree, or graduate degree, for free reduced lunch responses were coded as students who received free/reduced lunch or if they did not receive either.

Research Question 1. What is the relative contribution of SES indicators (parental education level, self-reported income, free/reduced lunch status, etc.) in predicting performance on standardized cognitive (executive functioning, memory, etc.) tasks?

Predictive Hypothesis 1. Socioeconomic status affects neurocognitive abilities.

Hypothesis 1.1 Lower SES status will significantly predict lower neurocognitive abilities.

Research Question 2. What is the relative contribution of indicators of SES (parental education level, self-reported income, free/reduced lunch status, etc.) in predicting performance on standardized achievement (reading, writing, and math) tasks?

Predictive Hypothesis 2. Socioeconomic status affects academic abilities.

Hypothesis 2.1 Lower SES status will significantly predict lower academic abilities.

This study explored the potential relationship of SES with academic abilities and neurocognitive skills in children with T1DM. Throughout the analysis, we do not adjust for any other factors (such as demographics or disease characteristics). However, we allow for random shocks to be correlated, which means that they can be sensitive to some underlying unexplained factors. Partly that is due to the research agenda and due to a relatively small data set. There were 111 participants in the study, and for some of them some of the responses are missing (i.e., some of the important variables are measured for fewer than 111 participants). A parsimonious, statistically efficient approach was to represent the measured variables with just a few underlying factors and study the connections between those (Shumacker & Lomax, 2015). This can be done within the framework of structural equation modeling (SEM). SEM integrates several multivariate techniques into one model fitting framework. It is a combination of factor analysis and multiple regression analysis, which helps examine the structural relationship between measured variables and latent constructs (Shumacker & Lomax, 2004).

For estimation and diagnostic purposes, SPSS AMOS was used. SEM models are estimated using full information maximum likelihood (FIML). This version of maximum likelihood allows one to account for missing data. An underlying assumption of the AMOS implementation is the normality of the coefficient estimates. The assumption is approximately valid on data set. Even though the measured variables are not normally distributed for the most part, as indicated by the Kolmogorov-Smirnov and Shapiro-Wilk tests, the coefficient estimates are approximately normal due to the effect of the Central Limit Theorem. As a by-product of asymptotic normality, the respective Wald tests are valid as well.

The analysis is performed in the following sequence of steps. Descriptive statistics and plots were generated to allow the exploration of distributional properties. Bivariate relationships

were explored among the measured variables using Pearson correlations and non-linear association measures (Kendall's tau and Spearman's rho). Measured variables were highly correlated with the three groups: SES, academic abilities, and cognitive skills, suggesting there is no evidence they cannot be represented with just a handful of factors. Also, the discrepancies between Pearson correlation and non-linear association measures are not big, indicating that potential relationships among the measured variables are close to being linear. A linear model is a good first approximation.

Measured variables were standardized to avoid dependence on the choice of scale (Jacobucci et al., 2019). Reliability analysis was run to check whether the variables in each group answer the same question and understand the underlying dependency structure (completed on the standardized variables). Variables with factor loadings of .20 or less were not included in the final model to improve model fit and make the model more parsimonious (Meyers et al., 2013). Those factor correlations with values of .20 or higher were retained in the final confirmatory factor analysis for each group.

Chapter 4: Results

Chapter four presents the results of the current study. The study model will be broken down through latent constructs; first, the construction of measurement models will be described, then the structural model, followed by the results of an exploratory analysis. The study's primary purpose was to determine the influences SES has on students with T1DM neurocognitive and academic abilities.

SES

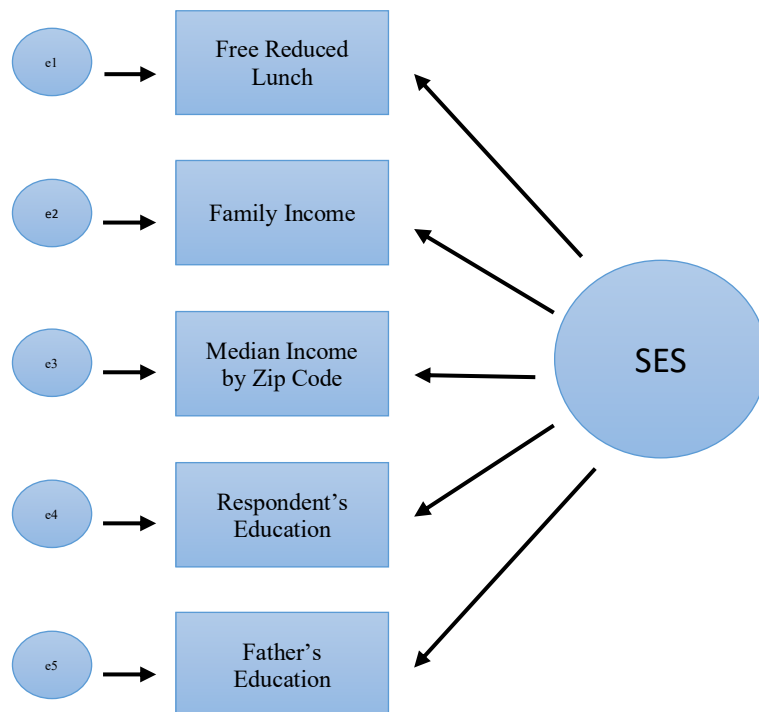
Five variables measured the SES latent construct: self-reported household income, median income by zip code, free and reduced lunch eligibility, father's education, and respondent filling out questionnaire's education level (see figure 1). As seen in Table 2, descriptions of the population depict 18.9% of participants' parents reported their education to be less than a high school diploma, though over 50% reported an educational level higher than a high school diploma. 48.6 %, slightly under half selected an annual household income category of less than \$50,000. The average median income based on zip code was \$52,055. 42.9% of the participant's caregivers report qualifying for free/reduced lunch.

All five variables demonstrated to load significantly onto their latent factor, SES. The measurable variable self-reported family income was found to be significantly correlated, $r(111) = .91, p < .001$. The participants response to free/reduced lunch question displayed a high correlation, $r(111) = .82, p < .001$. Fathers' education was found to be significantly correlated ($r(111) = .68, p < .001$) as well as median income based off zip code, $r(111) = .57, p < .001$. Respondent's education had a moderate correlation, that although lower than the other variables, was still significant, $r(111) = .36, p < .001$. The reliability analysis on SES measurable variables resulted in a Cronbach's alpha of .80, indicating a large degree of agreement among the

variables. The measurable variables in this factor grouping successfully explained between 13% to 88% of the variance associated with the latent variable socioeconomic status with the measurable variables of SES.

Figure 1

SES Measurable Variables



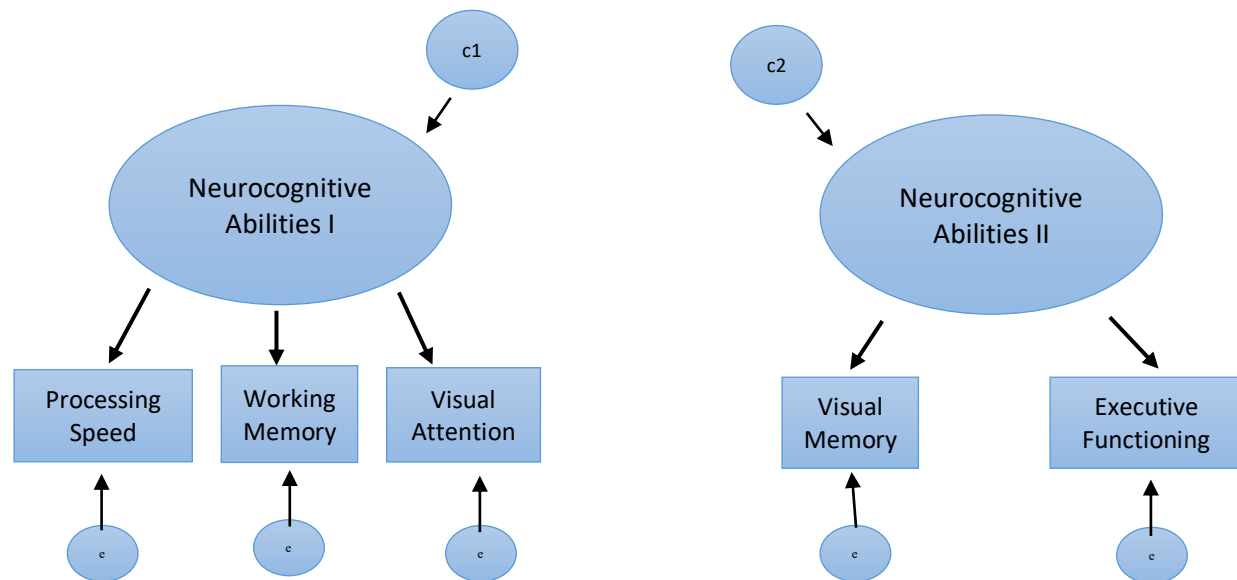
Neurocognitive Abilities

The latent construct of *neurocognitive abilities* is represented by the Cogstate assessment results in the SEM model to investigate the hypothesis that SES influences neurocognitive abilities. Table 3 presents the summary statistics of the neurocognitive subtests scores. The original model consisted of measuring latent construct *neurocognitive abilities* with measurable variables Groton Maze Learning (executive functioning), Detection (processing speed), One Card Back (working memory), Identification (visual attention), and One Card Learning (visual memory). See figure 2.

Table 3*Descriptive Statistics for Neuropsychological Variables*

<i>Composite/Subtest</i>	<i>n</i>	<i>Mean</i>	<i>Std. Deviation</i>	<i>Range</i>
Identification	100	82.68	18.48	31-121
Detection	101	79.41	17.71	31-119
Groton Maze	102	100.53	18.26	33-132
Learning	102	97.52	21.54	45-144
One Card Back	102	93.01	15.35	53-135

Note: Standardized means and standard deviations for all variables are a mean of 100 and standard deviation of 15.

Figure 2*Neurocognitive Measurable Variables*

Several items were found to be significant and reliable indicators of the latent variable: *neurocognitive abilities*. These included visual attention, $r(111) = .91, p = < .001$, processing

speed, $r(111) = .77, p = < .001$, and working memory, $r(111) = .66, p = < .001$. However, visual memory, $r(111) = .68$, and executive functioning, $r(111) = .53$, did not present as reliable measures of neurocognitive abilities in this theoretical model. The reliability analysis on all five measurable variables for neurocognitive skills resulted in a Cronbach's alpha of .70, indicating a low degree of agreement among the variables. Factor analyses suggested two distinct clusters of variables. Due to executive functioning and visual memory not being significant measurable variables ($\alpha = .48$) in the model and there not being a direct effect between *SES* and *neurocognitive II* ($\beta = .08, p = 0.57$) the latent construct *neurocognitive abilities* was then separated into two sections: *neurocognitive I* and *neurocognitive II*. This rejects the studies hypothesis that children coming from lower SES backgrounds will significantly depict worse executive functioning abilities.

Due to this, the model had to be updated to separate neurocognitive skills to *neurocognitive skills I* and *neurocognitive skills II*. *Neurocognitive skills I* measurable variables are processing speed (detection test), working memory (one card back assessment), and visual attention (identification test). *Neurocognitive skills II* measurable variables are visual memory (one card learning assessment) and executive functioning (Groton maze learning). The two factors explained 80.29% of variability in the cognitive variables. With follow-up reliability analysis, *neurocognitive skills I* displayed good internal consistency ($\alpha = .80$) therefore keeping these measurable variables in the model. *Neurocognitive skills II* link may be measuring several phenomena, suggesting there exist other variables beyond the scope of this study that can be playing a role and not just measuring cognitive aptitude, therefore were not kept in the final model. The final model removes the path analysis from *SES* and *neurocognitive skills II*. With

the removal for *neurocognitive skills II*, all other terms are significant at the 5% significance level.

Academic Abilities

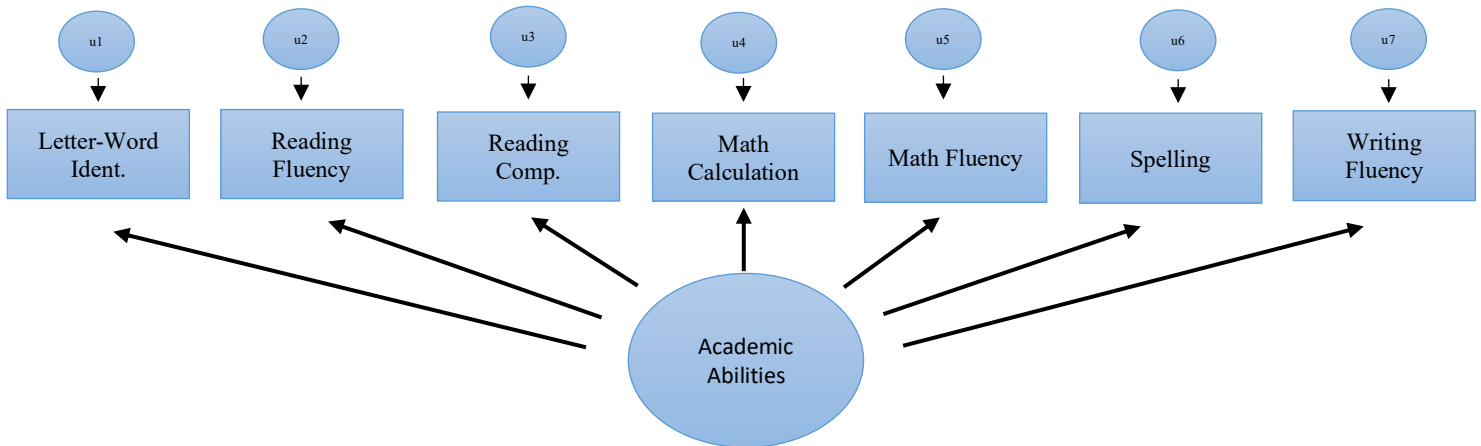
The latent construct of *academic abilities* was measured by seven different variables comprised of the WJ-III-NU Achievement scores in the SEM model to investigate the hypothesis that SES influenced academic abilities. Table 4 presents the descriptive statistics of the academic subtests scores. The reading subtests used in the *academic abilities* latent construct are Letter-Word Identification, Passage Comprehension and Reading Fluency assessments. The metrics of math are derived from the standardized scores of the WJ-III Achievement Calculation and Math Fluency subtest. To measure writing skills both the Spelling and Writing Fluency subtest results are used. See figure 3.

Table 4

Descriptive Statistics for Academic Variables

<i>Composite/Subtest</i>	<i>n</i>	<i>Mean</i>	<i>Std. Deviation</i>	<i>Range</i>
Letter-Word Recognition	103	99.93	11.97	69-128
Reading Fluency	103	98.28	14.52	66-135
Math Calculation	103	102.50	18.02	57-152
Math Fluency	102	95.41	18.19	61-155
Spelling	103	99.53	15.26	60-132
Writing Fluency	102	98.06	15.38	64-138
Reading Comprehension	103	95.71	10.77	62-121

Note: Standardized means and standard deviations for all variables are a mean of 100 and standard deviation of 15.

Figure 3*Academic Abilities Measurable Variables*

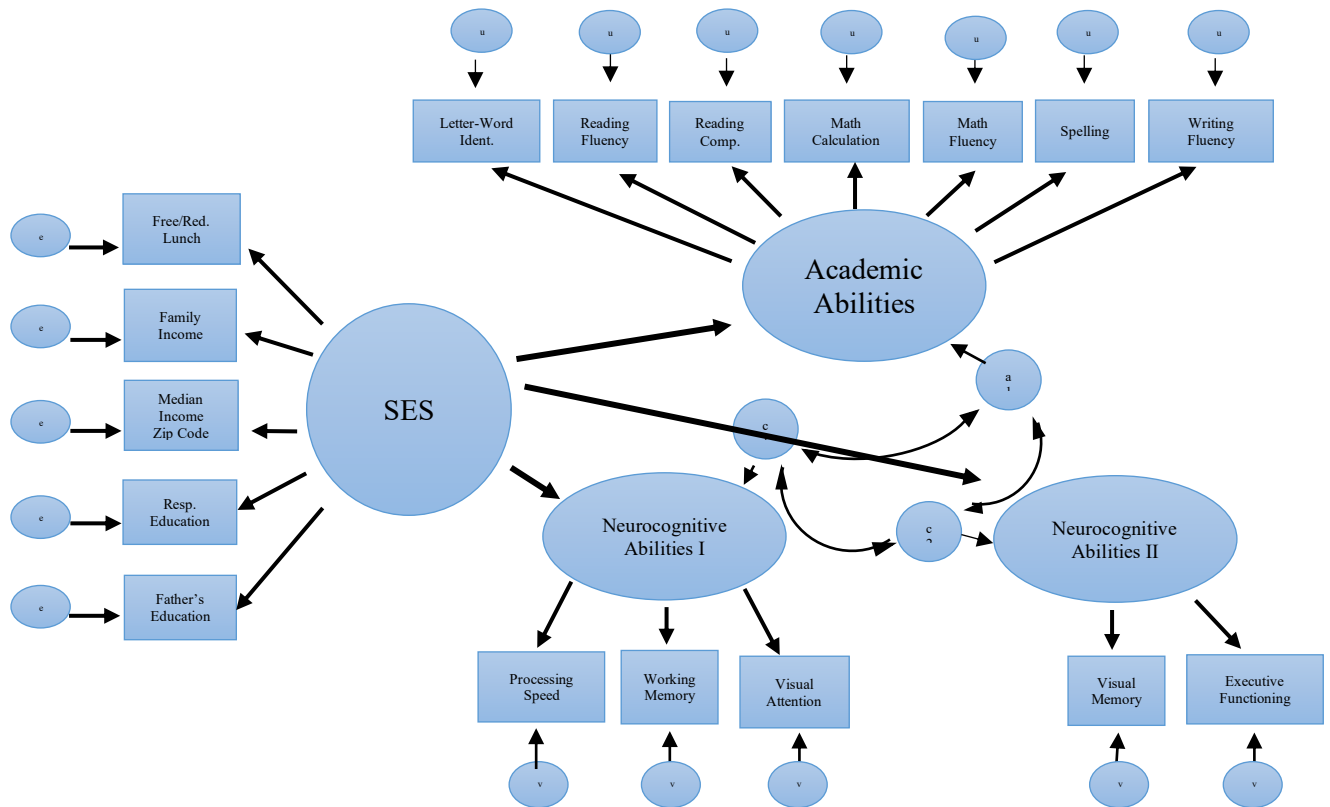
With the outcome of academic performance, several items were also found to be significant and reliable indicators of the latent variable *academic abilities*. The students' abilities to identify letters and words, $r(111) = .81, p < .001$, read fluently, $r(111) = .87, p < .001$, and comprehend what they read $r(111) = .78, p < .001$, demonstrated to be significant and reliable indicators. These variables were able to account for 60% to 74% of the variance associated with the latent variable titled *academic abilities*. The participants' math abilities measured through math calculation, $r(111) = .81, p < .001$, and math fluency $r(111) = .76, p < .001$, were also found to be significantly correlated with latent factor *academic abilities*. Significant correlations were found between the participant's spelling abilities, $r(111) = .88, p < .001$, writing fluency, $r(111) = .76, p < .001$ and the latent factor *academic abilities*. The measurable variables were found to explain 77% and 57% of the variance associated with the latent factor *academic abilities*, respectively. The reliability analysis for *academic abilities* measurable variables resulted in a Cronbach's alpha of .93, indicating a large degree of agreement in measuring the latent construct *academic abilities* among the variables.

Analytical Model

Please see Figure 4 for the full model investigating the relationship between SES to neurocognitive and academic abilities of student with T1DM. View Table 5 to look at all factor loadings for each measurable variable. The full model tests the hypothesis that SES may have on a student’s neurocognitive abilities (*neurocognitive skills I & II*) and academic abilities.

Figure 4

Analytical Structural Equation Model



Note: This structural equation model looking at analytical model predicting neurocognitive and academic abilities from SES.

Table 5*Regression Weights of Structural Equation Model*

			Estimated path coefficient	Standard Error	Critical Ratio	P- Value
Letter-Word Identification	<---	Academic Abilities	.96	.10	9.61	***
Reading Fluency	<---	Academic Abilities	1.07	.10	10.63	***
Reading Comprehension	<---	Academic Abilities	.96	.11	9.18	***
Math Calculation	<---	Academic Abilities	1.00			
Math Fluency	<---	Academic Abilities	.94	.11	8.86	***
Spelling	<---	Academic Abilities	1.09	.10	10.89	***
Writing Fluency	<---	Academic Abilities	.93	.11	8.81	***
Free/Reduced Lunch	<---	SES	.82	.08	9.79	***
Family Income	<---	SES	.91	.08	11.39	***
Median Income by Zip Code	<---	SES	.57	.09	6.20	***
Respondent's Education	<---	SES	.36	.10	3.69	***
Father's Education	<---	SES	.68	.09	7.50	***
Processing Speed	<---	Neurocognitive Skills I	.83	.10	8.26	***
Working Memory	<---	Neurocognitive Skills I	.71	.10	7.00	***
Visual Attention	<---	Neurocognitive Skills I	1.00			
Visual Memory	<---	Neurocognitive Skills II	1.35	.35	3.88	***
Executive Functioning	<---	Neurocognitive Skills II	1.00			

Note: N = 111; *** means $p < 0.001$; ←-represents effect one variable had to the other.

The observed model suggests a direct causal relationship between the latent construct *SES* and latent variables of *academic abilities* and *neurocognitive abilities (neurocognitive skills I)*. The structural model was evaluated against five criteria: The chi-square (χ^2) likelihood ratio statistic, goodness of fit index (GFI), the Tucker-Lewis index (TLI), the comparative fit index (CFI) and the root mean square error of estimation (RMSEA). The chi-square test of the model does not fit the data perfectly (p -value < 0.001). This could be explained by the explicit omission of correlations between error terms. Introducing the correlations and identifying the significant ones in a systematic fashion would have required a much bigger sample size. Researchers have also suggested that a sample size of 100 is sufficient to detect a difference in still allow for a difference to be detected (Loehlin, 2004).

According to the CFI and TLI, the model explains 92.7% and 91.5% of variation in the data, respectively. Likewise, the RMSEA shows a .07 predictive error per degree of freedom: a moderately good fit. Overall, our modeling construct does not answer all the questions, but it is exhaustive enough to answer questions about strongest underlying relationships.

Overall, the fit indices indicate an acceptable model fit with the data. Two significant correlations were found among latent factors. The direct effect of *SES* on *neurocognitive abilities I* is .46 ($\beta = .46, p = < .001$). A significant effect ($\beta = .35, p = < .001$) was found between the latent factors' *SES* and *academic abilities*. The fit indices on the observed model are shown in Table 6. A graphical representation of the results on the structural model is shown in Figure 5.

Table 6

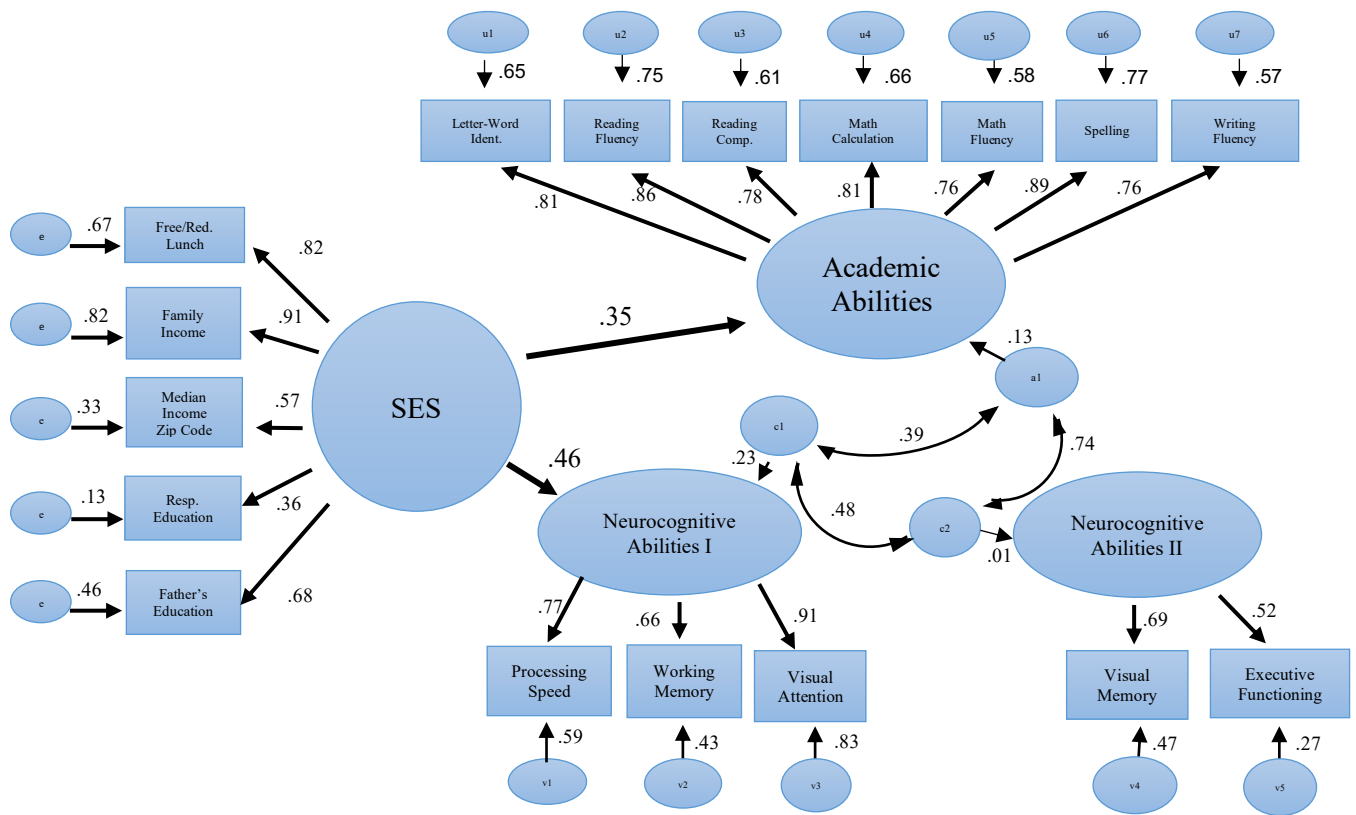
Fit Indices of the Observed Model (N=111)

Fit Index	Observed Model	Recommended Level	References
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Chi Square	Not significant	p-value > 0.05	Hair et al., 2009
Tucker Lewis Index	.92	≥.90	Hu & Bentler, 1999
Comparative Fit Index	.93	≥.90	West et al., 2012
Root Mean Square Error of Estimation	0.07	≤.05	Schumacker & Lomax, 2015

Figure 5

Structural Equation Model Predicting SES Impact on Children with T1DM Neurocognitive and Academic Abilities.



Note: This structural equation model predicts children’s neurocognitive skills and academic abilities from socioeconomic status in children with T1DM. Statistics are standardized regression coefficients. Bold straight one directional lines represent significant direct paths, curved bidirectional bold lines represent correlations or covariances. N=111, ***p<.001. Model fit: Chi-square not significant; Tucker Lewis Index = .92; Comparative Fit Index = .93; Root Mean Square Error of Estimation = .07.

Table 7 shows the path coefficients for the structural model. SES was a significant predictor of academic abilities, $\beta = .35$, $p = < .001$. The path coefficient of .35 indicates a moderate effect size ($>.25$ Keith, 2006). The model also shows that people with higher SES tend to have higher academic abilities, which confirm the hypotheses for the study; children from lower SES backgrounds will demonstrate lower reading and mathematical abilities.

SES was a significant predictor of *neurocognitive abilities I*, $\beta = .46$, $p = < .001$, indicating a large effect size ($>.25$ Keith, 2006). *Neurocognitive Abilities II* was not significantly affected by SES, $\beta = .08$, $p = .567$. Through the acceptance of the model, it depicts people with higher SES status to have higher *neurocognitive skills I*. In particular, they tended to have higher visual attention, higher processing speed, and higher working memory abilities.

Table 7

Direct Effects for Latent Constructs within the Structural Model

Relationships	Estimate	Standard Error	Critical Ratio	<i>p</i> -Value
SES – Academic Abilities	.35	.07	3.89	<.001
SES – Neurocognitive I	.46	.09	4.59	<.001
SES – Neurocognitive II	.08	.08	.57	.567

Note: SES: Socioeconomic Status

Exploratory Analysis

Since SEM examined the independent variable of SES as a latent construct, follow up exploratory analyses were conducted to further examine the bivariate correlations between the SES metrics and the academic abilities and neurocognitive subtests scores. See Table 8 to review all correlations between measurable variables.

To recall characteristics of the study population, refer to Table 1 and 2. SES characteristics depict 33.3% of the participants' parents reported a high school diploma or less. Their self-reported household income ranged from \$25,811 to \$101,888. The mean annual household income per zip code was \$52, 055. 42.9% of the participants that participated in the study receive free and reduced lunch.

Academically approximately 103 individuals' data was collected across all academic areas measured by the WJ-III-NU Achievement scores for the 111 participants. The mean scores for all areas fell in the average range. By looking at the measurable variables of SES we can see that the variable self-reported income was significantly related to all seven *academic abilities* subtest, Letter-Word Identification, $r_s(111) = .30, p < .01$, Reading Fluency, $r_s(111) = .32, p < .01$, Reading Comprehension, $r_s(111) = .38, p < .01$, Math Calculation, $r_s(111) = .20, p < .05$, Math Fluency, $r_s(111) = .25, p < .01$, Spelling, $r_s(111) = .26, p < .01$, and Writing Fluency, $r_s(111) = .28, p < .01$. The measurable variable father's education was also significantly correlated to all seven academic abilities, Letter-Word Identification, $r_s(111) = .30, p < .01$, Reading Fluency, $r_s(111) = .30, p < .01$, Reading Comprehension, $r_s(111) = .34, p < .01$, Math Calculation, $r_s(111) = .34, p < .01$, Math Fluency, $r_s(111) = .25, p < .05$, Spelling, $r_s(111) = .25, p < .05$, and Writing Fluency, $r_s(111) = .31, p < .01$. Median income by zip code was significantly associated with Reading Fluency, $r_s(111) = .27, p < .01$, Reading Comprehension, $r_s(111) = .21, p < .05$, Math Calculation, $r_s(111) = .29, p < .01$, Math Fluency, $r_s(111) = .33, p < .01$, Spelling, $r_s(111) = .21, p < .05$, and Writing Fluency, $r_s(111) = .23, p < .05$. Free/reduced lunch eligibility significantly correlated to all areas of academia except spelling, Letter-Word Identification, $r_s(111) = .28, p < .01$, Reading Fluency, $r_s(111) = .30, p < .01$, Reading Comprehension, $r_s(111) = .36, p < .01$, Math Calculation, $r_s(111) = .29, p < .01$, Math Fluency, $r_s(111) = .36, p < .01$ and

Writing Fluency, $r_s(111) = .26, p < .01$. Respondent's education was only found to significantly correlate to Reading Fluency, $r_s(111) = .30, p < .01$, and Reading Comprehension, $r_s(111) = .28, p < .01$.

The measurable variables of SES: self-reported income, median income by zip code, free/reduced lunch were significantly associated with three of the five neurocognitive abilities. They did not prove to have a significant effect on visual memory and executive functioning. Self-reported income was significantly related to *neurocognitive abilities* subtest measuring processing speed, $r_s(111) = .38, p < .01$, working memory, $r_s(111) = .40, p < .01$, and visual attention, $r_s(111) = .34, p < .01$. Further, median income by zip code significantly correlated with *neurocognitive abilities*, processing speed, $r_s(111) = .24, p < .05$, working memory, $r_s(111) = .33, p < .01$, and visual attention, $r_s(111) = .25, p < .05$. Qualifying for free/reduced lunch was significantly associated with processing speed, $r_s(111) = .38, p < .01$, working memory, $r_s(111) = .27, p < .01$, and visual attention, $r_s(111) = .28, p < .01$. Father's education was related to processing speed, $r_s(111) = .26, p < .01$. Respondent's education was not related to any of the subtest scores on Cogstate tests. Table 9 presents these correlational findings.

Table 8

Spearman Correlations Among Independent (SES) Variables with Dependent Variables

Variable	Self-reported Income	Median Income by Zip Code	Free/Reduced Lunch	Respondent's Education	Father's Education
Academic Abilities					
Letter Word	.30**	.17	.28**	.15	.30**
Reading Fluency	.32**	.27**	.30**	.30**	.30**

Reading	.38**	.21*	.36**	.28**	.34**
Comprehension					
Math Calculation	.20*	.29**	.29**	.05	.34**
Math Fluency	.25**	.33**	.36**	.08	.25*
Spelling	.26**	.21*	.18	.11	.25*
Writing Fluency	.28**	.23*	.26**	.17	.31**
<hr/>					
Neurocognitive Abilities					
<hr/>					
Processing Speed	.38**	.24*	.38**	.03	.26**
Working Memory	.40**	.33**	.27**	-.01	.19
Visual Attention	.34**	.25*	.28**	-.04	.19
Visual Memory	-.01	.11	.04	-.02	-.07
Executive Functioning	.14	.06	.11	-.09	.135

Note: *- Significant at $p > .05$, ** - Significant at $p > .01$.

Further, due to the population of this study having a high rate of IEPs and 504s, correlations in relation to SES and academic abilities were completed (See Table 9). The only measurable SES variable that had a significant correlation with 504s ($r_s(111) = .29, p < .01$) and IEPs ($r_s(111) = -.31, p < .01$) was household income, all other measurable SES variables were not significantly correlated with having a 504 or an IEP. Having an IEP was also related to lower academic scores on the measurable variables of WJ-III-NU Achievement subtest; Letter-Word Identification ($r_s(111) = -.24, p < .05$), Reading Fluency ($r_s(111) = -.31, p < .01$), Calculation ($r_s(111) = -.26, p < .05$), Math Fluency ($r_s(111) = -.22, p < .05$), Spelling ($r_s(111) = -.29, p < .01$) and Writing Fluency ($r_s(111) = -.34, p < .01$).

Table 9*Spearman Correlations for 504s and IEPs*

	Self-reported Income	Letter-Word Identification	Reading Fluency	Calculation	Math Fluency	Spelling	Writing Fluency
504s	.29**	.10	.16	.21*	.19	.09	.25*
IEPs	-.31**	-.24*	-.31**	-.26*	-.22*	-.29**	-.34**

Note: *- Significant at $p > .05$, ** - Significant at $p > .01$.

In summary, the model concludes the two empirical findings. First, the SEM analysis of the students attested as a piece of evidence of the effect's SES has on neurocognitive abilities and academic abilities. Children with higher SES displayed higher neurocognitive and academic abilities overall.

Chapter 5: Discussion

Low SES has been known to contribute to inequalities in many areas of a child's life, including academic, cognitive, medical, and environmental disparities. Research has shown that although many youth with T1DM do well academically, many struggle with consistent performance or perform lower in certain cognitive or academic domains (Gaudieri et al., 2008). The purpose of this study was to investigate differences in neuropsychological and academic functioning according to SES in adolescents with T1DM. This study adds to the body of research that has examined SES effects on neurocognition and academic performance by extending the investigation to a T1DM population. This study also addresses limitations in past research by emphasizing SES as a construct comprised of multiple variables instead of single metrics (El-Sheikh et al., 2013).

The current study consisted of four hypotheses for which SEM was used to test whether there was a direct causal relationship between the latent variables of *SES* (self-reported household income, median income by zip code, free and reduced lunch eligibility, father's education, and respondent filling out questionnaire's education level) and *academic abilities* (Letter-Word Identification, Passage Comprehension, Reading Fluency, Calculation, Math Fluency, Spelling and Writing Fluency subtest from the WJ-III Achievement assessment) and two sets of neurocognitive abilities (*neurocognitive abilities I*: Detection Test, One Card Back assessment, Identification Test; *neurocognitive abilities II*: Groton Maze Learning, One Card Learning). *Neurocognitive abilities I* measured processing speed, working memory, and visual attention, whereas *neurocognitive abilities II* encompassed executive functioning and learning. The study validated the theoretical model. Specifically, the SES indicators directly affected academic abilities, with SES significantly affecting performance on all individual WJ-

Achievement Subtests (Letter-Word Identification, Passage Comprehension, Reading Fluency, Calculation, Math Fluency, Spelling, and Writing Fluency). Regarding neurocognition, SES indicators directly affected several individual Cogstate assessment results (Detection Test: processing speed, One Back assessment: working memory, and Identification Test: visual attention). Two of the measurable variables for neurocognitive abilities did not attain statistical significance (Groton Maze Learning: executive function and One Card Learning assessment: visual memory).

SES Predicts Neurocognitive Abilities in Children with T1DM

The hypothesis for this study proposed there would be a significant effect of SES of children with T1DM on their neurocognitive abilities. Previous studies have found that adolescents with T1DM score lower than their healthy peers on neuropsychological measures (Naguib et al., 2009). Perantie et al. (2007) suggested that individuals with T1DM may have compromised memory function based on neuroanatomical findings comparing individuals with T1DM (ages 7 to 17) to their siblings who were not diagnosed with diabetes. The findings showed that there was a significant difference in grey and white matter volumes in their brains. A meta-analysis of articles conducted in 2008 involving adolescents with T1DM and their neurocognitive functioning indicated that participants with T1DM scored lower than the comparison groups on processing speed, attention, executive functioning, and visual-motor integration.

Again, this study showed that children with T1DM performed lower on the *neurocognitive abilities I* latent construct. Showing that children from lower socioeconomic backgrounds displayed lower scores on subtests measuring visual attention, working memory, and processing speed tasks. The participants displayed below average-to-average abilities on

these specific subtests when compared to same aged peers (visual attention: mean SS = 82; working memory: mean SS = 93 and processing speed: mean SS = 79). These lower scores may have impacted the results of this study, but also suggests that aside from SES, children with T1DM also display lower overall cognitive abilities.

Visual memory and executive functioning demonstrated to be inadequate measures of neurocognitive abilities in children with T1DM in this study. This suggests that SES does not affect the participants' executive functioning and their ability to recall visual information. The finding on executive functioning is contrary to other research that has shown that SES does affect executive functioning (Gaudieri et al., 2008; Hackman et al., 2010; Piccolo et al., 2016). The limited study sample size might have been a factor in the failure to find statistical significance. Additionally, performance in these areas was consistent with same-aged peers as standardized scores were in the average range. Also, executive function is a neurocognitive system that develops over time and can be affected by SES while developing; therefore, it can lead to susceptibility later (Noble et al., 2006). This potentially could also be a factor in why the adolescent population in this study did not show significant effects.

The findings of this study help future researchers and school personnel understand the importance of interventions that stimulate neurocognition to support academic progress. On a broader lens, this study also showed public health and public policymakers that investment in child development and chronic illnesses is essential. Also, it shows the value in considering the differences in SES in the formulation of their studies on cognitive development.

SES Predicts Academic Performance in Children with T1DM

Studies have also found the performance of adolescents with T1DM to be below their average, healthy peers in measures of reading, writing, and math (Naguib et al., 2009).

Studies conducted on children with T1DM have shown that their phonological processing skills are lower than their healthy peers (Honnonen et al., 2010). Participants in this sample performed consistently with normative data as standardized scores on all WJ-III Achievement subtests were in the Average range. Consistent with the hypothesis that lower SES would predict lower academic abilities, the model demonstrated that SES has a significant influence on children's written language, reading, and mathematics performance. Each WJ-III Achievement subtest relationship to SES showed that as students came from lower SES backgrounds, they would display lower Letter Word Identification, Reading Comprehension, Reading Fluency, Math Calculation, Math Fluency, Spelling, and Writing Fluency.

One of the consequences of having a chronic illness such as T1DM is missing more days of school due to poor health and healthcare appointments, which leads to less time focused on schoolwork and receiving direct instruction from their classroom teacher. Further, a study conducted by Parent et al. (2009) found that teachers of students with T1DM often perceived them as having significantly lower academic success than their siblings. Parent et al. (2009) determined that higher levels of HbA1c were associated with lower perceived math and writing performance. Further demonstrating a glucose-performance connection, Knight and Perfect (2019) conducted a substudy from the GRANES dataset and discovered that youth who had glucose levels that were in the target range (70 – 139 mg/dl) performed significantly better on measures of reading and writing fluency than those who were classified as having glucose in the suboptimal range and hyperglycemic range. Conversely, timing and frequency of hypoglycemia significantly predicted performance up to 12 hours later. These findings suggest that there may be disease-related factors, including momentary effects, that should be taken into account when assessing students with T1DM as well as determining the optimal time to conduct evaluations.

With these findings, schools (general and special education teachers and school psychologists) should keep in mind that plans (health plans) need to be put in place to better support students with T1DM. Further, through the research we can see that a child struggling with T1DM often struggles to keep up academically due to impacts of disease such as attendance and regulating their glucose. Therefore, the school team should monitor the students' needs to make sure accommodations are in place to support the student, such as educating students on managing their diabetes, RTI support for work that is missed, and more time to complete an assignment. If warranted even starting the process of determining eligibility for a 504 or IEP would be beneficial. In this study's population, 23% of the participants had an IEP and 30% had a 504. The analysis showed that individuals who performed lower on academic measurable variables were more likely to have an IEP. This may suggest that without supports for students coming from lower SES backgrounds, their academic performance may be impacted and thus it is important for practitioners to discern if students are lagging academically due to limited instructional opportunities or overrepresentation of lower SES students in special education. This study did not determine if the IEPs and 504s were due to diabetes or another reason.

SES Relationship to Neurocognitive and Academic Variables

The present study's findings are consistent with those from other studies that have demonstrated the contribution of SES to cognitive performance at different ages (Piccolo et al., 2016). Exploratory follow-up non-parametric analyses revealed several relations between SES metrics and scores on neurocognitive and academic tests.

Self-Reported Household Income

The measures of self-reported income show children of parents with lower-income displayed lower neurocognitive abilities in the following areas processing speed, working

memory, and visual attention. Approximately half of the participants (48.6%) reported an annual household income of less than \$50,000. For a family of five, the poverty guideline is \$31,040 (Department of Health and Human Services, 2021). Even though we did not look at household size for this study, approximately one-fifth of the participant's household was making less than the poverty guideline. As previously noted, children who come from parents of lower-income may be exposed to less stimulating environments; not being exposed to books, technology, and extracurricular activity opportunities (Bradley et al., 2001). Children from families with higher income also have advantages in supports such as tutors, private schools, opportunities to foster child's talents through organized activities. These advantages favor children higher-income families, thus confirming the cultural inequalities between classes and students from lower-income families.

Annual Household Income (Zip Code).

The measure of income obtained by their zip code showed that the children of parents with lower income displayed weaker neurocognitive skills, specifically in their processing speed, working memory, and visual attention. Academically, their reading fluency, reading comprehension, writing skills, and math abilities were also shown to significantly relate to the annual household income obtained per zip code. The mean household income by zip code of this study was \$52,055. Keeping in mind the census tract data reported a median household income of a given area, many participants fell below this mean income level, seeing that the range of income was from \$25,811 to \$101,888.

The socioeconomic composition of different zip codes or neighborhoods plays a role in the overall supports for students. Neighborhoods are often divided by racial and socioeconomic backgrounds. Schools being partially funded by local property taxes, schools in neighborhoods

with lower-income families may be comprised and may produce educational inequality. Therefore, the gap between students of higher-income to lower-income households continues to widen, making some of the risk factors that impact their academic and neurocognitive abilities to be out of their control.

Father's Education and Other Respondent's Education

Research has shown that the lower the family's SES, the less frequent literacy is practiced (Grieshaber et al., 2012). Noteworthy was the fact that 18.9% reported not having received a high school diploma as the highest education of at least one caregiver. The educational level of parents', especially mothers', has been shown to be associated with higher cognitive performance (Cesare et al., 2013; Noble et al., 2007). A study conducted by Carneiro et al. (2013) found that an additional year of a mother's schooling increases the child's performance on a standardized math and reading test by 0.1 standard deviations.

When looking further at the data, children with T1DM that had fathers with lower education levels displayed lower abilities in their basic word reading skills. Their reading comprehension and reading fluency were also affected by SES and the measurable variables of both parents' educational levels. The study also found that a father's education was significantly related to children's performance in written language (writing fluency and spelling), as previously demonstrated by other studies (Noble et al., 2007). A child's mathematical fluency and ability to calculate math problems were noted to be significantly correlated to father's education. Neurocognitively, the only area for this study that was impacted by the father's education was processing speed.

Free and Reduced Lunch

In this study, 42.9% of participants reported qualifying for free/reduced lunch. This SES measurable variable showed a strong correlation with a child's visual attention, working memory, and processing speed, as well as their reading, mathematical, and writing fluency abilities. The measurable variable of free and reduced lunch was not found to significantly impact spelling, visual memory, and executive functioning skills.

Limitations of the Study

There are several advantages to the present research. For example, this study examined the effects that SES had on different domains of neurocognitive and academic abilities. This research also represents one of the few studies investigating the role of SES on T1DM. Finally, this research is also unique because of the application of structural equation modeling, which is ideally suited to studying complex models and comparing groups (Shumaker & Lomax, 2010).

There are, however, several limitations to the present research. One such limitation is that the present research was unlikely to have captured all factors associated with SES, academic, and neurocognitive abilities; thus, much can be learned from including a wider variety of indicators. Our findings suggest that there may have been compromised power that may have diminished the model's ability to reach statistical significance.

Future research should consider using multiple data sources and seek to identify and utilize the best predictors of SES, academic abilities, and neurocognitive abilities in research to address these limitations. Having the best predictors of these latent constructs provides a complete picture of the relationships among aspects of the child's life. For that reason, researchers should continue simultaneously investigating risk and protective factors in several domains. Future research should confirm these findings, ideally using similar statistical

techniques and a larger sample size. Additional research should also be completed in order to understand the role of SES in children with T1DM.

Minimal sample sizes of 100 have been recommended for evaluating statistical models using structural equation modeling (Hair et al., 2009). The sample size for this study was 111, which places it within the minimum recommended number of cases. However, samples of 200-400 can help obtain precise parameter estimates and standard errors (Loehlin, 2004) to preserve statistical power and obtain more precise results and greater accuracy (Schumacker & Lomax, 2015).

Future Research

Through these findings, it is suggested that the SES differences impact a child's neuropsychological and academic performance. However, as noted in the literature review, there are many other potential indicators of SES that relate to academic and neurocognitive outcomes. Future research could expand the current model and identify other contributors of these outcomes for youth with T1DM.

Additional SES Considerations

Although parental SES is associated with resource challenges and poorer school-related outcomes, many other SES indicators and non-SES related factors negatively affect/mitigate the risks. As previously noted, children who come from parents who earn less income may be exposed to less stimulating environments. With a higher income ratio, families could potentially afford homes in neighborhoods with higher SES and potentially schools.

The school system is also an environment that can play a role in the student's performance. Such additive indicators of economic advantage or school resources could include their supports through teachers, Title I funds, after school programs, tutoring, and technology.

Much research has noted that a teachers' experience and school resources affect their overall abilities (Pribesh et al., 2011).

This study gathered zip code data, which allowed for the median income to be obtained. The census tract website now enables for entry of specific addresses rather than just zip code to provide a precise estimate of their environment and household income.

Given this population has a chronic illness, insurance status would be another vital variable to gather to make a better connection with the effect's SES may have on chronic illness and if having insurance may impact neurocognitive and academic abilities. Overall, having insurance with adequate coverage may lead to better access to healthcare, promoting a better health status and lower hospitalization rates (Ahmed et al., 2001). Inequalities in health access, resource distribution, quality of life are realities families need to face, and policy makers, public health officials need to reduce the deep gaps in socioeconomic status in society.

Diabetes-Specific Influences on Academic and Neurocognitive Abilities

Future research should also examine the role of disease characteristics such as glycemic control, insulin delivery method, years since diagnosis, age of diagnosis as control variables or as mediating factors. It would be valuable to add disease characteristics in the pathways between SES, academic and neurocognitive abilities as a mediating factor with a bidirectional effect. This study did not look at this specific model due to population size and limitations this may cause the study's power to find significance to the model.

Measures of Academic and Neurocognitive Outcomes

Further research would be necessary in looking at other measures of academic abilities compared to academic assessment results. Having other measurable variables (e.g., grades, state standardized test scores, curriculum-based assessments, etc.) that can represent academic

abilities may be important for schools when a child may not have participated in a formal assessment often done when assessed for special education services or a gifted program. Additionally, this study focused on the cognitive component of executive functioning, but dimensions of executive functioning such as a behavioral, emotional regulation, organizational, attentional, and verbal would also help to pinpoint the development of these skills on this population or the potential manifestation of executive dysfunction.

The Intersection of Race/Ethnicity and SES

Although this study focused on SES, it is often intertwined with race/ethnicity due to statistics that highlight the fact that 39% of children of African American descent are living in poverty, while 33% of Latino children are living in poverty in the United States. These percentages are double the percent of Caucasian peers (Kids Count Data Center, Children in Poverty 2014). The population of this study had a diverse population with 50% of the population identified as White, close to 30% reported to be Hispanic, Latino, Spanish or Mexican and approximately 18% reported more than one ethnicity.

Research has also shown that race and ethnicity play a role in health disparities (Bahls, 2011; Braveman et al., 2010). Concerning T1DM, studies have shown that African American children displayed struggles controlling their glucose levels compared to White peers with T1DM. Another study found that the SES and educational level for African American and Hispanic youth described some the discrepancies in glucose management of youth when compared to White youth (Willi et al., 2015). The combination of both these risk factors highlights the significant difficulties minorities face. Latinx adolescents who come from lower socioeconomic backgrounds encounter a disadvantage from both these sources simultaneously. The odds inherited due to their background suggest they will potentially have to overcome

slightly more obstacles in their academic performance and manage their chronic health condition (Gracy et al., 2017).

Conclusions

Understanding SES and how it affects an individual's life trajectory is valuable. Even students who come from low-income backgrounds can be successful and overcome adversity, some SES factors are likely to contribute to outcomes.

The cyclical motion that SES displays on generations and how it coincides with individuals' overlapping identities (family income, education status, neighborhood environment, school status) is an important way to understand social disadvantage and complexity. The relationship on education level has to occupation, leading to income and that leading to environmental choices such as school and neighborhood creates a complex web for researchers, school personnel, public health members. Often on a systematic level, different areas such as more support in schools for lower-income neighborhoods are targeted, just like promoting higher education for minorities or individuals with lower SES. With this study, we can see the need for SES to be addressed as a group. The achievement gap between students from different socioeconomic backgrounds is evident in education systems where income inequality is apparent. Improving the performance of all students, with the goal of a faster rate of improvement in achievement for children from low-SES households will help reduce the gap (Mullis et al. 2016).


Appendix A: Definition of Terms


This paper utilizes numerous relevant terms. Definitions have been provided for the following terms that are based on present scientific literature.

Academic Abilities – The extent to which an individual has acquired the information expected of them as compared to peers of the same age or level of education.

HbA_{1C} – Refers to glycated hemoglobin. In all individuals, excess glucose in the blood stream binds to the hemoglobin in red blood cells. Individuals who have poor control of their blood sugars will have longer or more frequent periods of hyperglycemia and in turn have higher HbA_{1C} numbers.

Type 1 Diabetes Mellitus (T1DM) – Total insulin deficiency as the result of the destruction of pancreatic beta cells.

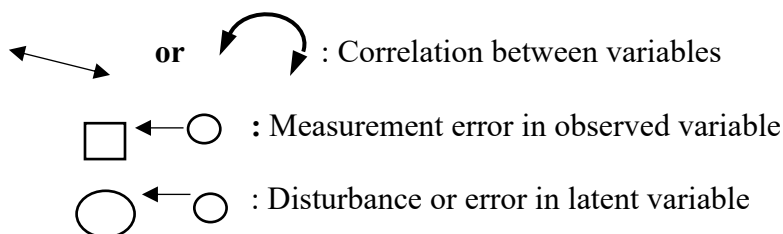
Latent Construct (variable): A variable that is not directly measured. This is  represented by a (circle) in the model.

Observed Variables (manifest variable): A variable that is directly observed or measured. This is represented by a  (square) in the model.

Fit indices: Indicate the degree to which a pattern of parameters specified in the model are consistent with the pattern of variances and covariances from a set of observed data.

Examples of fit indices are chi-square, CFI, RMSEA.

More common path diagram symbols:



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