FEASIBILITY OF A SCHOOL-BASED INTERNET INTERVENTION FOR ADOLESCENTS WITH T1DM

By

LESLIE STREETER

A Thesis Submitted to The Honors College

In Partial Fulfillment of the Bachelors degree
With Honors in

Nursing

THE UNIVERSITY OF ARIZONA

MAY 2014

Approved by:

Dr. Marylyn Morris McEwen

Dr. Marylyn Morris McEwen, PhD, PHCNS-BC, FAAN

College of Nursing

The University of Arizona Electronic Theses and Dissertations Reproduction and Distribution Rights Form

The UA Campus Repository supports the dissemination and preservation of scholarship produced by University of Arizona faculty, researchers, and students. The University Library, in collaboration with the Honors College, has established a collection in the UA Campus Repository to share, archive, and preserve undergraduate Honors theses.

Theses that are submitted to the UA Campus Repository are available for public view. Submission of your thesis to the Repository provides an opportunity for you to showcase your work to graduate schools and future employers. It also allows for your work to be accessed by others in your discipline, enabling you to contribute to the knowledge base in your field. Your signature on this consent form will determine whether your thesis is included in the repository.

Name (Last, First, Middle)
Streeter, Leslie

Degree title (eg BA, BS, BSE, BSB, BFA):
BSN

Honors area (eg Molecular and Cellular Biology, English, Studio Art):
Nursing

Date thesis submitted to Honors College:

Title of Honors thesis: Feasibility of a School-Based Internet Intervention For Adolescents with T1DM

The University of Arizona Library Release Agreement

I hereby grant to the University of Arizona Library the nonexclusive worldwide right to reproduce and distribute my dissertation or thesis and abstract (herein, the "licensed materials"), in whole or in part, in any and all media of distribution and in any format in existence now or developed in the future. I represent and warrant to the University of Arizona that the licensed materials are my original work, that I am the sole owner of all rights in and to the licensed materials, and that none of the licensed materials infringe or violate the rights of others. I further represent that I have obtained all necessary rights to permit the University of Arizona Library to reproduce and distribute any nonpublic third party software necessary to access, display, run or print my dissertation or thesis. I acknowledge that University of Arizona Library may elect not to distribute my dissertation or thesis in digital format if, in its reasonable judgment, it believes all such rights have not been secured.

[X] Yes, make my thesis available in the UA Campus Repository!

Student signature: [signature] Date: 4-26-14

Thesis advisor signature: [signature] Date: 05/05/2014

[ ] No, do not release my thesis to the UA Campus Repository.

Student signature: ______________________ Date: ______________________

Last updated: 04/01/13

Table of Content

LIST OF TABLES AND FIGURES

TABLES

FIGURES

ABSTRACT

The purpose of this study was to conduct a review of the current literature to identify the effectiveness of various methods for achieving desirable hemoglobin A1c (A1c) levels in adolescents with type 1 diabetes mellitus (T1DM) in order to develop a tool that school nurses in TUSD can utilize to improve metabolic control and quality of life in high school students with T1DM. Approximately 186,300 Americans under 20 years old are affected by T1DM (ADA, 2011). Maintaining hemoglobin A1c (A1c) values below 7.5% is the most effective way to reduce complications associated with T1DM (ADA, 2007). Less than one-third of youth with T1DM consistently sustain A1c levels below 8% (Chase & Maahs, 2012). Maintaining tight metabolic control is strongly associated with diabetes self-care behaviors (Silverstein et al., 2005). A review of current literature supports improving adherence to diabetes self-care behaviors in adolescents by increasing: diabetes knowledge, coping skills, social support, and use of technological innovations. Based on these findings, an intervention was developed which uses Managing Diabetes and TeenCope online learning tools, and Motivational Interviewing to increase diabetes knowledge, skills, and motivation, resulting in increased adherence to treatment regimens (Borusa & Laffelb, 2010). This would result in improved metabolic control for adolescents with T1DM (Silverstein et al., 2005). Methods for implementing and evaluating the intervention were also outlined. Evidence suggests that if the intervention is implemented, there would be an improvement in glycemic control among adolescents.

CHAPTER ONE: INTRODUTION

Statement of Purpose and Significance of the Problem

The purpose of this study was to conduct a review of the current literature to identify the effectiveness of various methods for achieving desirable hemoglobin A1c (A1c) levels in adolescents with type 1 diabetes mellitus (T1DM) in order to develop a tool that school nurses in TUSD can utilize to improve metabolic control and quality of life in high school students with T1DM. Approximately 186,300 Americans under the age of 20 years old are affected by T1DM (American Diabetes Association, 2011). 15,600 more children are diagnosed with T1DM each year (American Diabetes Association, 2011). T1DM is the second most common chronic illness in teenagers (Chase & Maahs, 2012. p. 15). The disease can occur at any age, but is most frequently first diagnosed between the ages of 10 and 15 (Hockenberry & Wilson 2013. p. 992).

Background: Historic Perspective on T1DM

T1DM is a chronic disorder of metabolism that occurs when beta cells in the islets of Langerhans in the pancreas are destroyed (Hockenberry, & Wilson 2013. p. 992). Beta cell destruction can be caused by autoimmune and non-immune factors (Hockenberry & Wilson 2013. p. 992). Non-immune T1DM occurs secondary to other diseases (Hockenberry & Wilson 2013. p. 992). Autoimmune T1DM is more common and is caused by genetic and environmental factors (Hockenberry & Wilson 2013. p. 993). Fifteen to twenty percent of T1DM patients have a family history of the disease (Chase & Maahs, 2012). In autoimmune T1DM, the immune system initiates a cell-mediated attack on pancreatic beta cells (McCance, Huether, Brashers, & Rote, 2010. p.747). Lymphocytes, macrophages, and autoantibodies infiltrate the islets of Langerhans, resulting in inflammation and beta cell death (McCance, Huether, Brashers, & Rote,

2010. p.747). Beta cells produce and secrete insulin. Necrosis of these cells leads to insulin deficiency (Hockenberry & Wilson, 2013. p. 993). Insulin is a hormone that facilitates the entry of glucose into the cells and stimulates the metabolism of glucose for energy production (Hockenberry & Wilson 2013. p. 993). Deficiency of insulin leads to hyperglycemia because glucose is not able to enter the cells. This causes serum concentrations of glucose to rise (Hockenberry & Wilson 2013. p. 993). Lack of insulin also causes a state of metabolic catabolism and an increase of glucagon, growth hormone, cortisol, and adrenaline (Hockenberry & Wilson 2013. p. 993). This induces gluconeogenesis in the liver and wasting of adipose and muscular tissues (Hockenberry & Wilson 2013. p. 993). Gluconeogenesis further raises blood sugar, resulting in high serum osmolality, which draws fluids out of the intercellular and interstitial spaces (Hockenberry & Wilson 2013. p. 993). This fluid is filtered out of the body by the kidneys with the excess serum glucose and causes dehydration and loss of electrolytes (Hockenberry & Wilson 2013. p. 993). As lipids are increasingly broken down for energy, fatty acids and glycerol are converted to ketones, which reduce the plasma pH resulting in diabetic ketoacidosis (Hockenberry & Wilson 2013. p. 993). Because insulin is not needed for glucose to enter nerve cells or vascular tissue, over time, hyperglycemia can cause glycosylation of the microvasculature and macrovasculature leading to nephropathy, retinopathy, neuropathy, atherosclerotic cardiovascular disease, stroke, hypertension, amputations, arthritis, dental disease, and death (Hockenberry & Wilson 2013. p. 993). Vascular changes can be seen within three years in poorly controlled T1DM; however, in well controlled diabetes, vascular changes may not appear for twenty years or more (Hockenberry & Wilson 2013. p. 993).

Several innovations have brought about significant advances in the treatment of T1DM. The first of these was the production of exogenous insulin in 1922 (Silverstein et al., 2008). The next was the development of blood glucose monitors in 1972 (Silverstein et al., 2008). Another important advancement was the development of the glycated hemoglobin test (A1c) which provides an objective and accurate assessment of blood glucose levels over a period of three months (Golden et al. 2012) The A1c test is the preferred method of assessing long-term glycemic control. (Golden et al. 2012, p. 1)

Importance of Adherence to Management Regimen

The Diabetes Control and Complications Trial (DCCT) (2005) confirmed that keeping glucose levels as close as possible to the normal range reduced the microvascular and macrovascular complications associated with diabetes. In adolescents, intensive management leading to improved metabolic control, reduced complications by 27% to 76% (DCCT/EDIC, 2005).

Maintaining tight metabolic control has been strongly associated with self-care behaviors including: dietary monitoring, regular physical activity, monitoring and recording blood glucose four to six times daily, multiple daily insulin injections or use of a continuous subcutaneous insulin infusion pump, carbohydrate counting and matching insulin doses to the grams of carbohydrate consumed, and regular visits to healthcare providers (Silverstein et al., 2005). Adherence to this multifaceted and difficult treatment regimen requires consistent effort by the adolescent and the family. Following a diabetes management regimen is challenging for all patients, however glycemic control is poorest in children between the ages of thirteen and eighteen (Chase & Maahs, 2012. p. 200). The American Diabetes Association recommends that adolescents maintain an A1c value below 7.5% (American Diabetes Association, 2007). Less than one-third of youth with T1DM consistently sustain an A1c level below eight percent (Chase & Maahs, 2012. p. 200).

Developmental Barriers to Adherence to Management Regime

Adolescence is a period of major physiological, cognitive, psychological, moral, and social changes (Hockenberry & Wilson 2013. p. 477). Normal adolescent development can add challenges to the management of T1DM. Glycemic control often deteriorates during adolescence due to hormonal changes and decreased adherence to treatment regimens (Chase & Maahs, 2012. p. 206).

Physiological changes of adolescence are due mostly to increased hormonal activity: primarily, human growth hormone, testosterone, and estrogen (Hockenberry & Wilson, 2013. p. 477). These hormones cause a rapid growth in height and the development of adult sexual characteristics (Hockenberry & Wilson, 2013. p. 477). Human growth hormone increases insulin requirements dramatically (Chase & Maahs, 2012. p. 206). Testosterone and estrogen can either increase or decrease insulin sensitivity (Chase & Maahs, 2012. p. 206). Blood sugars often increase during menstruation (Chase & Maahs, 2012. p. 206). Also, about half of youth with T1DM have some amount of thyroid gland dysfunction (Chase & Maahs, 2012. p. 206). Thyroid hormone is essential for normal physiological development during teenage years (Chase & Maahs, 2012. p. 206).

Due to the cognitive development that takes place in middle adolescence, teenagers become increasingly more capable of complex, logical, and abstract thought (Hockenberry & Wilson, 2013. p. 482). They are now able to understand that the choices they make now will impact their future (Hockenberry & Wilson 2013. p. 482). This can have a positive effect on diabetes management as adolescents begin to understand that maintaining tight glucose control now can prevent complications later (Chase & Maahs, 2012. p. 197). Teens are also more capable of carbohydrate counting, understanding which foods to eat, and are usually more willing to have multiple daily injections (Chase & Maahs, 2012. p. 197). At this age, an inadequate knowledge of treatment regimens, increases future risk of complications (Chase & Maahs, 2012. p. 197). Despite teenagers increased ability to understand and perform diabetes management skills, their behavior lacks consistency (Hockenberry & Wilson 2013. p. 482). Adolescents often ignore activities that are arduous, repetitive, or must be performed at regular times (Hockenberry & Wilson 2013).

Psychosocial development during adolescence leads youth to explore their personal identity and develop a sense of who they are and how they fit in to society. As teens seek to establish a sense of self, they may experiment with different behaviors, roles, and, activities. This is an essential part in the process of forming an identity and developing a sense of direction (Hockenberry & Wilson, 2013. p. 481). Adolescents with T1DM often do not want their identity to be based on their disease (Chase & Maahs, 2012. p. 207). They may disassociate themselves from the disease and ignore care, experiment with behaviors that are contrary to maintaining health, or become involved with other activities and neglect their diabetes management regimen (Chase & Maahs, 2012. p. 207).

During this stage the body image of the adolescent changes and teens may be preoccupied with body-image and appearance (Hockenberry & Wilson 2013. p. 281). Although T1DM does not alter physical appearance, it can cause adolescents to perceive themselves as different. They may wear baggy clothes to hide insulin pumps or refuse to wear medical identification bracelets (Chase & Maahs, 2012. p. 206).

Adolescents often have a sense of immortality and engage in risk-taking behaviors and experimentation (Chase & Maahs, 2012. p. 207). These behaviors are often contradictory to effective diabetes management. Teens may feel invincible and disregard the consequences of failing to maintain glycemic control (Chase & Maahs, 2012. p. 207).

Adolescence can also be a period of vacillating emotions (Hockenberry & Wilson, 2013. p. 482). Rapid mood swings and depression are more common during teenage years (Hockenberry & Wilson, 2013. p. 482). Youth with T1DM have depression rates of 15%, which is almost double that of their peers (Hood, et al., 2006). Eating disorders are also more prevalent in adolescents with T1DM (Chase & Maahs, 2012. p. 211).

Moral Development is an important, but often overlooked aspect of adolescent progression. Teens' growing realization that they are separate entities from their parents and society induces them to search for their own moral identity and adopt a moral code to guide their behavior (Hockenberry & Wilson, 2013. p. 482). They are able to understand abstract moral principles and are often idealistic (Hockenberry & Wilson, 2013. p. 482). A belief in God and religious attendance may help adolescents with T1DM make better choices (Chase & Maahs, 2012. p. 201). "Greater levels of religiosity and spirituality are associated with fewer risk-taking behaviors and more health-promotion behaviors" in youth (Hockenberry & Wilson, 2013. p. 483).

Adolescence is a time of intense social development (Hockenberry & Wilson, 2013. p. 483). Teens become more autonomous from their parent and develop relationships outside of the home (Hockenberry & Wilson, 2013. p. 483). Acceptance by peers and the support of family are both important for social adjustment and growth (Hockenberry & Wilson, 2013. p. 483).

Peer relationships serve an important role in adolescent development (Hockenberry & Wilson, 2013. p. 483). Peer groups can serve as a support system for teens, provide them with a sense of belonging, and influence their decisions (Hockenberry & Wilson, 2013. p. 483).

Teenagers are extremely vulnerable to social approval and acceptance (Hockenberry & Wilson, 2013. p. 484). Their sense of identity often relates to conforming to their peer group (Chase & Maahs, 2012. p. 207). Adolescents with T1DM are often reluctant to disclose their disease out of fear of rejection by peers (Davidson, Penney, Muller, & Grey, 2004). They are not as adherent to diabetes management regimens due to worries about fitting in and may intentionally skip insulin injections or blood glucose monitoring when friends are present (Davidson, Penney, Muller, & Grey, 2004). Peers can also have a positive influence on adolescent behaviors and encourage adherence to diet or frequent blood glucose monitoring (Bearman & La Greca, 2010).

Establishing independence is an important step in transitioning from childhood to adulthood (Hockenberry & Wilson, 2013. p. 481). This transition causes changes in family dynamics which may lead to conflict (Hockenberry & Wilson, 2013. p. 283). Parental support is often regarded as intrusive (Hockenberry & Wilson, 2013. p. 483). In adolescents with T1DM, the desire for independence can be at odds with the need for parental support in disease management. A decrease in family involvement and an increase in family conflict are related to worsened diabetes self-management and poorer metabolic control (Greene, Mandleco, Roper, Marshall, & Dyches, 2010).

Despite preoccupation with social acceptance, parents are still the primary influence on an adolescent's life (Hockenberry & Wilson, 2013. p. 483). This is especially true for youth with T1DM. Tight glycemic control necessitates the active involvement of parents throughout teen years (Chase & Maahs, 2012. p. 193). Research indicates that parental knowledge about T1DM management is a better predictor of A1c levels, than adolescent knowledge, and there are significant decreases in A1c levels when caregivers are involved (Wysocki, et al. 2008).

School, leisure activities, and work are also important in adolescent social, physical, and cognitive development (Hockenberry & Wilson, 2013. p. 484). Adolescents spend, on average, thirty hours a week in school. Teachers, academic performance, school culture, and extra-curricular activities can all influence an adolescent's identity, knowledge, and skill level (Hockenberry & Wilson, 2013. p. 484). Teens also spend a large amount of time on leisure activities which may include opportunities for physical activity and social interaction (Hockenberry & Wilson, 2013. p. 484). An increasing amount of adolescent free time is spent using technology and social media, which provides entertainment and occasions for youth to interact with others (Hockenberry & Wilson, 2013. p. 484). A job outside the home, affords opportunities for some degree of financial autonomy and a sense of accomplishment and competency (Hockenberry & Wilson, 2013. p. 485). Adolescence can be a hectic time as youth juggle school, leisure activities, and work responsibilities (Hockenberry & Wilson, 2013. p. 485). This poses challenges in adhering to a time consuming diabetes management regimen. School, extracurricular activity, and work schedules may interfere with the timing of meals, snacks, injections, monitoring, or regular visits to healthcare providers (Chase & Maahs, 2012. p. 253). Finding a place at school or work to monitor blood glucose, or administer insulin may be difficult (Chase & Maahs, 2012. p. 253). Many teens are too busy or distracted to make time for regular physical activity, meal planning, and record keeping (Chase & Maahs, 2012. p. 143).

Summary

Diabetes is a serious, lifelong disease, with life threatening complications. Technological advancements have provided a means for managing the disease and reducing the occurrence of complications. However, management is complicated and time consuming. There are many barriers to achieving tight glycemic control, especially during adolescence. Physiological, cognitive, psychological, moral, and social changes affect teenagers’ adherence to a self-care regimen and A1c levels. School, leisure activities, and work also present challenges and cause distractions that limit adherence.

CHAPTER TWO: REVIEW OF LITERATURE

This chapter will review current research about the effectiveness of various methods for achieving desirable A1c levels in adolescents with T1DM in order to develop an effective tool for improving adherence to treatment regimens and decreasing A1c levels.

Review of Literature

Research articles were found by searching PubMed and Ovid databases, using the key words "Type 1 diabetes management during adolescence". Inclusion criteria were: nursing journal articles published in English within the past 10 years, and clinical trials, meta-analysis, observational studies, or systematic reviews involving humans from 13 to 18 years of age. Eighteen research reports were identified. The first three studies in this review focus on the tools used to control blood sugar. Specifically, insulin delivery methods and glucose monitors. The next five articles focus on the knowledge needed to control blood sugar, primarily education and life style modification. The final ten articles focus on the need for motivation and social support in controlling blood sugar. Maintaining steady glucose control requires a combination of effective tools, adequate knowledge, and consistent motivation and social support (Chase & Maahs, 2012. p. 207).

Tools for Treating Type 1 Diabetes Mellitus

Technological advancements, such as exogenous insulin and blood glucose monitors, have provided a means for managing T1DM and reducing the occurrence of diabetes related complications. A variety of insulins, delivery methods, and blood glucose monitors are now available. The following research evaluates the effectiveness of some of these products and practices for reducing A1c in adolescents with T1DM.

Golden et al. (2012) conducted a meta-analysis to review randomized controlled trials. The controlled trials compared the effectiveness of continuous subcutaneous insulin infusion (CSII) with multiple daily injections (MDI), and real time-continuous glucose monitoring (rt-CGM) with self-monitoring of blood glucose (SMBG) for achieving better glycemic control, having fewer incidents of hypoglycemia, and improved quality of life in people with T1DM (Golden et al., 2012). The review included studies of both type 1 and type 2 diabetes, but for this paper only the results concerning T1DM were used. The reviewers searched MEDLINE®, Embase®, and Cochrane Central Register of Controlled Trials (1966 to July 2011) to find randomized controlled trails (Golden et al., 2012). They used pilot tested standardized forms for data extraction. Nine studies compared CSII with MDI for insulin delivery in children and adolescents with T1DM. Studies were conducted in the U.S., Italy, Sweden, Spain, Saudi Arabia, the Netherlands, and Israel. The average length of the studies was 52 weeks. The average sample size was 32 patients with a mean age of 16.5 years. The participants' mean A1c was 8.5 percent at the start of the study. Nine studies compared rt-CGM use with SMBG use in children with T1DM. The studies were conducted in the U.S., France, and Australia. The median length of the studies was 24 weeks. Average sample size was 66 participants with a mean age of 24.0 years. The mean baseline A1c was 8.5 percent in both the rt-CGM and SMBG groups.

Four studies in the review by Golden et al. (2012) compared a sensor-augmented pump (CSII+ rt-CGM) with MDI used with SMBG in adolescence with T1DM. The studies were conducted in the U.S. and in Europe. The average length of the studies was 28 weeks. The mean baseline A1c was 8.6. No difference was shown in the effect of CSII and MDI on A1c or on incidents of hypoglycemia for adolescents with T1DM. CSII users reported an improved quality of life compared with MDI. Rt-CGM was shown to be more effective than SMBG on achieving lower A1cs. There was no difference in the occurrence of hypoglycemia or the reported quality of life between rt-CGM and SMBG. Sensor-augmented pump (CSII with rt-CGM) use showed a significantly improved A1c compared with MDI used with SMBG in T1DM. There was no significant difference in the occurrence of hypoglycemia or the reported quality of life between the two groups. The findings of this review indicated that CSII and MDI are equally effective on glycemic control and incidence of hypoglycemia, therefore either form of insulin therapy can be recommended. Rt-CGM was shown to be superior to SMBG in lowering A1c and would be a preferred method of glucose monitoring for most T1DM patients. Based on the results of these studies the most effective method for achieving desirable A1c is sensor-augmented pump (CSII with rt-CGM) use. Limitations of this study include the small sample size of most of the randomized controlled studies cited, that most of the studies were of fair to poor quality, and that participants were primarily Caucasian.

The effectiveness of an injection port for insulin delivery and the use of an alarmed blood glucose monitor for improving glycemic control in youth with T1DM was evaluated by Burdick et al. (2009) in a three-arm randomized protocol. Sixty-six youth between the ages of five and eighteen were recruited from the Barbra Davis Clinic in Colorado. All participants started the study with suboptimal glycemic control (A1c 8.0% or greater) and used glargine for their basal insulin and aspart in an insulin pen for their rapid-acting insulin. The participants were randomly assigned into the injection port, the alarmed monitor, or the control group. All participants were asked to test their blood glucose four times daily. The infusion group used the Insuflon infusion port and an insulin pen to administer multiple daily insulin injections. The alarmed monitor group used FreeStyle Flash meter with daily alarms set for meal times and an insulin pen for MDIs. The control group used the insulin pen and their usual diabetes care regimen. A1c levels were recorded at baseline, three months, and six months. Participants using the Insuflon had a decreased A1c values from an average of 9.4% at baseline, to 8.7% at three months, and 8.5% at six months in. This was a significant reduction in A1c values (p, 0.001). There was not a significant change in Alc levels in the alarmed monitor group or the control group. Based on the results of this study, use of an injection port may help adolescents with T1DM to improve A1CA1c values. This may be because insulin is given more often when delivery is convenient and painless. Alarmed meter use with MDI did not decrease A1c values. However, other studies have shown that alarmed meter use with CSII use does improve glycemic control (Burdick, 2009). It is possible that avoidance of pain is a factor in infrequent insulin injections. Some limitations of this study were a high dropout rate in the injection port group and a short duration of only six months (Burdick, 2009).

The effect of not changing the insulin pump infusion site every forty-eight to seventy-two hours, as recommended, on glycemic control and A1C levels was investigated by Thethi et al. (2010). The study also tested whether the use of Aspart and Lispro insulin made a difference in how often the infusion site should be changed. A double-blind, randomized, crossover trial design was used. Twenty patients with T1DM participated in the study. Sixteen were female, four male, with a mean age of eighteen year, and an A1c greater than 8.0%. Patients were randomized into two groups that used either Aspart or Lispro for one week. The infusion line was not changed for 100 hours. Retrospective continuous glucose monitoring was used to determine the average glucose over each day. Serum 1,5-anhydroglucitol, carboxymethyllysine, and Free 15-F2t Isoprostane levels were analyzed. Participants also kept a diary of insulin dose requirements. After one week, patients changed their infusion site, switched to using the other type of insulin, and test levels were recorded again. This process was repeated twice. The results showed that the average glucose level increased from 122.7 to 163.9 mg/dL ($P < 0.05$), and the fasting glucose level increased from 120.3 to 154.5 mg/dL ($P < 0.05$) post prandial from day two to day five of continuous pump site use. Glucose levels were above 180 mg/dL, 14.5 % to 38.3 ($P< 0.05$) more often from day two to day five of site use. Glucose control worsened even though total daily insulin doses increased from 48.5 ± 11.8 units to 55.3 ± 17.9 units ($P = 0.05$). There was no difference in results based on the type of insulin used. This study demonstrates that the pump infusion line should be changed every 48 hours for optimum glucose control. Failure to rotate the pump line may be why some patients using CSII do not achieve glycemic control. As this was a crossover study, each patient served as their own control, which added to the reliability of the study. However, the small sample size limits the generalizability of the results. Also, the study was not long enough to show a significant effect on A1c levels.

Knowledge and Lifestyle Modification for Treating Type 1 Diabetes Mellitus

Another component of T1DM treatment is life style modification. An adolescent's diet and physical activity level directly affect A1c values. A diabetes management regimen is complex and requires continuing education to increase diabetes specific knowledge and improve self-care skills (Chase & Maahs, 2012. p. 207). These studies focus on the effectiveness of diet, exercise, knowledge, and education for improving glycemic control.

Rovner, Nansel, & Gellar (2009) conducted a study to determine the effects of a low glycemic index (LGI) diet on blood glucose levels, and to compare the macronutrient composition of LGI diet with the usual diet eaten by participants. This pilot study used a within subjects, cross-over experimental design. Twenty-three participants between the ages of seven and seventeen years with T1DM were recruited from a pediatric endocrinology clinic in

Maryland. Forty-four percent of participants were males and sixty-five percent were Caucasian. The study lasted two days. Participants were instructed to eat their normal diet on one day of the study. On the other day, they were given foods with a glycemic index greater or equal to fifty-five and instructed in what they were to eat. Half of the subjects ate their normal diet the first day, and the other half ate their normal diet on the second day. Blood sugars on both days were recorded using a continuous blood glucose monitoring system (CGMS). Participants kept a diary of their diet on both days. Participants mean daytime blood glucose values on the LGI diet day were 125 ± 28 mg/dl vs. 185 ± 58 mg/dl on the usual diet day ($p<0.001$). On the LGI diet day high blood glucose index was 5.1 ± 5.1 vs. 13.6 ± 7.6 ($p <0.001$) on the usual diet day. The LGI diet had a lower glycemic index (34 ± 6), was higher in fiber (24.5 ± 12.3 g), and lower in fat (45.7 ± 12.2 g) than participants usual diet, which had a glycemic index of 57 ± 6 ($p<0.0001$), fiber content of 14.5 ± 6.1g, ($p<0.007$), and a fat content of 76.8 ± 32.4 g, $p<0.005$). No differences in intake of protein, calories, or carbohydrates were noted. LGI diet was associated with lower blood sugars and a higher fiber, lower GI, and lower fat content. This study is limited by its small sample size, and extremely short duration. Also, it relied on self-report of food eaten. However, this pilot study warrants further research because a LGI diet may be effective for maintaining tighter glycemic control in children with T1DM and preventing complications.

Another study that also focused on diet in management in adolescents with T1DM was conducted to determine if diet composition was associated with A1c (Delahanty et al., 2009). This longitudinal study followed 532 participants in the Diabetes Control and Complications Trial (DCCT) through five years. The mean age of participants was 27 years (range: 13–39), and 52 % were women. The diet for participants in the DCCT consisted of 10 to 25 % protein, 30 percent fat, 45–55% carbohydrate, 10% saturated fat, and 300 mg cholesterol. Participants were educated on diet composition, consistency and meal regularity. Participants were examined each month in the DCCT clinics and laboratory data was obtained. Participants kept a diet history which was analyzed for carbohydrate, protein, fat, and cholesterol composition. Data were analyzed using a linear regression model and a multivariable logistic regression model. The participants mean carbohydrate intake during the study was 45.5 %, total fat was 36.8%, and saturated fat intake was 12.7%. Percent of carbohydrate in diet was inversely associated with A1c concentrations (R2 ¼ 7%), with a significance of (P ¼ 0.01). Fat intake and insulin dose were directly associated with A1c (P ¼ 0.002, 0.02, and 0.004, respectively). Lower insulin dose needed, higher carbohydrate consumption, and lower total fat intake were associated with lower A1c. People with T1DM generally have diets higher in fat and lower in carbohydrates (Delahanty et al. 2009). Currently, T1DM patients are given widely varying advice on diet. This study indicates that a diet higher in carbohydrates and lower in fat would be more effective in lowering A1c levels and thereby reducing complications of diabetes. This study's reliability was strengthened by a large sample size and long duration. Future research could be done to determine why persons with diabetes increase their fat intake and reduce carbohydrate intake.

The benefit of exercise for improving glycemic control in T1DM is not yet established. Cuenca-Garcı´a, Jago, Shield, & Burren, (2012) researched the relationship between physical activity and fitness levels with glycemic control (A1c) in adolescence with T1DM. This case–control cross-sectional study recruited 97 children ages 8 to 16 years from pediatric diabetes clinics in England. 62% were male. Sixty participants had T1DM. Thirty-seven participants were siblings who did not have T1DM. Height, weight, waist circumference, BMI, waist to height ratio, pubertal status, blood pressure, and insulin regimen were all recorded at the beginning of the study. Accelerometry was used to assess physical fitness. Results were used to determine light, moderate, and vigorous activity levels. A multistage sub-maximal bicycle ergometer test was also used to determine physical fitness. A1c was used to assess glycemic control. Participants participated in light, moderate, or vigorous activity five times each week, for at least 20 minutes each session. No differences in body composition, blood pressure, physical activity and fitness between children with T1DM and their siblings without diabetes (all $P > 0.05$) were noted. Moderate and vigorous physical activity were both associated with better glycemic control, 30–37% ($R2 = 0.295–0.374$). A high level of physical fitness, without current physical activity, was not associated with lower A1c levels. Moderate and vigorous physical activity may be an effective part of therapy for improving A1c levels in children with T1DM. A strength of this study was its use of objective, reliable methods to assess physical activity and physical fitness levels. Study limitations include a 28% retention level. Less active adolescents may have chosen not to participate. Also, the amount and type of exercise was done by self-report and was not standard throughout. Further research to determine the long term effects of moderate-to-vigorous physical activity on glycemic control among adolescents with is needed.

The A1c test is the most reliable measurement of long-term glycemic control (Chase & Maahs, 2012). Patiño-Fernández, Eidson, Sanchez, & Delamater, (2009) conducted a study to evaluate adolescents' understanding of the A1c test and their own A1c level. The study tested adolescents' ability to predict health risks associated with A1c values. The study also analyzed the correlation between knowledge of A1c values, patient demographics, and the adolescents' A1c values. This descriptive study recruited 70 youth with T1DM from a diabetes clinic in Miami, Florida. Participants were between the ages of 11 and 16 years. Forty were male. Mean duration of T1DM was 4 years and mean A1c was 10.5%. Adolescents were 62% Hispanic, 31% Black, and 7% White and of lower income. The Diabetes Related Health Problems (DRHP) was used to evaluate adolescents' knowledge of the A1c, the implication of its values, and short-term and long-term consequences of diabetes. A1c levels were tested at regular outpatient appointments. Just 13% of youths accurately defined the A1c test. Only 11% knew the A1c value ranges and only 4% knew the actual blood glucose values that correspond to specific A1c results. Less than 20% correctly estimated the short-term and long-term risks associated with elevated A1c values. 30% did not know the lower and upper limit for their daily glycemic goal. Biserial correlations showed that older age was associated with greater knowledge of what the A1c test measures and of the consequences of elevated A1c levels. Higher economic status was related to increased knowledge of blood glucose values corresponding to A1c values. Knowledge of A1c was not related to the participants' mean A1c. This study showed that despite diabetes education at diagnosis, and continuing education during physician visits, the majority of adolescents do not understand the meaning and significance of the A1c test. This indicates a need for improved education methods. The limitations of this study are that it did not include an assessment of parents' knowledge of the A1c test and that the sample was primarily low income, minority youth. This may limit the generalizability of the results. Further studies could explore methods that combine education and behavioral intervention with knowledge of the A1c test.

A longitudinal, analytical, and observational study was conducted by Aguilar, Garcı´a, Gonza´lez, Pe´rez, & Padilla, (2011) to evaluate the effectiveness of an educational intervention using One Touch UltraSmart Software to improve dietary habits, physical activity, blood glucose monitoring, and A1c levels in youth withT1DM. This study lasted eighteen months and followed thirty-seven youth, aged nine to sixteen years, with T1DM. Participants were given a One Touch UltraSmart System and instructions on its use for recording and assessing physical activity, diet, medication, and blood glucose levels. Participants and their families attended seven educational sessions that covered topics related to diet, physical activity, alcohol use, hypoglycemia, and hyperglycemia. After the final session, children and parents were evaluated to assess the level of knowledge acquired. A1c levels were taken at the first and the final sessions. Parents and youth completed a questionnaire to measure their satisfaction with the One Touch UltraSmart System and their diet and activity habits. The data in the One Touch UltraSmart Systems were collected for analysis. Data on HbAlc levels, diet and exercise, and the frequency of blood glucose self-tests were analyzed using three separate ANOVAs and Bonferroni tests. The A1c levels of participants in the educational intervention with One Touch UltraSmart Software were found to be significantly reduced ($p < 0.0001$), with an average A1c reduction of 1.01 points. Dietary habits, activity levels, and frequency of glucose monitoring all improved significantly after the educational intervention and use of One Touch UltraSmart system. Because this was an observational study with no control group, changes in behaviors and A1c levels could be attributed to a cause other than the intervention. The educational intervention was “very well received” by youth and retention levels were high for the study. Combining an educational intervention with One Touch UltraSmart Software may be an effective tool for improving diet, activity, and monitoring habit, and reducing A1c values in youth with T1DM. The software may also be a valuable resource for health professionals for gathering and evaluating information on their patients.

Motivation and Social Support for Treating Type 1 Diabetes Mellitus

Adherence to a complex diabetes management regimen requires consistent motivation and social support (Chase & Maahs, 2012). There are a variety of barriers to adherence to self-care behaviors. Several interventions to improve motivation, problem solving skills, and social support for youth with T1DM have been implemented. The following studies explore barriers to adherence and methods that increase motivation and social support and their impact on A1c levels in adolescents with T1DM.

Adolescence is a period of change that can include stressful life events. Helgeson, Escobar, Siminerio, & Becker, (2011) examined the relationship between stressful life events and glucose control. The participants in this longitudinal study consisted of 132 adolescents (70 girls) with T1DM. Their average age at enrollment was 12 years. They were interviewed annually for 5 years. The Yeaworth, York, Hussey, Ingle, and Goodwin's (1980) Adolescent Life Change Event Scale was adapted and used to measure stressful life events. Psychological distress was measured using the Children's Depression Inventory, the Stark and Laurent (2001) Manifest Anxiety Scale, and the anger subscale of the Differential Emotions Scale. Self-care behavior was measured using the 14-item Self-Care Inventory for adolescents and blood glucose levels downloaded from blood glucose meters. Glycemic control was measured using A1c data obtained from medical records. Results were analyzed using a longitudinal growth curve model. Stressful life events were associated with increased psychological distress, inferior self-care behavior, and higher A1c values in both cross-sectional and longitudinal analyses. This was especially true for older adolescents. Youth should be assessed for potential stressors at their clinical visits. Interventions could be implemented during stressful life events to help maintain A1c. A limitation of this study is the homogeneous ethnicity of the sample which limits the generalizability of the findings. A strength of this study was its length.

A systematic review by Borusa, J. S. & Laffelb, L. (2010) reviewed barriers to adherence to disease management regimens and interventions that improve adherence in adolescence with T1DM. Inadequate information was provided on the number of studies reviewed, sample size, and setting. Significant barriers to adherence were found to be peer influences and social concerns, depression, disordered eating, diabetes-specific family conflict, lack of family involvement, developmental behavior, and physiological changes associated with adolescence. Successful interventions included family therapy and conflict management, motivational interviewing, preventing loss-to-follow-up care, less stringent eating regimens, technologies that improve patient and provider communication, telephone support, and text and e-mail messaging. Adolescents with T1DM exhibit worse adherence to management regimens compared with other age groups with T1DM. Poor adherence to self-management leads to increased morbidity and mortality. Successful interventions reduce barriers to adherence by focusing on family support to share the burdens of care, reducing family conflict, increasing internal motivation, and using technology to simplify management of T1DM. Optimal glycemic control for many adolescents will not be obtained until a closed loop systems is readily available.

A study done by Mulvaney, et al. (2011) was also aimed at adolescents with T1DM. The purpose of this study was to describe psychosocial barriers to self-management, explore the use of an internet self-management problem solving intervention, and relate the participant characteristics to use of the program. Fourty-one adolescents who had T1DM for more than six months were recruited from a pediatric diabetes clinic in Tennessee. The mean age of participants was 15.1 years and 49 percent were female. This observational pilot study used the Your Way Internet Intervention, which consists of stories that model problem solving. The adolescents were encouraged to complete six stories and two guided problem solving cycles. Demographic and psychosocial data were collected from the participants before their use of the program. A semi-structured interview with each participant was conducted by telephone after ten weeks. The frequency of use of the online intervention was recorded using the website database. Participant A1c were obtained from medical records. The Spearman correlation (rs) was used to relate gender, age, A1c, and duration of diabetes to intervention participation. Mann–Whitney tests were used to assess differences. SPSS v.17 was used to conduct analyses. Psychosocial self-management barriers were found to be 45 percent social, 24 percent psychological, 21 percent time management, six percent planning, and four percent forgetting. The study also observed that teens were receptive to the use of an internet program to teach problem solving skills and address psychosocial barriers to self-management. 87 percent of parents participated with their youth in some way. Gender was related to participation (r=33, p=.036). Age, HbAlc, and duration of diabetes were not related to use of the internet program. The main weaknesses of this study were its small sample size and relatively short duration. Using an internet problem solving program to reinforce diabetes management in teens is an innovative option for diabetes clinics to use to improve self-management outcomes. Further studies should be conducted to test the efficacy of such programs over time.

Whittemore, Grey, Lindemann, Ambrosino, and Jaser, (2010) also conducted a study that used an internet intervention aimed at adolescents with T1DM. Its purpose was to develop an internet coping skills training program for this demographic and test the feasibility, acceptability, and preliminary efficacy of the intervention. This study used a multi-phased, mixed method design. It started with a qualitative focus group, followed with an experimental pilot study, and concluded with a qualitative program evaluation. The focus group consisted of adolescents and their parents, health professionals, and the research and information technology team. Participants reviewed a prototype of the intervention and shared their thoughts about it. A content analysis approach was used to analyze field notes and identify common themes. Twelve teenagers with T1DM participated in the pilot study. Their mean age was 14.4 years, 58 percent were female, and their mean duration of T1DM was 5.9 years. The teens were randomized to the

TEENCOPE (N=6) or the Managing Diabetes internet interventions (N=6). TEENCOPE consisted of five weekly internet sessions while Managing Diabetes consisted of four weekly internet sessions. Alc and psychosocial data were collected at baseline, three months, and six months after intervention using Bayer Diagnostics DCA 2000 and a finger-stick blood sample to analyze the A1c, the Quality of Life Inventory (PedsQL teenager version), the Issues in Coping with IDDM-Child scale, the Self-efficacy for Diabetes Scale, and the Children's Depression Inventory. Feasibility and acceptability were measured by the amount of time participants logged on to the program. Acceptability was also evaluated with a five-item satisfaction survey. The final phase of the study consisted of a systematic evaluation of both sites by an independent reviewer for quality and an assessment by teens with T1DM for acceptability. The results of this study demonstrated the feasibility of converting an in-person educational program for teens with T1DM to an internet program. Participants in TEENCOPE demonstrated improved diabetes self-efficacy ($p = .20$), improved coping ($p = .07$), improved quality of life ($p = .20$), and lower stress levels ($p = .20$). Participants in Managing Diabetes demonstrated better diabetes communication over time ($p = .20$). Participation and satisfaction levels were high with both internet interventions. One problem with this study was that e-mails were sent to inform participants when new sessions were posted, but half of the participants did not check their e-mail accounts regularly. Sending a text message might be a more effective way to communicate with teens. Another weakness was that the internet interventions were tested against each other, but not against an in-person education intervention. Also, because this was a pilot study, it used a very small sample size. In spite of its weaknesses, the results of this study are significant in that they indicate the feasibility of utilizing an internet program to provide education and support for teenagers with T1DM. Additionally, an internet intervention was found to be well accepted by teenagers. Furthermore, an internet intervention may be more cost effective and convenient than an in-person intervention. A clinical trial is in progress to further test the effectiveness of these internet interventions for adolescents with T1DM.

Another study dealing with psychosocial interventions for adolescents with T1DM was conducted by Santiprabhob, et al. (2008). The intent of this study was to determine the effect of diabetes camp attendance on glycemic control, diabetes knowledge, and psychosocial attitudes towards T1DM; to assess participants' satisfaction with their camp experience; and to determine the relationship between the rate of self-monitoring and glycemic control. Participants in this study were 60 T1DM patients older than 10 years and younger than 21 years. The mean age of participants was 16 years. 68 percent were female. The study was conducted in Thailand. The study used a quasi-experimental design. Data were collected using a 40-question multiple choice test to assess diabetes knowledge, a 5-pt Likert scale to assess psychosocial benefits and camp satisfaction, and Alc levels were monitored to assess glycemic control. The participants were tested before attending camp and at months three and six following their camp experience. Alc levels decreased significantly three months post camp ($p<.001$). However, the Alc level decrease was not sustained six months post camp ($p=.94$). Frequent self-monitoring of blood glucose was found to correlate to lower mean Alc levels. Increased knowledge and better attitude toward diabetes were seen at three and six months post camp ($p<.001$). One weakness of this study was that there was not a control group that did not attend camp to act as a comparison group. Another weakness was that five days of diabetes education at the camp failed to demonstrate a long term effect on the participants' behavior. The researcher suggested that finding ways to provide continuous education after camp would reinforce consistency in adolescent self-management. Including a diabetes camp in a management plan for youth with T1DM would be a way to significantly improve their knowledge of diabetes self-care and their psychosocial attitudes towards living with T1DM. This study also shows the importance of continuous education to improve patients' long-term glycemic control and adherence to diabetes self-management.

The school nurse can be an important resource for assisting teenagers in managing diabetes. Nguyen, Mason, Sanders, Yazdani, & Heptulla, (2008) performed a study to evaluate the effect of school nurse supervision on A1c level in youth with inadequately controlled T1DM. This randomized, controlled study recruited 36 subjects age 10 through 17 with A1c greater than nine percent. Eighteen subjects were randomized into the control group and eighteen to the intervention group at the second visit and A1c levels were recorded. Intervention group adolescents, their parents, and the school nurses were instructed in the use of insulin pens and the OneTouch Ultra glucometer. The nurse reviewed adolescents' blood glucose records weekly, and adjusted insulin doses as needed. The intervention group continued their usual insulin and glucose monitoring routine. After three months, A1c levels were recorded again. The A1c levels did not change in the control group. The average A1c was lowered by 1.6 percent in the intervention group. This study showed that supervision and insulin dose adjustments by school nurses can improve the A1c levels in adolescents with T1DM. Weaknesses of this study include its short length and small sample size.

Keough, Sullivan-Bolyai, Crawford, Schilling, & Dixon (2011) conducted a study to explore the differences in self-management behaviors between early, middle, and late adolescence and the role of regimen and gender in self-management behavior in youth with T1DM. The sample consisted of 504 participants from age 13 to 21 that had been diagnosed with T1DM for more than a year. Data were taken from the Self-Management of Diabetes–Adolescent instrument development study. The Keough, et al. study was a secondary analysis that used a cross-sectional descriptive survey design to analyze data from the final phase of the MOST study. The researchers defined the stages of adolescence as early (13-14 years of age), middle (15-16 years of age), and late adolescence (17-21 years of age). Self-management behaviors examined were collaboration with parents, diabetes care activities, diabetes problem solving, diabetes communication, and goal setting. The study found a decline in the Collaboration with Parents Scale between early, middle, and late adolescence ($p=.000$). The Diabetes Problem Solving Scale showed an increase between early, middle, and late adolescence ($p=.000$). Regimen was found to be a significant covariate for Collaboration with Parents, Diabetes Care Activity, and Diabetes Problem Solving ($p=.001$). Gender was shown to be a significant covariate for Diabetes Care Activity ($p=.002$) and Diabetes communication ($p=.005$). The strengths of this study were its large sample size, the reliability of the measurements used, and the thoroughness of the data analysis. An understanding of the influence of adolescent stage and development on self-management is beneficial when educating youth and their families about diabetes management. Parents would especially benefit from education regarding the implications that establishing a regular regimen of care will have on daily self-management as their children become adolescents.

A second study concerning family influence on T1DM management was conducted by Greene, Mandleco, Roper, Marshall, & Dyches (2010). This correlational pilot study investigated the relationship between self-care behaviors, A1c values, and parenting styles in adolescents with T1DM. Twenty-nine adolescents (14 male; mean age, 14.1 years) and their parents were recruited from diabetes clinics and camp registrations in the western USA. Four A1c values were taken and averaged prior to the study to determine each adolescent's metabolic control. Adolescents completed The Diabetes Self-care instrument, a twelve item questionnaire, to measure self-care behaviors. The sixty-two item Parenting Practices Report questionnaire was completed by parents to assess parenting style. Descriptive statistics and preliminary correlations were calculated for all variables to determine possible confounding variables. Correlations and regression analyses were used to assess the relationships between self-care behaviors, A1c levels and parenting styles. The average A1c for all participants was 8.5%. The average score for self-care behaviors was 4.93 (out of twelve) Authoritative mothering was significantly related to adolescent self-care behaviors and metabolic control. Authoritative fathering was positively correlated with some self-care behaviors. Authoritative mothering was found to be the strongest predictor of metabolic control ($\beta = -.52$; $P < .01$) and positively predicted total self-care ($\beta = .63$; $P < .001$) behaviors in the adolescents. Participants in this study were primarily Caucasian, middle income, two parent families, thus its lack of diversity may limit its generalizability. This was a pilot study with a small sample size which may have affected the generalizability of the findings. However, based on this study authoritative parenting may improve self-care behavior participation and A1c levels in adolescents with T1DM. Further research is warranted.

Families of youth with T1DM have a large influence in the management of their child's diabetes. Vesco, et al, (2010) conducted a descriptive study to analyze associations between scores for caregiver responsibility for diabetes management with A1c scores and blood glucose monitoring (BGM) frequency. 261 adolescents with T1DM, between the ages of thirteen and eighteen, and their parents were recruited from pediatric diabetes centers in the Northeastern and Midwestern United States. The participants took the 17-item Diabetes Family Responsibility Questionnaire (DFRQ). The questionnaire assessed how responsibilities of diabetes management are shared in the family. Adolescents' blood glucose levels were downloaded from glucose meters and the frequency of blood glucose monitoring was assessed for the past 14 days. A1c levels were taken and recorded. The correlates of glucose monitoring frequency and A1c with the DFRQ scores were determined using general linear modeling. Greater adolescent perception of responsibility sharing with their parents' on diabetes management tasks was associated with more frequent blood glucose monitoring and lower A1c values. These results suggest that interventions that encourage parents' sharing of responsibility of diabetes management through adolescence would improve metabolic control in youth. One limitation of this study was the cross-sectional design. A longitudinal research study could reinforce the results of this study. Also the study relied on self-report instead of objective measures

The final study reviewed was conducted by Carroll, DiMeglio, Stein, & Marrero, (2011) to evaluate the effectiveness of a behavioral contract paired with a cell phone–based glucose monitoring system to improve diabetes self-management and A1c levels in adolescents with T1DM. Ten adolescents between the ages of 14 and 18 years, and their parents, were recruited from pediatric diabetes clinics in Indianapolis for this descriptive pilot study. Parents and adolescents were instructed in the use of a cell phone glucose meter system and were assisted in developing a behavioral contract. The adolescents used the GlucoPack to monitor blood glucose and data were stored on the cell phone and an Internet site accessible by the adolescent, parent, and health care providers. A health care provider monitored the blood glucose levels and frequency of testing and notified the patient via text message if adjustments were needed. Glycemic control was assessed using A1c values taken at baseline and 3-months. Regression analysis was used to identify significant changes. Significant improvement was found in scores on the Diabetes Self-Management Profile (55.2 to 61.1 $P<0.01$). A1c levels were significantly reduced from 8.1% to 7.6%, ($P<0.04$). Cell phone based glucose monitoring systems and behavioral contracts maybe useful interventions to improve self-care behaviors and A1c levels in adolescents with T1DM. The study's small sample size limits it's generalizable and reliability. Also, due to its short duration, long term effects of the interventions cannot be evaluated.

Summary

The focus of this chapter was a literature review related to improving T1DM management during adolescence. Eighteen research reports examining various interventions for T1DM management in adolescence were reviewed. Two used an experimental design, one was a quasi-experiment, two were crossover studies, three used descriptive design, two were cross-sectional studies, three were longitudinal studies, two were systematic reviews, two were cross-sectional studies, one was an observational study, and one was a multi-phased study that included both a qualitative focus group and an experimental or quasi-experimental pilot study. The samples varied from 10 to 532 participants. The mean age of youth participating was 12-18 years. The participants were adolescents with T1DM or parents of adolescents with T1DM. Most were recruited from pediatric diabetes centers in the United States. One study was conducted in England, one in Thailand, and one in Spain. Results showed that effective management of T1DM requires a multifaceted approach that would include: current knowledge of insulin delivery methods, blood glucose monitoring, diet, physical activity, and self-management behaviors; improved social support, responsibility sharing, and family involvement; Psycho-educational to motivate behavior changes and daily adherence, technological innovations and ongoing, long-term interventions.

The research showed that CSII and MDI are both effective insulin delivery methods, and are most effective at lowering A1c levels when paired with rt-CGM. An injection port helped some adolescents with T1DM to improve A1c values. Changing the insulin pump infusion site every 48 hours increased the efficiency of CSII use. Although T1DM patients are often instructed that diet modification is not necessary, research shows that a diet higher in fat and saturated fat and lower in carbohydrate is associated with higher A1c levels. A low glycemic index diet is associated with lower A1c levels children with T1DM. Although research is inconclusive, moderate to vigorous physical activity may lead to better glycemic control. Research also indicated a need for more education for youth with T1DM.

Educational and behavioral interventions that use technology, such as, One Touch UltraSmart Software and internet based programs appear to be effective tools for improving knowledge, attitudes, coping skills, and self-care in adolescence. Poorer glycemic control was associated with stressful life changes indicating a need for increased interventions for adolescents experiencing transitions and crisis. Diabetes camps, school nurse involvement, and parental support were associated with better metabolic control throughout adolescence. An understanding of the influence of adolescent stage of development on self-management is critical when educating youth and their families about diabetes management. An authoritative parenting style, establishing a regular regimen of care, and behavioral contracts were shown to improve self-care behavior participation and A1c levels in adolescents with T1DM.

Based on these findings, priority should be given to insuring that adolescents with T1DM have access to continuous education concerning insulin delivery methods, blood glucose monitoring, diet, physical activity, and self-management behaviors, and psycho-educational to motivate behavior changes and daily adherence. Interventions that improve social support, responsibility sharing, and family involvement and include technological innovations are especially effective.

Table 1

Table of Literature

Topic: DIABETES MANAGEMENT IN CHILDREN			DATE: March 2013	
Author(s) and Date	Questions, variables, objectives, hypothesis	Design, sample, setting	Findings	Limitations
Golden, S. H., Brown, T., Yeh, H. C., Maruthur, N., Ranasinghe, P., Berger, Z., Suh, Y., Wilson, L.M., Haberl, E.B., Bass, E.B. 2012.	*Whether continuous subcutaneous insulin infusion (CSII) vs. multiple daily injections (MDI) and/or real time-continuous glucose monitoring (rt-CGM) vs. self-monitoring of blood glucose (SMBG) results in better glycemic control, less hypoglycemia, improved quality of life, and improved clinical outcomes in individuals with T1DM.*	*Systematic review* *41 randomized controlled trials that compared the effects of CSII with MDI or rt-CGM with SMBG among children, adolescents, or adults with T1DM.* *Johns Hopkins University*	*1.Continuous subcutaneous insulin infusion (CSII) and multiple daily injections (MDI) demonstrate similar effectiveness on glycemic control and severe hypoglycemia in adolescents with T1DM* *2.CSII was associated with improved quality of life compared with MDI* *3.Real time-continuous glucose monitoring (rt-CGM) showed greater lowering of A1c without affecting the risk of severe hypoglycemia or quality of life compared with self-monitoring of blood glucose (SMBG):*	*small sample size; most of studies were of fair to poor quality, participants were primarily Caucasian, meta-analyses are innately biased*

			4.Use of sensor-augmented insulin pumps (rt-CGM + CSII) is superior to the use of MDI/SMBG use in lowering A1c	
Burdick, P., Cooper, S., Horner, B., Cobry, E., McFann, K., & Chase, H. P. (2009).	*To determine effectiveness of an injection port (Insuflon) vs. an alarmable blood glucose meter vs. a control group on A1c in adolescents with T1DM and with A1c > 8.0%*	*A three-arm randomized experimental study* *66 youth with T1DM.* *A1c s values at baseline, 3, and 6 months.* *CO. USA*	*1.A1c values were significantly lower (p ¼ 0.025) for participants who used the injection port vs. the control group at 3 and 6 months.* *2. A1c values for participants using the injection port decreased an average of 0.7% at 3 months (p , 0.001) and 0.9% at 6 months (p , 0.001).* *3.No significant changes (p 0.05) in A1c values were noted in the alarmed monitor or the control group.*	*An injection Dropout rate Significant with injection port. (6 participants)* *Short study length*
Thethi, T. K., Rao, A., Kawji, H., Mallik, T., Yau, C. L. Christians, U., Fonseca, V. (2010).	*Effect of not changing the recommended insulin pump infusion site every 48 hrs* *Does type of insulin make a difference*	*Double-blind, randomized, cross over trial* *20 patients with T1DM (Mean age of 18) with A1c ≤ 8.0%*	*1. 2 to day 5 of pump site use, avg. glucose level increased from 122.7 to 163.9 mg/dL (P < 0.05), fasting glucose from 120.3 to 154.5 mg/dL (P <*	*Small sample size limits the reliability of the results.* *Study was not long enough to show a significant effect on A1c*

		U.S.A.	*0.05): post prandial glucose from 114.6 to 172.1 (P < 0.05): daily maximum glucose from 207.7 to 242.8 (P <0.05 for the trend).* *2.Time period that the glucose was > 180 mg/dL increased from 14.5 % to 38.3 (P < 0.05).* *3.Loss of control occurred despite increase in total daily insulin dose from 48.5 ± 11.8 units to 55.3 ± 17.9 units (P = 0.05).* *4. No difference in loss of control between insulin types.*	*levels.*
Rovner, A. J., Nansel, T. R., & Gellar, L. (2009).	*Low glycemic index (LGI) diet effect on blood glucose levels.* *Macronutrient composition of LGI diet* *vs usual diet*	*A within subjects, cross-over design experimental pilot study.* *23 participants ages 7-17 years with T1DM; (44%) were males; 65% Caucasian, 15% African-American, 15% Bi-racial and 5% Other*	*1. On LGI diet day, mean daytime blood glucose values = 125 ± 28 mg/dl vs. 185 ± 58 mg/dl on usual diet day, p<0.001),* *2. On LGI diet day high blood glucose index =5.1 ± 5.1* *vs. 13.6 ± 7.6, p <0.001) on usual diet day.*	*Small sample size* *Two day long study, too short to assess effect on A1c* *Self-report of food eaten* *Pilot study that warrants further research*

		Baltimore, MD	*3.Composition of LGI diet vs usual diet:* *LGI day:* *GI 34 ± 6* *Fiber 24.5 ± 12.3 g* *Fat 45.7 ± 12.2 g* *Usual diet day* *GI 57 ± 6 (p<0.0001).* *Fiber14.5 ± 6.1g, p<0.007)* *Fat 76.8 ± 32.4 g, p<0.005);* *No differences in intake of protein calories, or carbohydrates.* *3.LGI diet was associated with lower blood sugars and a higher fiber, lower GI and fat diet*	
Delahanty, L. M., Nathan, D.M., Lachin, J. M., Hu, F. B., Cleary, P.A., Ziegler, G. K., Wylie-Rosett, K., & Wexler, D. J. (2009).	*Diet composition association with A1c for T1DM*	*Longitudinal study* *532 intensively treated participants in the Diabetes Control and Complications Trial (DCCT) who had complete dietary data through 5 y of follow-up.* *USA*	*1.Higher insulin dose, lower carbohydrate intake, and higher saturated, monounsaturated, and total fat intakes were associated with higher A1c* *2.Substitution of fat for carbohydrate was associated with higher A1c*	*Future research warranted to determine why persons with diabetes increase their fat intake and reduce carbohydrate intake.*

			(P ¼ 0.01);	
Cuenca-Garcı´a, M., Jago, R., Shield, J. P. H, & Burren, C. P.2012.	*Physical activity and fitness levels of children with T1DM compared to siblings without T1DM.* *Association between physical activity, physical fitness and glycemic control (A1c) in children with T1DM.*	*Case–control cross-sectional study* *97 children (ages 8 to 16 years) 62% male. 60 participants (67% male) had T1DM; 37 participants (54% male) were siblings without T1DM. from Pediatric Diabetes clinic England.*	*1. No differences between children with T1DM and siblings without diabetes in body composition, blood pressure, physical activity and fitness.* *2. Moderate-to-vigorous physical activity was associated with better glycemic control, 30–37% (R2 = 0.295–0.374) of the variance for A1c.* *3. Physical fitness was not associated With A1c.*	*Less active adolescents may have chosen not to participate. Amount and type of exercise done by self-report* *Further research to determine the long term effects of moderate-to-vigorous physical activity on glycemic control is needed.*
Patiño-Fernández, A. M., Eidson, M., Sanchez, J., & Delamater, A. M. 2009.	*Examine youths' knowledge of the hemoglobin A1c (A1c) test and glycemic control.*	*Descriptive study* *70 youths (11–16 year olds) with T1DM.* *Miami, FL*	*1. Only 13% of youths accurately described the A1c test.* *2. Less than 12% correctly identified the A1c ranges for good, fair, and poor glycemic control.* *3. More than 50% of youths did not know the blood glucose values corresponding to specific A1c results.*	*Study did not include an assessment of parents' knowledge of the A1c test Participants were mostly lower income, minority youths with T1DM (limits generalizability)* *Further studies to explore methods that combine education and behavioral intervention*

			4. Less than 20% of youth correctly estimated the short-term and long-term risks associated with maintenance of A1c of 7%	*with knowledge of the A1c test.*
Aguilar, M. J., Garcı´a, P. A., Gonza´ lez, E., Pe´rez, M. C., & Padilla, C. A. (2011).	*Educational intervention to improve dietary habits, physical activity, blood glucose monitoring, and A1c levels in children withT1DM.* *Evaluate effectiveness of use of One Touch UltraSmart Software to manage T1DM*	*Longitudinal, analytical and observational study (18-months)* *37participants age 9–16 years with T1DM.* *Granada, Spain*	*A1c levels of participants in the educational intervention with One Touch UltraSmart Software were significantly lowered (p < 0.0001) average A1c reduction of 1.01 points* *Dietary habits, activity levels, and frequency of glucose monitoring all improved significantly with the educational intervention and use of One Touch UltraSmart Software to manage T1DM*	*Observational study only; no control group* *Need for further testing.*
Helgeson, V. S., Escobar, O., Siminerio, L., & Becker, D. 2011.	*Relation between stressful life events and glucose control (A1c).*	*Longitudinal study* *Adolescents with T1DM (n=132; average age at enrollment 12 years) for 5 years*	*1.Stressful life events predicted worse metabolic control* *2. Self-care behavior partly mediated this association.*	*Homogeneous ethnicity (limits generalizability)*

		USA		
Borusa, J. S. & Laffelb, L. (2010).	*To review barriers to adherence in adolescence with T1DM* *To review interventions that improve adherence in adolescence with T1DM*	*Systematic Review* *Inadequate information on number of studies reviewed, sample size, and setting.*	*1.Barriers reviewed: Peer influences and social concerns, depression, disordered eating, diabetes-specific family conflict, lack of family involvement, developmental behavior, and physiological changes* *2. Successful Interventions: Family support, therapy and conflict management; Motivational interviewing; Preventing loss-to-follow-up care; less stringent eating regimens; technologies that improve patient/ provider communication; telephone support; and text and e-mail messaging.*	*Inadequate information on number of studies reviewed, sample size, and setting.*
Mulvaney, S. A., Rothman, R. L., Osborn, C. Y., Lybarger, C., Dietrich, M. S., & Wallston, K. A., 2011	*Psychosocial barriers to self-management, internet intervention effectiveness, self-*	*Observational pilot study 41 adolescence with T1DM for >6mo recruited from pediatric diabetes clinic;*	*1.Pyschosocial self-management barrios were found to be 45% social, 24% psychological, 21% time*	*Small sample size, short duration.* *Further studies should be*

	management problem solving process, parent participation levels, participants' characteristics related to use	*mean age=15.1yrs, 49% female USA*	*management, 6% planning, 4% forgetting* *2.Psychsocial barriers to self-management may be addressed by teaching problem solving via the internet* *3.87% of parents participated in some way* *4.Gender related to participation r=33, p=.036* *5.Age, HbAlc, and duration of diabetes were not related to use.*	*conducted to test the efficacy of such programs over time*
Whittemore, R., Grey, M., Lindemann, E., Ambrosino, J., & Jaser, S., 2010	*Development of internet coping Skills training program for adolescence with T1DM, feasibility, acceptability, and preliminary efficacy of the intervention*	*Multi phased, mixed method design; Qualitative focus group and program evaluation Experimental pilot study 12 adolescence with T1DM; mean age =14.4, 58% female, mean duration of T1DM 5.9 yrs. USA*	*1. Feasibility of translating in-person psychosocial program for teens with T1DM to the internet* *2.TEENCOPE participants demonstrated better diabetes self-efficacy (p = .20), better coping (p = .07), better general T1DM treatment QOL (p = .20), and less perceived stress (p = .20)*	*Use of e-mails to communicate with teens. Internet interventions were not tested against an in-person education intervention. Small sample size.*

			3.*Education participants demonstrated better diabetes communication over time (p = .20* 4. *Participation and satisfaction levels with both internet interventions was high.*	
Santiprabhob, J., Likitmaskul, S., Kiattisakthavee, P., Weerakulwattana, Chaichanwattanakul, K., Nakavachara, P., Nitiyanant, W., 2008	*Diabetes camp effect on glycemic control, knowledge, psychosocial benefits, rate of self-monitoring effect on glycemic control, participants satisfaction*	*Quasi-experimental 60 T1DM patients >10yrs; mean age=16 68% female Thailand*	*1.HbAlc levels decreased significantly 3 months post camp p<.001* *2. HbAlc level decrease not sustained 6 months post camp p=.94* *3.Frequent self-monitoring of blood glucose correlated to lower mean HbAlc levels* *4.Increased knowledge and better attitude toward diabetes seen at 3 and 6mo. post camp p<.001*	*No control group that did not attend camp*
Nguyen, T. M., Mason, K. J., Sanders, C. J., Yazdani, P.,& Heptulla, R. A. 2008	*School nurse supervision of glucose and insulin-dose adjustment*	*Experimental study* *36 adolescence with T1DM and*	*1.Average A1c was lowered by 1.6%,* *2. Supervision*	*Short length and small sample size.*

	effect on A1c level in pediatric patients with poorly controlled T1DM.	*A1c > 9%. (age 10-17) n=18 receive 3-month intervention. n=18 received no intervention* *USA*	*and insulin dose adjustments by school nurses can improve the A1c levels in adolescents with T1DM*	
Keough, L., Sullivan-Bolyai, S., Crawford, S., Schilling, L., & Dixon, J., 2011	*Differences in self-management behaviors between early, middle, and late adolescence, role of regimen and gender in self-management behavior*	*Cross sectional descriptive survey 504 participants ages 13-21 with T1DM for >1yr. using data from Self-management of Diabetes in Adolescence Instrument Development Study* *USA*	*1..Decline was found in Collaboration with Parents scale between early, middle, and late adolescence p=.000* *2.Increase in Diabetes Problem Solving Scale between early, middle, and late adolescence p=.000* *3.Regimen is a significant covariate for Collaboration with Parents, Diabetes Care Activity, and Diabetes Problem Solving p=.001* *4.Gender is a significant covariate for Diabetes Care Activity p=.002, and Diabetes communication p=.005*	*Cross sectional descriptive survey*
Greene, M.S.,	*To investigate*	*Correlational*	*1.Average A1c =*	*Participants*

Mandleco, B., Roper, S. O., Marshall, E. S. & Dyches. T. (2010).	*the relationship between self-care behaviors, A1c values, and parenting styles in adolescents with T1DM*	*pilot study* *29 adolescents (14 male; mean age, 14.1 years) and their parents.* *UT, USA*	*8.5%* *2.Average for self-care behaviors was 4.93* *3.Authoritative mothering was significantly related to adolescent self-care behaviors and metabolic control.* *4.Authoritative fathering was positively correlated with some self-care behaviors.*	*were primarily Caucasian, middle income, 2 parent families (lack of diversity limiting generalizability)* *Small sample size (pilot study)*
Vesco, A. T., Anderson, B. J., Laffel, L. M. B, Dolan, L. M., Ingerski, L. M , &. Hood, K. K. (2010).	*Analyze associations between scores for caregiver responsibility for diabetes management with A1c and blood glucose monitoring (BGM) frequency.*	*Descriptive study* *261 adolescents with T1DM (aged 13–18 years) and their caregivers*	*1. Adolescent perception of greater responsibility sharing with caregivers on direct management tasks was significantly associated with higher BGM frequency.*	*Cross-sectional design. Study relied on self-report instead of objective measures* *A longitudinal research study could reinforce the results of this study.*
Carroll, A. E., DiMeglio, L. A., Stein, S., & Marrero, D. G. (2011).	*Effectiveness of a behavioral contract and a cell phone–based glucose monitoring system to improve diabetes self-management and A1c levels*	*Descriptive pilot study* *10 adolescent age 14-18 years and their parents* *IN, USA*	*1.Significant improvement in scores on the Diabetes Self-Management Profile (55.2 to 61.1 $P<0.01$).* *2.Significant reduction in A1c levels (8.1% to*	*Small sample size limits generalizable and reliability. Short study duration so cannot evaluate long term effect.*

	in adolescents with T1DM.		*7.6%, P<0.04).*	

Note: T1DM = type 1 diabetes mellitus; QOL = quality of life; A1c = glycated hemoglobin

CHAPTER THREE: PROPOSED INTERVENTION

Chapter Three consists of a proposed intervention for improving glycemic control in high school students that can be administered by a school nurses. It also includes the targeted outcomes of the intervention.

Intervention Aims

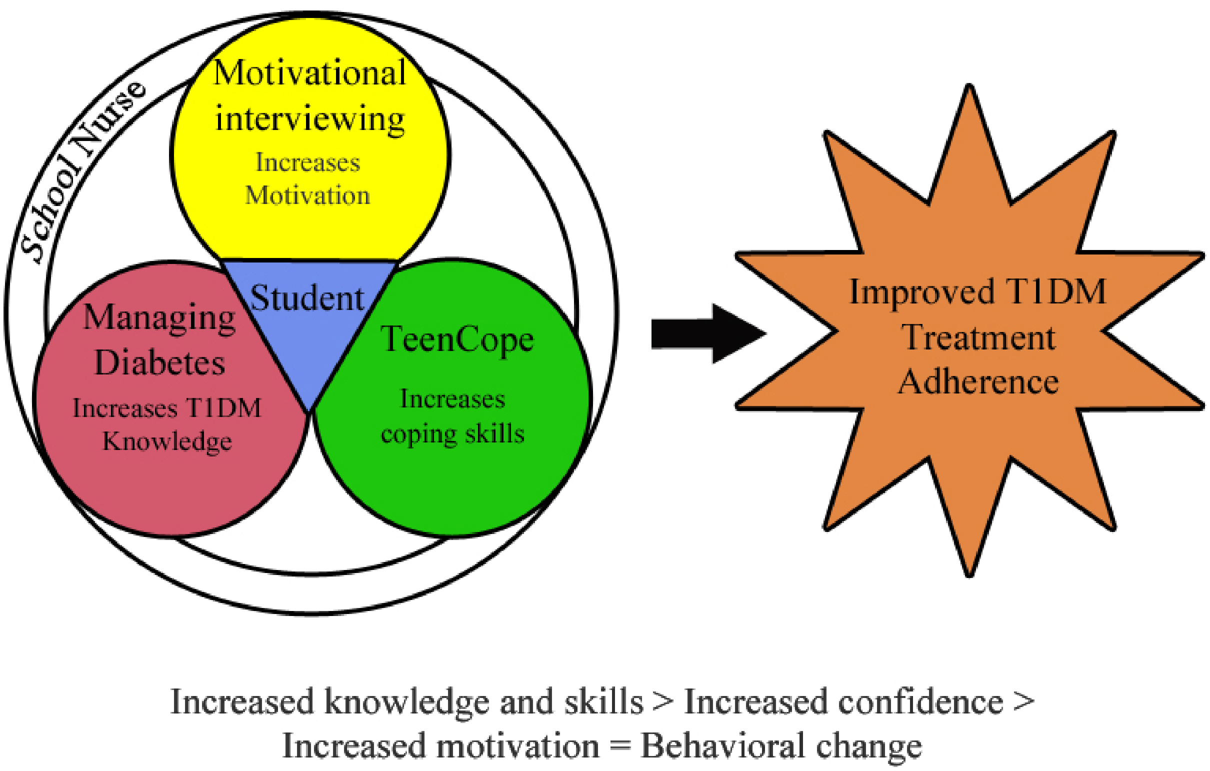
The purpose of this intervention is to create a tool that school nurses in TUSD can utilize to improved metabolic control and quality of life in high school students with T1DM. The intervention aims to do this by: increasing students' knowledge of insulin delivery methods and blood glucose monitoring tools; providing education about diet, physical activity, and self-management behaviors; increasing stress management, coping skills, self-efficacy, and social competence; and motivating behavior changes and encouraging adherence to treatment regimens. The intervention will also evaluate the feasibility and acceptability of implementation of an online intervention by a school nurse.

Theoretical Framework

This intervention is based on the Social Cognitive Theory (SCT) of behavior change. SCT postulates that increasing knowledge and skills, increases confidence and motivation, which leads to changes in behavior (Baranowski, Perry, & Guy, 2008). This intervention proposes to increase diabetes knowledge through use of the Managing Diabetes online learning tool (Grey, et al, 2012), increase coping skills through use of the TeenCope online learning tool (Grey, et al, 2012), and facilitate motivation through Motivational Interviewing (Borusa & Laffelb, 2010). The desired effect of this increase in knowledge, skills, and motivation, would be behavior changes toward adherence to treatment regimens, which would result in improved metabolic control and quality of life for adolescents with T1DM (Borusa & Laffelb, 2010).

Figure 1

Social Cognitive Theory (SCT) Basis for Proposed Intervention



Intervention Components

TeenCope (Coping Skills Training)

TeenCope is an online education program adapted from an in-person coping skills training (CST) program for youth with T1DM. It consists of 6 weekly sessions that teach self-talk, social skills training, cognitive behavior modification, assertive communication, stress reduction, and conflict resolution. Each session is uploaded to a password-protected website on the Yale server and takes about 30 minutes to complete. Text messages are automatically generated when a new weekly unit of TeenCope is available. Sessions include interactive scenarios in a graphic novel format. Animated characters act out challenging social situations that adolescents with T1DM commonly experience with friends or family. The characters model problem solving, coping skills, decision making, and consequences of decisions.

The TeenCope website also includes a social networking component that connects adolescents with T1DM (see Table 2) across the nation. Youth create their own profiles and join discussion groups moderated by a healthcare professional. Adolescents are assigned to a group of peers who all complete the same weekly session. After each session, individual responses can be posted to personal profiles so that youth can learn from each other. All participants are challenged to practice the new coping skill presented in that week's session during the week and post their experiences to the discussion board. Teens and the moderator can also ask questions, contribute to the discussion topics, and provide positive feedback. The moderator reviews all postings within 24 hours for appropriate content and language.

Table 2

TEENCOPE (Coping Skills Training) Session Content

Session	Description
Introductory animation	Introduction to the "coach"/moderator. Discussion of session content, structure, online rules. Introduction to website capabilities, sharing on discussion board.
Self-talk	"Coping Skills"— what they are, how they help. "My diabetes story" — introduction of self and consideration of

	positives and negatives associated with diabetes. Identification of feelings to understand associations between feelings, thoughts, and behaviors. Presentation of a cognitive model of “self-talk” to further explore links and responses.
Communication skills	Exploration of effective communication — barriers/improving communication. Discussion about styles of communication (passive, aggressive, and assertive) and assumptions about others. Skill practice and discussion about managing difficult or embarrassing moments.
Social problem solving	Training in a step-by-step model of social problem solving. Presentation of challenging diabetes-specific situations, with encouragement to consider/discuss responses and alternatives.
Stress management	Reflection on the mental and physical effects of stressful situations. Training in a variety of stress management techniques, including deep breathing, muscle relaxation, and guided imagery.
Conflict resolution	Discussion about different conflict styles (avoidance, giving in, confrontation, being humorous, and problem solving). Animal photos depict styles, participants identify style. Reflection and encouragement to consider/discuss the most positive ways to handle conflict and difficult situations

Managing Diabetes (diabetes education)

Managing Diabetes is an online education program adapted from an in-person program for adolescents with T1DM (see Table 4). It consists of 5 weekly sessions on insulin regimens, glucose control, nutrition, carbohydrate counting, exercise, sick days, and new technology. As with TeenCope, each session is uploaded to a password-protected website on the Yale server and takes about 30 minute to complete. Text messages will be automatically generated when a new weekly unit of Managing Diabetes is available. Sessions includes age-appropriate, illustrated case studies and interactive problem-solving exercises. Answers to questions and problem-solving activities give programmed responses and tailored feedback to improve adolescents' ability to make diabetes-related decisions.

Table 3

Managing Diabetes (diabetes education) Session Content

Session	Description
Healthy eating	Three basic food groups (carbohydrates, protein, and fats). Carbohydrate counting and fiber. Discussion of choosing food wisely (limiting sugar, reading food labels, and increasing intake of fruits and vegetables). Sharing of healthy recipes.
Exercise	Health benefits of exercise. Consideration of diabetes and exercise. Guidelines for exercise when you have diabetes. Exercise problem solving when using multiple daily injections or the pump with examples.
Glucose control	Glucose control, target glucose, and blood sugar trends. Emphasis on how participants feel when blood sugar is well controlled, and how good blood sugar control prevents health complications. Problem solving and instruction in adjusting insulin when using multiple daily injections or the pump with examples.
Preventing and managing sick days	Hints to prevent sick days. A sick day kit for diabetes management. Guidelines for sick days and when to call your nurse or doctor. Exercise and sick-day problem solving. Fun foods for sick days.
Technology and research	New developments in diabetes technology and research (meters, pumps and pump features, continuous

	Glucose monitoring systems, real-time glucose monitoring systems, pump and real-time glucose monitoring systems). Diabetes organizations that are resources for information or referral.

Motivational Interviewing and skills check

Motivational interviewing is a tool that has been shown to be effective in promoting behavior change in adolescents (Borusa & Laffelb, 2010). It is based on the idea that behavioral change frequently fails when adolescents are coerced, but succeeds when interviewers work with youth to demonstrate discrepancy between their behaviors and their goals and then encourages the student as they explore alternatives and make behavioral changes based on their own motivation (Borusa & Laffelb, 2010). During each interview the nurse and student will review the previous week's goal, recognize and encourage progress, and set goals related to the content of that weeks' TeenCope or Managing Diabetes session. The interview should typically last 10 minutes.

Skills check will be conducted at the time of the motivational interview. During skills checks the student will demonstrate competency in a diabetes management skill related to that weeks' Managing Diabetes session. Skill checks will be replaced with online discussions during the weeks that the student participates in TeenScope sessions.

Proposed Intervention

This proposed intervention will be administered by a school nurse and utilizes both the TeenCope and the Managing Diabetes online learning tools. These weekly online lessons will be reinforced with a moderated online discussion where users share experiences and support;

monitored by a TeenCope nurse or diabetes educator (see Table 3). Also, the school nurse will conduct a weekly motivational interview and skills check privately with each participating student. Text messages will be sent when a new weekly unit of TeenCope or Managing Diabetes is available and to remind student of in person appointments. The intervention will be continuous throughout one semester of the school year.

Table 4

Overview of Proposed Intervention

Week of School Year	Online Teaching Topic and Skill	Discussion Topic/ Skill Review	In person Motivational Interview	Other
Weeks 1-4	None	None	None	Obtain district and school administrator permission during Summer. Identify students with T1DM using school health records (green cards) Contact parent/ guardians to get permission for student to participate Contact student about willingness to participate and get commitment Obtain most resent A1c **Group meeting with student and parents:** Motivation, Introductions, explanation and expectations; how to use website and supervised

				practice use of site; T1D appropriate refreshments.
Week 5	**Topic:** TeenCope Introductory animation **Teaching objectives:** Introduction to the "coach"/moderator. Discussion of session content, structure, online rules. Introduction to website capabilities, sharing on discussion board.	None	**Pre-assessment** for knowledge, skills, and T1D self-care behaviors; A1c	
Week 6	**Topic:** TeenCope Self-talk **Teaching objectives:** "Coping Skills"—what they are, how they help. Identification of feelings to understand associations between feelings, thoughts, and behaviors. Presentation of a cognitive model of "self-talk" to further explore links and responses.	**Topic:** "My diabetes story": introduction of self and consideration of positives and negatives associated with diabetes.	**Interview:** Initial interview and set goal related to improving coping skills	
Week 7	**Topic:** TeenCope Communication skills **Teaching objectives:** Exploration of effective communication —	**Topic:** Communication: managing difficult or embarrassing moments.	**Interview:** Review previous weeks goal Recognize and encourage progress. Set goal related to	

	barriers/improving communication. Discussion about styles of communication (passive, aggressive, and assertive) and assumptions about others. Skill practice		improving communication with a friend or family member	
Week 8	**Topic:** TeenCope Social problem solving **Teaching objectives:** Training in a step-by-step model of social problem solving. Presentation of challenging diabetes-specific situations	**Topic:** Consider/discuss responses and alternatives to challenging diabetes-specific situations	**Interview:** Review previous weeks goal Recognize and encourage progress. Set goal related to improving problem solving skills	
Week 9	**Topic:** TeenCope Stress management **Teaching objectives:** Reflection on the mental and physical effects of stressful situations. Training in a variety of stress management techniques, including deep breathing, muscle relaxation, and guided imagery.	**Topic:** mental and physical effects of stressful situations.	**Interview:** Review previous weeks goal Recognize and encourage progress. Set goal related to use of positive stress management techniques	
Week 10	**Topic:** TeenCope Conflict resolution **Teaching objectives:**	**Topic:** consider/discuss the most positive ways	**Interview:** Review previous weeks goal Recognize and	

	Discussion about different conflict styles (avoidance, giving in, confrontation, being humorous, and problem solving). Animal photos depict styles, participants identify style.	to handle conflict and difficult situations	encourage progress. Set goal related to improving current conflict management methods	
Week 11	None	None	**Mid-term Assessment** for knowledge, skills, and T1D self-care behaviors; A1c	
Week 12	**Topic:** Managing Diabetes: Healthy eating **Teaching objectives:** Three basic food groups (carbohydrates, protein, and fats). Carbohydrate counting and fiber. Discussion of choosing food wisely (limiting sugar, reading food labels, and increasing intake of fruits and vegetables). Sharing of healthy recipes.	**Skill Review:** Student will: Demonstrate how to calculate carbohydrates for determining insulin doses.	**Interview:** Review previous weeks goal Recognize and encourage progress. Set goal related to improving current eating habits	
Week 13	**Topic:** Managing Diabetes: Exercise **Teaching objectives:** Health benefits of exercise. Consideration of	**Skill Review:** Student will: describe an exercise plan which includes blood sugar monitoring to prevent hypoglycemia	**Interview:** Review previous weeks goal Recognize and encourage progress. Set goal to improve current activity level	

	diabetes and exercise. Guidelines for exercise when you have diabetes. Exercise problem solving when using multiple daily injections or the pump with examples.			
Week 14	**Topic:** Managing Diabetes: Glucose control **Teaching objectives:** Glucose control, target glucose, and blood sugar trends. Emphasis on how participants feel when blood sugar is well controlled, and how good blood sugar control prevents health complications. Problem solving and instruction in adjusting insulin when using multiple daily injections or the pump with examples.	**Skill Review:** Student will: Demonstrate proper insulin delivery skills for individual type of insulin delivery method used.	**Interview:** Review previous weeks goal Recognize and encourage progress. Set goal related to insulin use for achieving better glycemic control	
Week 15 Thanksgiving	None	None	None	None
Week 16	**Topic:** Managing Diabetes: Preventing and managing sick days **Teaching objectives:** Hints to prevent sick days.	**Skill Review:** Student will: identify when and how to test for ketones	**Interview:** Review previous weeks goal Recognize and encourage progress. Set a goal related to improving sick management routine	

	A sick day kit for diabetes management. Guidelines for sick days and when to call your nurse or doctor. Exercise and sick-day problem solving. Fun foods for sick days.		.	
Week 17	**Topic:** Managing Diabetes: Technology and research **Teaching objectives:** New developments in diabetes technology and research (meters, pumps and pump features, continuous glucose monitoring systems, real-time glucose monitoring systems, pump and real-time glucose monitoring systems). Diabetes organizations that are resources for information or referral	**Skill Review:** Student will: Demonstrate how to test blood sugar on their specific type of meter and how to download and store data from their meter	**Interview:** Review previous weeks goal Recognize and encourage progress. Set goal related to frequency of blood glucose monitoring for achieving better glycemic control .	
Week 18 (program ends 1 week before the end of semester)	**Topic:** None	None	**Post-assessment** for knowledge, skills, and T1D self-care behaviors; A1c	**Group meeting with student and parents:** Feedback, questions, suggestions, T1D appropriate refreshments.

Summary

Chapter Three proposed an intervention for improving glycemic control in high school students that can be administered by a school nurses. It also included the aims of the intervention. The intervention is based on the Social Cognitive Theory (SCT) of behavior change. This intervention utilizes the Managing Diabetes online learning tool, the TeenCope online learning tool, and weekly Motivational Interviewing and skills checks to increase knowledge, skills, and motivation in adolescents with T1DM. The result of utilizing this intervention would be behavior changes toward adherence to treatment regimens, which would result in improved metabolic control and quality of life for adolescents with T1DM

CHAPTER FOUR: IMPLEMENTATION AND EVALUATION

The purpose of this thesis was to conduct a review of the current literature to identify the effectiveness of various methods for achieving desirable A1c levels in adolescents with type 1 diabetes mellitus (T1DM) in order to develop a tool that school nurses in TUSD can utilize to improved metabolic control and quality of life in high school students with T1DM. Chapter Four presents a hypothetical plan to implement the school nurse driven proposed intervention at Catalina Magnet High School (CMHS), part of Tucson Unified School District, in Tucson, Arizona. It also outlines methods for evaluating the effectiveness of the intervention.

Catalina High School is located on the East side of Tucson, Arizona. There are approximately 905 students enrolled in grades 9-12 for the 2013-2014 year. Demographics from the 2013-2014 school year, obtained from the TUSD (2014) website report 43.7% (n=396) Hispanic, 25.2% (n=228) White, 15.6% (n=141) African American, 5.7% (n=77) Asian, 3.4% (n=31) Native American, and 2.6% (n=24) two or more races. CMHS is served by one full time registered nurse and a full-time health assistant (C. Wood, CMHS RN, personal communication, April 9, 2014). Four students with T1DM are currently enrolled at CMHS (C. Wood, CMHS RN, personal communication, April 9, 2014). The average number of students with T1DM enrolled at CMHS per year, for the past 10 years, is six, with a range of three to 10 per year (C. Wood, CMHS RN, personal communication, April 9, 2014).

Implementation

Everett M. Roger's (2003) Theory of Diffusion of Innovations (DI) will be used as a framework for implementing the proposed intervention. DI outlines a five stage process for disseminating new ideas and technology. The five stages are knowledge, persuasion, decisions, implementation, and confirmation.

Knowledge Stage

According to DI theory, knowledge transpires when decision-makers are introduced to an innovation and gain a basic understanding of the function of the intervention (Rogers, 2003). The decision makers for facilitating and supporting the students' management of T1DM at CMHS are the school nurse, the parents, the students, and the administration. The nurse at CMHS must be cognizant of the challenges to maintaining glycemic control faced by adolescents with T1DM, the importance of maintaining glycemic control, and the need for innovative methods for improving teens' adherence to treatment. The nurse will likely have obtained this knowledge from personal experience in working with students with T1DM. Because the nurse is aware of the potential for non-adherence to treatment in students with T1DM, she will be more receptive to new methods for improving compliance. Barriers to change often occur due to a lack of consciousness of the need for change (Rogers, 2003).

Other barriers to change the school nurse may encounter in working with students with T1DM center around feasibility. This includes the cost, time, knowledge, and resources necessary to implement the program. Costs associated with implementation of this intervention include fees for using TeenCope and Managing Diabetes online programs, and training for the school nurse. Cost of using TeenCope and Managing Diabetes has yet to be determined by developers (Grey et al., 2012). Cost of training the school nurse would be minimal as it would be conducted online, during regular working hours. Funding for the intervention would not be available through TUSD. Therefore, funding would be obtained through private organizations or grants before introducing the intervention.

Change also requires time and effort. The CMHS nurse will need time, outside of regular class time, to hold an initial and a final group meeting with all participants, and for 10 minutes weekly individual motivational interviews with each student. Both of these activities could be scheduled during one of the biweekly conference periods at CMHS.

The nurse may experience resistance to change related to a lack of skills or knowledge needed to implement an innovation (Rogers, 2003). Education on using TeenCope and Managing Diabetes, and conducting a motivational interview is important for the nurse to be comfortable and competent delivering the intervention. A 30 minute introductory online tutorial is provided on the TeenCope and Managing Diabetes website. Motivational interviewing would also be taught using a short online tutorial. Increasing the nurse’s knowledge and skills related to the proposed intervention will theoretically increase motivation for program implementation (Baranowski, Perry, & Guy, 2008).

Availability of recourses is another issue of feasibility. One resource needed to implement the proposed intervention is access to computers with internet access. CMHS has many lower income students who do not have internet access at home. However, the school computer lab can be used before and after school to complete time online sessions

The nurse will be introduced to the proposed intervention through a presentation conducted by the developer of the intervention. The presentation will describe the intervention, stress the need for the intervention, the purpose, significance, and expected outcomes. This information will reduce barriers to the nurse accepting and implementing the intervention.

Persuasion Stage

During the persuasion stage, decision makers form attitudes about the innovation and becomes psychologically invested (Rogers, 2003). If the decision-makers develop a favorable outlook, they will accept the new idea and move forward with its implementation (Rogers, 2003). If their impression is unfavorable, they will be resistant and progression toward implementation will discontinue (Rogers, 2003). Decision-makers are more likely to perceive an innovation positively when they believe it will affect change toward a desired goal (Rogers, 2003). It is vital that the CMHS nurse believes that the proposed intervention will positively impact adherence to T1DM management regimes in high school students. At the introductory presentation the Pueblo High School nurse stated, “If I believe the program will help my students, I’ll find the time and money to make it happen (K. Straub, personal communication, April 9, 2014). Therefore the proposed intervention must be evidence-based and applicable to the students at CMHS. The nurse will then become a catalyst for change and meet with administrators, parent(s), and the student to educate them on the proposed intervention and obtain support and permission for its use.

Decisions Stage

In the decision stage, the innovation is formally accepted or rejected (Rogers, 2003). The decision-maker will then initiate a trial of the innovation, which will influence the final decision of whether or not to embrace the innovation (Rogers, 2003). In this stage, the school nurse will present the proposed intervention to the administrators and obtain permission to begin a trial implementation. Parental permission and student permission commitment must also be obtained. Currently, the CMHS nurse identifies students with T1DM at the beginning of each school year, using school health records, and schedules meetings with parents or guardians and students, in order to update the health portion of the students’ Individual Education Plans (CMHS Nurse). This meeting would be used to educate parents and students about the proposed intervention and obtain permission and commitment for student participation.

Implementation Stage

During the implementation stage, the decision- maker begins the innovation (Rogers, 2003). The new user acquires necessary knowledge, considers possible problems, and seeks solutions, in order to implement the innovation (Rogers, 2003). The CMHS nurse will begin implementation by holding a group meeting with student and parents. The intent of the meeting is to motivate participation, provide further education about the intervention, and give instruction for accessing the TeenCope and Managing Diabetes websites. A pre-assessment of students' A1c, quality of life, diabetes knowledge and skills, stress management and coping skills, and T1D1 self-care behaviors will also be conducted by the school nurse before implementing the program. During the following 11 weeks, students will participate in weekly online sessions of TeenCope or Managing Diabetes, online discussions, and motivational interviews with the CMHS nurse.

Evaluation

Confirmation Stage

During the confirmation stage, the decision-makers evaluate outcomes in order to decide about continuing, revising, or rejecting the innovation (Rogers, 2003). The CMHS nurse will evaluate the effectiveness of the proposed intervention based on the program aims. And then decide whether to continue or discontinue the program. At the end of the 11 week intervention, each student will participate in a post-assessment to evaluate A1c, quality of life, diabetes knowledge and skills, stress management and coping skills, and T1D1 self-care behaviors. Nurses, parents, and student will also evaluate the feasibility and acceptability of the proposed intervention. The evaluation will be conducted by the CMHS nurse in a final group meeting with students and parents to obtain feedback and recommendation for further use.

Evaluation of Objectives

Improvements in metabolic control will be evaluated using pre and post A1c values obtained from student medical records that are provided by parents. The A1c test is the preferred method of assessing long-term glycemic control (Golden et al. 2012). Improved quality of life (QOL) will be assessed using the Pediatric Quality of Life Inventory: teenager version, which consists of a 15-item measure of general health related QOL and a 28-item measure of diabetes-specific QOL (Whittemore, Grey, Lindemann, Ambrosino, & Jaser, 2010).

Increased knowledge and skills related to T1DM will be evaluated using the diabetes knowledge test, which consists of 14-items testing general diabetes knowledge and 9-item testing insulin-use (Grey et al. 2012). Increased stress management, coping skills, self-efficacy, and social competence will be measured by the Issues in Coping With IDDM-Child scale. This scale measures adolescents' perceptions of how hard or difficult to handle, and how upsetting issues related to their T1DM are (Whittemore, Grey, Lindemann, Ambrosino, & Jaser, 2010). Increased consistency in self-management behaviors and adherence to treatment regimen will be evaluated using The Diabetes Self-care instrument, a 12-item self-report which assesses diabetes self-management behaviors of diet, exercise, blood glucose monitoring, and insulin delivery. (Whittemore, Grey, Lindemann, Ambrosino, & Jaser, 2010)

Feasibility will be assessed using feedback from the school nurse, parents, and students, which will be gathered at the final meeting. Data about the amount of time required for implementing the intervention, cost, and the adequacy of needed resources and knowledge will be collected from the school nurse's records and verbal report, and be discussed. Acceptability will be measured using information from the website database on the amount of time students spent using the intervention, exit surveys on the ease of use, satisfaction with using the intervention, and student attrition rates.

Table 5

Evaluation of Objectives

Objectives/ Aims	Activity/ Intervention	Evaluation
Improved glycemic control for optimum health and reduction of complications (reduction in A1c or maintain A1c < 7.5 %.)	Participation in program for school semester	Before and after A1c values obtained from student medical records, provided by parents (Golden et al. 2012)
Improved quality of life	Participation in program for school semester	Pediatric Quality of Life Inventory (PedsQL teenager version) (Whittemore, Grey, Lindemann, Ambrosino, & Jaser, 2010)
Increased knowledge and skills related to T1DM (diet, exercise, insulin administration, blood glucose monitoring, hyperglycemia, hypoglycemia, ketoacidosis)	Managing Diabetes Interactive online educational sessions Discussions, Peer posts and input	The diabetes knowledge Test (Grey, et al. 2012).
Increased stress management, coping, self-efficacy, and social competence	TeenCope: coping skills and problem solving practice, TeenCope: modeling behaviors to improves skill building and self-efficacy	Issues in Coping With IDDM-Child scale (Whittemore, Grey, Lindemann, Ambrosino, & Jaser, 2010)
Motivation and behavior change: Increase consistency in disease self- management behaviors (test blood sugar 4-6 times per day, site change every 48 hours, counting carbs and calculating insulin doses, regular exercise).	Discussions and Motivational interviewing provide positive feedback and encouragement, increased motivation and goal setting, and behavior change	Diabetes Self-Management Profile (Carroll, DiMeglio, Stein, & Marrero, 2011)

Feasibility of implementation of an online intervention by a school nurse.		Feedback from school nurse, parents, and student on adequacy of time, resources, and knowledge Cost analysis of spending
Acceptability of implementation of an online intervention by a school nurse.		Amount of time youth spent using each component obtained from website database Exit survey on ease of use, perceived effectiveness, and satisfaction with online component Student attrition rate

Strengths

The primary strengths of this intervention are that it is evidenced-based and has an online delivery method. The format allows the content to be standardized and easily updated (Grey et al., 2012). This allows content to be targeted to specific ages or developmental stages (Grey et al., 2012). Students can participate in the training at their convenience (Grey et al., 2012) and the program can mostly be done independently (CMHS Nurse). The intervention does not require an excessive commitment of the nurse's time for implementation or training (CMHS Nurse). The social media and graphic novel format appeals to teenagers and provides social interaction and support from peers (CMHS Nurse).

Limitations

TeenCope and Managing Diabetes are in the testing phase and are not currently available to the public. The online programs have not been tested on a large scale and they have never been used in the school health center setting. Also, the cost of using TeenCope and Managing Diabetes has yet to be determined by developers (Grey, et al., 2012). Other limitations are the need for more reliable methods for evaluation feasibility, and lack of consideration of methods for motivating students' participation. Also, data about parents' knowledge of T1DM, stress management, and coping skills was not collected.

Future Recommendations

There are various ways that this intervention could be improved or adapted to better meet the needs of high school students with T1DM. Student motivation, compliance, and consistency might be improved by offering tangible rewards, such as iTunes Target, or Egees gift cards, at weekly interviews provided that the weekly online sessions were completed. Informing parents about how their student is progressing in the program might also enhance student consistency. The health clerk could be responsible for sending text messages to remind student of interview appointments. This would reduce the time commitment required of the nurse. If the intervention is effective at CMHS it could be expanded for use district wide with all incoming freshman with T1DM. Also older students who have completed the intervention could provide mentorship to students new to the intervention. The intervention might also be adapted for use with pregnant teens with T1DM.

Summary

T1DM requires ongoing behavioral changes, frequent glucose monitoring, and daily insulin injection, in order to achieve good glycemic control and live a healthy life-style. Adolescents with T1DM need ongoing diabetes self-management education as well as emotional support to facilitate adherence to treatment (Grey et al, 2012). The aims of this thesis were to conduct a review of the current literature to identify the effectiveness of various methods for achieving desirable A1c levels in adolescents with type 1 diabetes mellitus (T1DM) in order to provide a tool that school nurses can utilize to improve metabolic control and quality of life in high school students with T1DM. The methods for implementation and evaluation of the intervention were also outlined. The intervention supports increased diabetes knowledge and skills, and increased stress management and coping skills, in order to increase consistency in disease self-management behaviors in high school students. Evidenced- based literature was used to determine the unique needs of adolescents in managing T1DM and the most effective methods available for improving glycemic control. The intervention was developed based on the findings of these studies and the evidence suggests that if the program is implemented, there could be an improvement in glycemic control among high school students at CMHS.

References

Aguilar, M. J., Garcı´a, P. A., Gonza´ lez, E., Pe´rez, M. C. & Padilla, C. A. (2011). A nursing educational intervention helped by One Touch UltraSmart improves monitoring and glycated haemoglobin levels in type I diabetic children. *Journal of Clinical Nursing*, 21, 1024–1032

American Diabetes Association (2011). *Diabetes Statistics*. Retrieved from http://www.diabetes.org/diabetes-basics/diabetes-statistics/

American Diabetes Association (2007). Standards of medical care for patients with diabetes mellitus. *Diabetes Care,* 5 (Suppl. 1): S4–S41.

Baranowski, T., Perry, C. L., & Guy, S. P. (2008). How individuals, enviroments, and health behaviors interact. In Glanz, K., Rimer, B. K., & Viswanath, K., *Health Behavior and Health Education: Theory, Research, and Practice, 4th ed.* (pp. 165-184). San Francisco, CA: Jossey-Bass.

Bearman, K. J. & La Greca, A. M. (2010). Assessing friend support of adolescents' diabetes care: the diabetes social support questionnaire-friends version. *Journal of Pediatric Psychology*, 27:417–428.

Borusa, J. S. & Laffelb, L. (2010). Adherence challenges in the management of type 1 diabetes in adolescents: prevention and intervention. *Current Opinion in Pediatrics*, 22,405–411. DOI:10.1097/MOP.0b013e32833a46a7

Burdick, P., Cooper, S., Horner, B., Cobry, E., McFann, K., & Chase, H. P. (2009). Use of a subcutaneous injection port to improve glycemic control in children with type 1 diabetes. *Pediatric Diabetes*: 10, 116–119. doi: 10.1111/j.1399-5448.2008.00449.x

Carroll, A. E., DiMeglio, L. A., Stein, S., & Marrero, D. G. (2011). Contracting and monitoring relationships for adolescents with type 1 diabetes: A pilot study. *Diabetes Technology & Therapeutics* 13, 543-549. DOI: 10.1089/dia.2010.0181

Chase, P. H. & Maahs, D. (2012) *Understanding Diabetes 12th ed*. Denver, CO: Children's Diabetes Foundation

Cuenca-Garcı´a, M., Jago, R., Shield, J. P. H, & Burren, C. P.(2012). How does physical activity and fitness influence glycemic control in young people with Type 1 diabetes? *Diabetic Medicine* 29, 369-376. doi:10.1111/j.1464-5491.2012.03740.x

Davidson, M., Penney, E. D., Muller, B., Grey, M. (2004). Stressors and self-care challenges faced by adolescents living with type 1 diabetes. *Applied Nursing Research*, 17: 72–80.

Delahanty, L. M., Nathan, D.M., Lachin, J. M., Hu, F. B., Cleary, P.A., Ziegler, G. K., Wylie-Rosett, K., & Wexler, D. J. (2009). Association of diet with glycated hemoglobin during intensive treatment of type 1 diabetes in the Diabetes Control and Complications Trial. American Journal of Clinical Nutrition. 89, 518–524.

The Diabetes Control and Complications Trial/ Epidemiology of Diabetes Interventions and Complications (DCCT/EDIC) Study Research Group. (2005) Intensive diabetes treatment and cardiovascular disease in patients with type 1 diabetes. *New England Journal of Medicine*, 353: 2643–2653.

Golden, S. H., Brown, T., Yeh, H. C., Maruthur, N., Ranasinghe, P., Berger, Z., Suh,Y., Wilson, L.M., Haberl, E.B., & Bass, E.B. (2012). Methods for insulin delivery and glucose monitoring: Comparative effectiveness. Agency for Healthcare Research and Quality Publication No. 12-EHC036-EF. Rockville, MD: www.effectivehealthcare.ahrq.gov/reports/final.cfm.

Greene, M.S., Mandleco, B., Roper, S. O., Marshall, E. S. & Dyches. T. (2010). Metabolic Control, Self-care Behaviors, and Parenting in Adolescents With Type 1 Diabetes : A Correlational Study. *The Diabetes Educator* 36, 326-336. DOI:10.1177/0145721710361270

Grey, M., Whittemore, R., Liberti, L., Delamater, A., Murphy, K., & Faulkner, M. S. (2012). A comparison of two internet programs for adolescents with type 1 diabetes: Design and methods. *Contemporary Clinical Trials, 33*(4), 769-776. doi:10.1016/j.cct.2012.03.012; 10.1016/j.cct.2012.03.012

Helgeson, V. S., Escobar, O., Siminerio, L., & Becker, D. (2010). Relation of stressful life events to metabolic control among adolescents with diabetes: 5-year longitudinal study. *Health Psychology*. 29, 153–159. doi: 10.1037/a0018163153

Keough, L., Sullivan-Bolyai, S., Crawford, S., Schilling, L., & Dixon, J. (2011). Self-management of type 1 diabetes across adolescence. *The Diabetes Educator, 37*(4), 486-500. doi: 10.1177/0145721711406140

Hockenberry, M. J. & Wilson, D. (2013). *Wong's Essentials of Pediatric Nursing,(9th ed.).* St. Louis, MO: Mosby Elsevier

Hood, K. K., Huestis, S., Maher, A., Butler, D., Volkening, L., Laffel, L.M. (2006) Depressive symptoms in children and adolescents with type 1 diabetes: association with diabetes-specific characteristics. *Diabetes Care*, 29:1389–1398.

McCance, K. L., Huether, S. E., Brashers, V. L., & Rote, N. S. (2010). *Pathophysiology: The* *biologic basis for disease in adults and children.*(6th ed.). Maryland Heights, MO: Mosby Elsevier.

Mulvaney, S. A., Rothman, R. L., Osborn, C. Y., Lybarger, C., Dietrich, M. S., & Wallston, K. A. (2011). Self-management problem solving for adolescents with type 1 diabetes: Intervention processes associated with an internet program. *Patient Education and Counseling, 85*(2), 140-142. doi: 10.1016/j.pec.2010.09.018

Nguyen, T. M., Mason, K. J., Sanders, C. J., Yazdani, P.,& Heptulla, R. A. (2008). Targeting blood glucose management in school improves glycemic control in children with poorly controlled type 1 diabetes mellitus. *The Journal of Pediatrics*. 153, 575-578.

Patiño-Fernández, A. M., Eidson, M., Sanchez, J., & Delamater, A. M. (2009). What do youth with type 1 diabetes know about the A1c test? *Children's Health Care*. 38, 157–167. doi: 10.1080/02739610902813328

Rogers, E. M. (2003) *Diffusion of Innovations* (5 ed). New York: The Free Press.

Rovner, A. J., Nansel, T. R., & Gellar, L. (2009). The effect of a low glycemic diet versus a standard diet on blood glucose levels and macronutrient intake in children with type 1 diabetes. *Journal of the American Dietetic Association*. 109, 303–307. doi:10.1016/j.jada.2008.10.047.

Santiprabhob, J., Likitmaskul, S., Kiattisakthavee, P., Weerakulwattana, P., Chaichanwattanakul, K., Nakavachara, P., & Nitiyanant, W. (2008). Glycemic control and the psychosocial benefits gained by patients with type 1 diabetes mellitus attending the diabetes camp. *Patient Education and Counseling, 73*(1), 60-66. doi: 10.1016/j.pec.2008.05.023.

Silverstein, J., Klingensmith, G., Copeland, K., Plotnick, L., Kaufman, F., Laffel, L., Clark, N. (2005). Care of children and adolescents with type 1 diabetes: a statement of the American Diabetes Association. *Diabetes Care*, 28: 186–212.

Thethi, T. K., Rao, A., Kawji, H., Mallik, T., Yau, C. L. Christians, U., Fonseca, V. (2010). Consequences of delayed pump infusion line change in patients with Type 1 DM treated with continuous subcutaneous insulin infusion. *Journal of Diabetes Complications*. 24, 73–78. doi:10.1016/j.jdiacomp.2009.03.002

Tucson Unified School District (2014). TUSD stats enrollment: single school ethnic/gender enrollment for any instructional day/date. Retrieved from http://tusdstats.tusd1.org/planning/profiles/curr_enr/anydate/anyenry.asp

Vesco, A. T., Anderson, B. J., Laffel, L. M. B, Dolan, L. M., Ingerski, L. M., &. Hood, K. K. (2010). Responsibility sharing between adolescents with type 1 diabetes and their caregivers: Importance of adolescent perceptions on diabetes management and control. *Journal of Pediatric Psychology*. 35, 1168–1177. doi:10.1093/jpepsy/jsq038

Whittemore, R., Grey, M., Lindemann, E., Ambrosino, J., & Jaser, S. (2010). Development of an internet coping skills training program for teenagers with type 1 diabetes. *Computers, Informatics, Nursing, 28*(2), 103-111. doi: 10.1097/NCN.0b013e3181cd8199

Whittemore, R., Jaser, S. S., Jeon, S., Liberti, L., Delamater, A., Murphy, K., . . . Grey, M. (2012). An internet coping skills training program for youth with type 1 diabetes: Six-month outcomes. *Nursing Research*, *61*(6), 395-404. doi:10.1097/NNR.0b013e3182690a29; 10.1097/NNR.0b013e3182690a29

Wysocki, T., Ianotti, R., Weissberg-Benchell, J., Laffel, L., Hood, K., Anderson, B.,& Chen, R. (2008). Diabetes problem solving by youths with type 1 diabetes and their caregivers: measurement, validation, and longitudinal associations with glycemic control. *Journal of Pediatric Psychology*, 33:875–884.

.