Educational Impact on Glycemic Outcomes Among Children and Adolescents Diagnosed with Type 1 Diabetes

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Abstract

While insulin remains the cornerstone therapy for managing blood glucose in children and adolescents with type 1 diabetes mellitus (T1DM), consistent adherence to this treatment has proven challenging over time. As a result, educational strategies have gained attention as a means to promote better compliance with insulin regimens, ultimately supporting more stable glycemic levels in pediatric T1DM patients. This review examined the scope of existing educational interventions and their outcomes in the management of T1DM among children and adolescents. Using the scoping review model proposed by Arksey and O'Malley, publications from 2000 to 2021 were systematically identified and evaluated to account for the wide range of study designs, intervention types, and participant demographics. After a rigorous selection process, 49 studies were selected from an initial pool of 5015. A significant number of these interventions were delivered through multidisciplinary approaches and demonstrated a reduction in glycated hemoglobin (HbA1c), sometimes accompanied by other benefits. Overall, the review demonstrated that educational interventions yield positive effects on glycemic regulation in children and adolescents with T1DM. These programs not only contributed to lower HbA1c levels but also supported behavioral improvements, psychological well-being, overall health status, and better quality of life (QOL).

Keywords: Education, Children, Type 1 diabetes, Adolescents

Introduction

By 2019, type 1 diabetes mellitus (T1DM) had affected an estimated 600,900 children under 15 years of age globally, with projections indicating that new annual cases could increase to 98,200 worldwide [1]. The principal goal of T1DM treatment is to reduce cardiovascular risks and mortality through strict glycemic regulation [2]. Adherence to diabetes care is a key factor in achieving optimal blood sugar control and has shown beneficial effects regardless of sociodemographic variables, age brackets, or disease profiles [3]. Despite this, adherence levels among children and adolescents with T1DM remain inconsistent, ranging from just 30% to 70% [4].

Previous investigations into T1DM in children suggest that patient and family-focused educational efforts not only offer a cost-effective strategy for caregivers but also play a critical role in reducing the frequency of hospital admissions and emergency care utilization. These benefits are especially evident when education is paired with intensive disease monitoring and open communication between patients and healthcare professionals [5]. Importantly, such education should be age-appropriate, engaging both children and their families, and addressing practical aspects of daily disease

management alongside emotional concerns [5]. However, gaps between recommended practices and actual clinical application persist, often due to a shortage of training, unfamiliarity with educational resources, and time limitations in clinical settings [6].

The term "patient engagement" refers to the involvement of individuals in making informed decisions about their treatment, understanding life-related health factors, and pursuing constructive changes [7]. This principle is central to developing self-care abilities and fostering meaningful interactions between patients and healthcare teams [8]. Educational initiatives are essential to enhancing patient engagement, particularly for children and adolescents managing long-term conditions like T1DM [9]. Many studies confirm a strong interest among children and adolescents with chronic diseases in gaining knowledge about their illness and its effect on everyday life [10].

Educational interventions for children and adolescents with T1DM often take the form of complex strategies [11], facilitated either by healthcare professionals or peers, and delivered to individuals or groups [12]. Group formats have shown success in supporting public health goals and are considered vital in helping patients manage chronic illnesses more effectively [13].

In light of these considerations, there is a growing necessity to identify the essential components and real-world impacts of educational approaches targeting pediatric diabetes. Although several studies have underscored the advantages of such interventions in young diabetic populations [9], limited research has focused solely on children and adolescents living with T1DM. To address this gap, the present review compiles and evaluates existing literature to highlight both the structures and effects of education-based interventions in this population.

This review is guided by two central questions:

1. What are the appropriate research designs, participant profiles, and intervention formats for education programs targeting children and adolescents with T1DM?

2. What types of outcomes have been observed as a result of these education-based interventions in children and adolescents with T1DM?
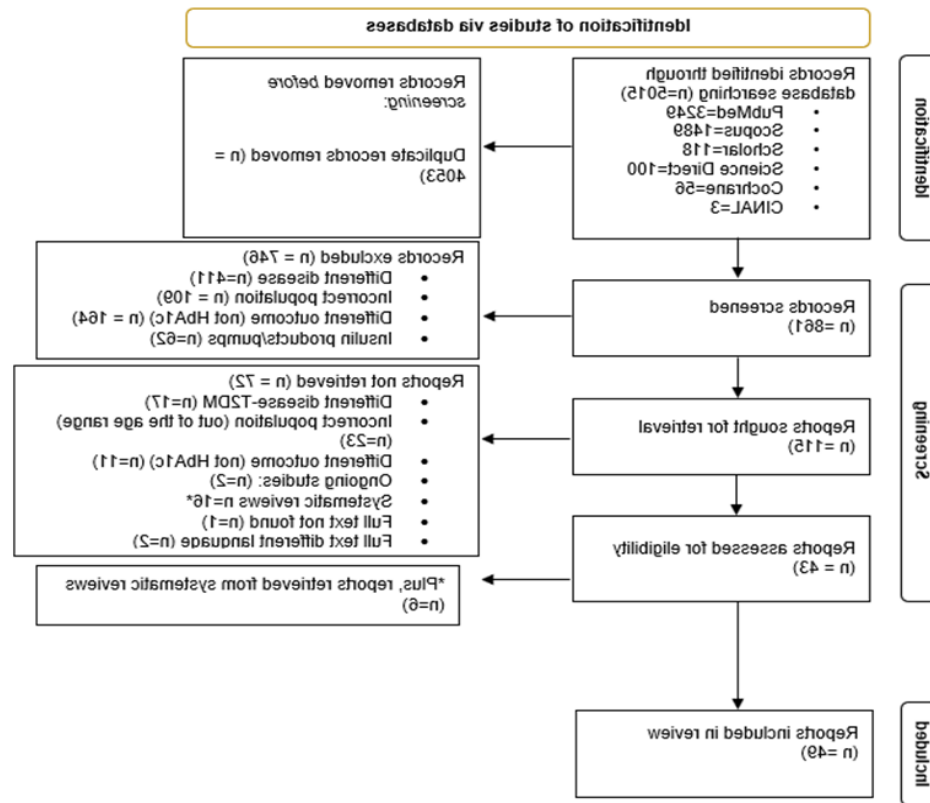
Materials and Methods

Search Strategy

To explore the impact of educational interventions on glycemic control in children and adolescents with T1DM, a comprehensive search was conducted targeting studies published between 2000 and 2021. The search aimed at identifying research that measured glycemic regulation using glycated hemoglobin (HbA1c) or related diabetes outcomes. Six major databases—PubMed, Scopus, Scholar, ScienceDirect, Cochrane, and CINAL—were systematically explored to gather relevant literature. The methodological framework adopted for this review was derived from the scoping review model proposed by Arksey and O'Malley [14], which is well-suited for mapping key concepts and examining a wide range of study types.

A scoping review approach was chosen to allow for the inclusion of diverse research methodologies and to comprehensively address the core research questions [15]. The initial search process yielded 5015 records. Following eligibility assessment, 4900 articles were eliminated due to not meeting the predefined inclusion criteria, as shown in **Figure 1**. An additional 66 studies were excluded during subsequent screening phases. However, six more articles were integrated into the review following the evaluation of prior systematic reviews covering comparable themes.

To resolve any inconsistencies in article selection, discussions among reviewers were conducted until mutual agreement was reached. In some cases, studies that involved participants older than 18 years were retained—particularly those where the overall cohort included children, adolescents, and young adults up to 25 years of age. Ultimately, this process culminated in the inclusion of 49 studies for detailed analysis in the present review.

Identification of studies via databases

Identification

Records identified through database searching (n=5015)
- PubMed=3249
- Scopus=1489
- Scholar=118
- Science Direct=100
- Cochrane=56
- CINAL=3

Records removed before screening:

Duplicate records removed (n = 4053)

Screening

Records screened (n = 861)

Records excluded (n = 746)
- Different disease (n=411)
- Incorrect population (n = 109)
- Different outcome (not HbA1c) (n = 164)
- Insulin products\pumps (n=62)

Reports sought for retrieval (n = 115)

Reports not retrieved (n = 72)
- Different disease-T2DM (n=17)
- Incorrect population (out of the age range) (n=23)
- Different outcome (not HbA1c) (n=11)
- Ongoing studies: (n=2)
- Systematic reviews n=16*
- Full text not found (n=1)
- Full text different language (n=2)

Reports assessed for eligibility (n = 43)

*Plus, reports retrieved from systematic reviews (n=6)

Included

Reports included in review (n = 49)

Figure 1. Flow diagram of identified, screened, and extracted studies

The literature review was designed using the PICO framework—Patient, Intervention, Comparison, and Outcome—as the foundation for identifying relevant studies. The search utilized specific keywords such as "children", "intervention", "education", "type 1 diabetes mellitus", "glycemic control", and "insulin" to gather pertinent articles.

This scoping review applied the following parameters:

• *Population*: The target group included children and adolescents.

• *Intervention*: Patient education programs—delivered either in-person or digitally—facilitated by healthcare professionals or trained facilitators, to enhance participants' self-care abilities, glycemic outcomes, and overall well-being.

• *Comparison*: Standard care, alternative educational strategies, or baseline measurements before the intervention.

• *Outcomes*: Changes in glycemic regulation as indicated by HbA1c, as well as secondary effects on knowledge, behavior, psychological well-being, health condition, and QOL.

To be considered for inclusion, studies needed to be qualitative or quantitative, published in English, and evaluate the effect of educational interventions on HbA1c levels in children and/or adolescents diagnosed with T1DM for a minimum of one year. Studies were excluded if they did not focus on children or adolescents, involved participants in critical conditions or with additional comorbidities, or lacked HbA1c as a measured outcome.

Data Extraction

The focus of this review was to assess how educational initiatives influenced HbA1c values in patients. The selected literature comprised studies implementing various educational strategies aimed at improving clinical, behavioral, and psychological outcomes, in addition to evaluating health conditions and QOL in children and adolescents with type 1 diabetes.

A standardized extraction form was developed collaboratively by the review team. Two reviewers

independently populated this form with information from the eligible studies, covering general bibliographic details (authors, year, country), participant demographics (age, sex), methodological data (design and duration), descriptions of the intervention, and key outcomes (HbA1c changes, behavioral shifts, psychological impact, knowledge gain, QOL, and general health measures). A third team member reviewed the extracted content to ensure accuracy. The synthesized data were then categorized in line with the core research objectives, as presented in **Table 1**.

Table 1. Description of the individual studies included in the scoping review

Study no. Study Year Country	Study design Study duration	Sample description (ND: No data) N: No of participants T: C (test: control) F: M (female: male) Age range	Setting	Intervention description	Clinical outcome Glycated hemoglobin (hba1c) (P-value)	Other outcomes
1 Afshar *et al.* [16] 2014 Iran	Pre- and post-test control groups 6 months	56 75%F:25%M 12-18 Years	Diabetes center/Out-patient clinic	Intervention: Peer-education education-based intervention Description: The group participated in discussion sessions focused on QOL related to DM, where members exchanged their personal experiences and challenges, while also following the guidance provided by diabetes specialists. Mode: group with parents Personnel: specific technician, DM specialist Duration: 4 months Delivery method: face-to-face and phone calls	Significant reduction by 1% Mean of 8% to 7% (P = 0.001)	Enhanced quality of life (QOL) and fasting blood glucose (FBG) levels.
2 Altundag *et al.* [17] 2016 Turkey	Pre- and post-test control groups 9 months	38 18 T:20 C 50%F:50%M 12-14 years	Pediatric endocrine clinic at a university hospital	Intervention: Peer education-based intervention Description: Initial sessions provide basic information on T1DM for adolescents with diabetes, including activities such as warm-up games, storytelling, Q&A, demonstrations, discussions, and role-playing, followed by the distribution of a training guide. Mode: Group Personnel: Dietitians, nurses, and child psychiatrist Duration: 6 months Delivery method: In-person	Significant reduction from 10.23 ± 2.39 to 8.02 ± 1.66 (P < 0.001)	Enhanced diabetes knowledge, self-esteem, and social support.
3 Edraki *et al.* [18] 2020 Iran	Randomized control trial 3 months	96 48 T:48 C 62%F:38%M 12-18 years	Center for diabetic patients, affiliated with Shiraz University of Medical Sciences	Intervention: Peer education-based intervention Description: Four workshops led by peers focusing on self-care behaviors for diabetes management. Mode: Group sessions with parents Personnel: Peer educators (supervised by diabetes specialists) Duration: 1 month Delivery method: In-person	Significant reduction (P < 0.001)	Enhanced self-care practices.

4	Walker *et al.* [19] 2020 USA	Randomized controlled study 9 months	42 teens 22 T:20 C 77%F:23%M 11-17 years	Pediatric endocrinology clinic	Intervention: Peer mentorship program Description: The All for ONE (Outreach, Networks, and Education) mentorship program included various components, such as social events incorporating diabetes education, daily SMS reminders for blood glucose monitoring for both mentors and mentees, weekly text communications between mentors and mentees, and regular clinic visits. Mode: Group sessions Personnel: College student mentors Duration: 9 months Delivery method: In-person and text messages	No significant difference (P = 0.38) / Better psychosocial outcomes and improved quality of life (satisfaction).
5	Likitmaskul *et al.* [20] 2002 Thailand	Cohort study 6 months	52 24 T:28 C Both Genders (unspecified) 7-9 years	Pediatrics department/hospital	Intervention: Intensive diabetes education program Description: A multidisciplinary team delivers self-management training, covering topics such as T1DM, insulin therapy, diet and exercise, monitoring, interpretation, and managing hypoglycemia. Mode: Group sessions with families Personnel: Pediatric endocrinologists, dietitians, psychologists, and nurses Duration: 10-12 days Delivery method: In-person and phone calls	Significant reduction (T = 9.19% C = 11.54%) (P = 0.03) / A reduction in hospital stays or complications by half.
6	Wang *et al.* [21] 2010 U.S.A.	Randomized controlled trial 9 months	44 21 T:23 C 50%F:50%M 12-18 years	Children's Medical Center	Intervention: Diabetes education program utilizing motivational interviewing (MI) versus structured diabetes education (SDE) Description: A 2-day workshop offering either MI or SDE, based on the American Diabetes Association's (ADA) essential content covering medication, monitoring, and acute complications. This is followed by two additional lifestyle-focused intervention sessions and two follow-up phone calls. Mode: Group sessions Personnel: Diabetes educators and physicians Duration: 6 months Delivery method: Face-to-face and phone calls	Significant reduction (P = 0.03) / Enhanced quality of life (QOL).

No.	Author / Year / Country	Study design / Duration	Sample	Setting	Intervention	HbA1c outcome	Other findings
7	Abolfotouh *et al.* [22] 2011 Egypt	Cross-sectional / quasi-experimental study 10 months	243 121 T:122 C 56.6%F:43.4M 12–20 years	Diabetes outpatient clinics	Intervention: Education program Description: The program consisted of four 120-minute sessions, one held each month, addressing topics such as i) both short- and long-term complications of diabetes, ii) medication and glucose monitoring, iii) diet and its relationship to diabetes, and iv) physical activity and foot care. Mode: Group sessions with parents Personnel: Pediatricians Duration: 4 months Delivery method: In-person sessions	No significant reduction in the experimental group compared to the control group (-0.18% T: +0.25% C) (P = 0.12)	A poorer quality of life (QOL) was strongly associated with older age (P = 0.001), higher frequency of hospitalization in the past 6 months (P = 0.006), increased depression levels (P = 0.001), lower self-esteem (P = 0.001), and poor self-efficacy (P = 0.001). After the intervention, the experimental group experienced significant deterioration in all QOL categories. However, the degree of deterioration was notably less severe in the experimental group compared to the control group.
8	Coates *et al.* [23] 2013 Ireland	Multi-centered pragmatic randomized controlled trial 5 months	135 70 T:65 C 53.4F:46.6%M 13–19 years	Seven hospital sites	Intervention: Structured diabetes education program Description: This program aimed to help adolescents modify their diets and insulin regimens, enabling them to lead a lifestyle that closely resembled that of their peers without diabetes. The program was delivered through three-hour interactive, group-based sessions totaling 12 hours. Mode: Group sessions with parents Personnel: Research secretary and assistants Duration: 1 month Delivery method: In-person and phone calls (CHOICE)	No significant difference in hba1c between across groups in hba1c (P = 0.22)	Improvement in dietary habits and practices.
9	Christie *et al.* [24] 2014 UK	Pragmatic, clustered Randomized trial 12 - 24 Months	362 181 T:181 C Both Genders (unspecified) 8-16 years	General hospital clinic or teaching hospital / tertiary clinic	Intervention: Structured educational group program Description: The intervention consisted of two one-day workshops designed to teach the adapted CASCADE approach (Child and Adolescent Structured Competencies Approach to Diabetes Education), which covers four modules: Module 1: The connection between diet, insulin, and blood glucose levels, Module 2: Blood glucose testing, Module 3: Insulin adjustment—benefits and challenges, and Module 4: Coping with diabetes. Mode: Group sessions Personnel: Pediatricians and nurses Duration: 2 days Delivery method: In-person	No significant difference in hba1c at 12 months (P = 0.584) Nor at 24 months (P = 0.891)	The intervention resulted in enhanced knowledge of diabetes management and related quality of life, along with improved family relationships and increased motivation.

No.	Author, Year, Country, Study design, Duration	Sample	Setting	Intervention	HbA1c outcome	Other outcomes
10	Hawkes *et al.* [25] 2019 USA Retrospective cohort 2 years	675 391 T:284 C 44%F:56% M <18 years	Pediatrics hospital	Intervention: A structured education program Description: A 10-hour educational curriculum was implemented to offer intensive coaching tailored to participants' family lifestyles and their readiness for greater independence. The program addressed challenges related to nutrition, emphasized carbohydrate counting, and supported dietary management strategies. Mode: Group sessions with family involvement Personnel: Primary outpatient clinician, inpatient nurses, and certified diabetes educator Duration: 1 year Delivery method: In-person	Significant reduction in hba1c levels in the T1Y1 group; In 6 months: 6.7% ($P < 0.001$) In 12 months: 7.3% ($P < 0.001$) In 18 months: 7.6% ($P = 0.01$) In 24 months ($P = 0.14$)	There was an increase in the time spent with a Certified diabetes educator (CDE) during the first year ($P < 0.001$), higher utilization of technology, and a greater number of patients using continuous glucose monitoring (CGM) ($P = 0.001$) and insulin pumps ($P = 0.2$).
11	Ramírez-Mendoza *et al.* [26] 2020 Mexico Pre- and post- Test (no control) 6 months	121 ND 58.7%F:41.3%M 0-18 years	Local health centers, general hospitals, pediatric hospitals, the National Institutes of Health, children obesity clinics, and private hospitals referred patients.	Intervention: Multidisciplinary educational program Description: The PAANDA program (a care initiative for adolescents and children with diabetes mellitus) teaches patients how to manage their blood glucose levels and encourages regular glucose testing. Mode: Group sessions with caregiver participation Personnel: Social workers, pediatric nurses, and endocrinologists Duration: 6 months Delivery method: In-person	Significant reduction average - 1.8%, ($P = 0.018$) The highest reduction occurred at ages 8-13 years by 2.3%	There was a reduction in the incidence of glycemic complications.
12	D' Souza *et al.* [27] 2021 UK Retrospective- questionnaire-based service evaluation (pre-SEREN/post-SEREN) 12 months	221 115T:106C 49.8%:50.2% 4-17 years	Diabetes clinic/hospital	Intervention: Structured education reassuring empowering nurturing (SEREN) Educational program for CYPs Description: The SEREN program covers topics such as the causes of T1DM, carbohydrate counting, insulin dose adjustments, hypoglycemia management, sick-day protocols, diabetic ketoacidosis management, complications, and the effects of exercise. Mode: Group sessions with parental involvement Personnel: Pediatric diabetes specialists, nurses, and dieticians Duration: 6 weeks Delivery method: In-person	No change in hba1c	Diabetes knowledge and quality of life (QOL) showed significant improvement.
13	Karagüzel *et al.* [28] 2005 Turkey Pre- and post-test control groups 12 months	25 64%F:36%M 7-17 years	Camp	Intervention: Summer camp and intensive insulin treatment Description: The educational program covered insulin injection techniques, blood glucose monitoring, identifying and managing hypoglycemia, hyperglycemia, and ketosis, insulin dosage adjustments based on diet and exercise, diabetic nutrition, carbohydrate counting, diabetes-related complications, the significance of maintaining diabetes control and exploring new therapies for testing glycemic control. Mode: Group sessions Personnel: Pediatric endocrinologists, nurses, dietitians, interns, and psychologists Duration: 7 days Delivery method: In-person	Significant reduction of HBA1c levels from pre-camp baseline up to 6 and 12 months (about -1.5%) ($P < 0.05$)	There was a significant enhancement in knowledge and self-management at both 6 and 12 months after the camp, along with a notable improvement in overall generic QOL scores ($P = 0.04$).

No.	Study	Design / Follow-up	Sample	Setting	Intervention	Glycemic outcome	Other outcomes
14	Santiprabhob *et al.* [29] 2005 Thailand	Pre-/post - observational study 3 months	62 7.7%:32.3%M 14.1 +/- 4.3 years	Camp	Intervention: Camp-based diabetes education program. Description: This 5-day camp involved small-group discussions on various diabetes self-management topics and lectures covering insulin therapy and injection techniques, the importance of diabetes control, blood glucose monitoring, exercise and diabetes, diabetic nutrition, complications of diabetes, managing special events, exploring new therapies for diabetes, and engaging in social programs. Mode: Group sessions. Personnel: Endocrinologists, fellows, nurses, psychologists, dietitians. Duration: 5 days. Delivery method: In-person	Significant reduction in mean pre-camp (10 ± 3%) and post-camp (9 ± 2.6%) HBA1c levels (P = 0.008)	The improvement in self-monitoring of blood glucose (SMBG) records, with an average of 1.8 recordings per day, contributed to better glycemic control, although the result was statistically insignificant (P = 0.091).
15	Santiprabhob *et al.* [30] 2008 Thailand	Pre-/post - observational study 6 months	60 68.3%F:31.7%M 16 +/- 7 years	Camp	Intervention: Camp-based diabetes education program. Description: This 5-day program featured lectures, games, and small-group discussions covering the disease's etiology and symptoms, insulin therapy and injection techniques, the importance of diabetes control, blood glucose monitoring, the role of exercise in managing diabetes, diabetic nutrition, complications of diabetes, as well as the recognition and management of hypo/hyperglycemia and ketosis. It also included discussions on insulin dosage adjustments based on dietary and activity changes, managing special situations like sick days, and concluded with a 6-month post-camp follow-up on glycemic control. Mode: Group sessions. Personnel: Endocrinologists, fellows, nurses, psychologists, dietitians. Duration: 5 days. Delivery method: In-person	Significant reduction in HBA1c levels after 3-months post camp (8.2+/-1.7, P < 0.001), and no significant difference in HBA1c between 6-month post-camp and baseline (P = 0.94)	There was an improvement in knowledge and psychosocial outcomes, particularly in coping, confidence, and self-esteem. At the 6-month follow-up, 14% of participants continued to perform self-monitoring of blood glucose (SMBG) 3-4 times per day.
16	Wang *et al.* [31] 2008 USA	Retrospective study 7 months	182 74 T:108 C 52.7%F:47.3%M 12-18 years	Camp	Intervention: Summer camp educational program. Description: The camp offered three separate 20-day sessions, each featuring daily educational lectures and discussions. Blood glucose levels were monitored four times a day, with adjustments made as needed before each meal. Insulin dosages were modified accordingly, and all insulin injections were supervised. Meals were carefully planned by a licensed dietitian. Mode: Group sessions. Personnel: Medical students and physicians. Duration: 20 days. Delivery method: Camp-based (in-person)	Significant reduction 8.6 to 8.3% (P < 0.005) Improvement in girls more than boys in P = 0.04	There was an improvement in adherence to insulin therapy.

#	Study	Design/Duration	Sample	Setting	Intervention	HbA1c Outcome	Other Outcomes
17	Troncone *et al.* [32] 2021 Italy	Follow-up investigation 3 months	20 ND 60%F:40%M 10-12 years	Camp	Intervention: Diabetes summer camp-educational program. Description: The program offers a combination of didactic and interactive activities for children, focusing on the disease's causes and symptoms, insulin therapy, blood glucose monitoring, nutrition, recognizing and managing complications, the interplay between exercise, food intake, and insulin doses, the importance of diabetes control, daily management of T1DM, stress management, and addressing other life challenges. Mode: Group sessions with parents. Personnel: Medical director, physician, dietitian, and psychologist. Duration: 1 week. Delivery method: Camp-based (in-person)	HBA1c levels increased from 7.02 to 7.28 % ($P = 0.010$)	There was an improvement in self-efficacy related to diabetes management and quality of life (QOL).
18	Cook *et al.* [33] 2002 USA	Randomized control trial 6 months	53 26 T:27 C 53% F:47% M 13-18 years	Diabetes clinics/children's hospital	Intervention: Choices diabetes program. Description: The behavioral intervention consists of six weekly 2-hour sessions covering: 1. Decision-making and record-keeping, 2. Meal planning, 3. Insulin timing, 4. Getting back on track, 5. Further decision-making, and 6. Managing the psychological effects of diabetes. Mode: Group sessions with parents. Personnel: Physician consultants, psychologists, and dietitians. Duration: 6 weeks. Delivery method: In-person	Significant reduction in hba1c after 6 months of intervention from 8.9 to 8.3%, ($P < 0.01$)	There was a significant increase in problem-solving scores from pre- to post-program, though no significant differences were observed in knowledge.
19	Lehmkuhl *et al.* [34] 2010 USA	RCT 3 months	32 18 T:14 C 71.9%F:28.1%M 9 -17 years	Virtually	Intervention: Telehealth behavioral therapy. Description: This intervention involves phone-based sessions with a therapist, focusing on self-care behaviors that promote effective diabetes management. The sessions emphasize setting goals for diabetes management, identifying challenges, and providing education to overcome potential barriers. Mode: Individual sessions with families. Personnel: Research coordinators, assistants, and clinical psychology interns. Duration: 12 weeks. Delivery method: Phone-based sessions	Significant reduction in hba1c by 0.74 compared to 0.09 in the waitlist ($P = 0.03$)	The Diabetes Self-Management Profile (DSMP) showed a significant increase ($P < 0.01$).
20	Whitemore *et al.* [35] 2010 USA	Multiphase- randomized control trial (pilot phase) 6 months	12 6 T: 6 C 58% F:42%M 13-16 years	Virtually	Intervention: Internet coping skills training program (TEENCOPE). Description: TEENCOPE is a web-based behavioral intervention designed to manage diabetes and develop coping skills. The program includes four weekly sessions focused on glucose control, nutrition, exercise, sick day management, and the use of new technology, along with five weekly sessions on self-talk, communication, social problem-solving, stress management, and conflict resolution. Mode: Group sessions with parents. Personnel: Nurses, clinical psychologists, and a web development team (web designers and programmers). Duration: 5 weeks. Delivery method: Web-based sessions	No significant reduction in hba1c values between both groups after 6 months of intervention (8% T:7.4% C)	There were positive trends observed in psychosocial outcomes, including stress, self-efficacy, and coping, as well as in quality of life (QOL) with respect to acceptability, with p-values ranging from 0.07 to 0.2.

#	Reference / Year / Country	Study design / Duration	Sample	Setting	Intervention	HbA1c outcome	Other outcomes
21	Mulvaney *et al.* [36] 2012 USA	Pilot trial 3 months	46 23T:23C 43.5%F:56.5%M 13-17 years	Virtually	Intervention: Tailored mobile and web-based diabetes messaging system. Description: This behavioral intervention utilized a text messaging system to encourage and remind adolescents about their diabetes self-care responsibilities. Adolescents received 10 personalized text messages per week, tailored to their individually reported barriers to managing diabetes. Mode: Individual. Personnel: Experts in diabetes adherence and clinical care. Duration: 3 months. Delivery method: Online-based	No change in the mean hba1c level in the intervention group (8.8%), while the mean level in the control group was significantly higher (9.9%), (P = 0.006)	None
22	Whittemore *et al.* [37] 2012 USA	Multisided-randomized control trial 6 months	320 167 T:153 C 55% F:45%M 11-14 years	Pediatric diabetes clinics	Intervention: Internet coping skills training (TEENCOPE) vs. managing diabetes (MD) program. Description: This behavioral intervention compares two programs: TEENCOPE, which includes five weekly sessions focusing on social skills training, cognitive behavior modification, assertive communication, stress reduction, and conflict resolution, and MD, an online diabetes education program consisting of five sessions, each featuring case studies and problem-solving exercises. Mode: Group. Personnel: Nurses, psychologists, and Ph.D. candidates. Duration: 5 weeks. Delivery method: Face-to-face and web-based sessions	No significant differences in hba1c levels (P = 0.144)	No significant differences were found in psychosocial outcomes, including quality of life (QOL), stress, depression, coping, and family conflict.
23	Grey *et al.* [38] 2013 USA	Randomized cross-over control trial 18 months	320 167 T:153 C 55% F:45% M 11-14 years	Virtually	Intervention: Internet psycho-education programs. Description: This behavioral intervention compares the effectiveness of TEENCOPE, which includes self-talk, interpersonal communication, social problem-solving, stress management, and conflict resolution, with managing diabetes, which emphasizes decision-making for optimal outcomes, both programs offer 30-minute sessions once a week for five weeks. Mode: Group with parents. Personnel: Trained research personnel. Duration: 5 weeks. Delivery method: Web-based sessions	No sig. Difference between the two groups (P = 0.05) Mean hba1c levels increased slightly in both groups by a mean of 0.12%	Both groups showed an improvement in quality of life (QOL) (P = 0.001), with no significant difference between the two groups.
24	Husted *et al.* [39] 2014 Denmark	Randomized controlled trial 12 months	71 37 T:34 C 62%F:38%M 13-18 years	Pediatrics out-patients clinic	Intervention: Guided self-determination youth (GSD-y) intervention. Description: This behavioral intervention focuses on life skills training that empowers both the patient and provider, involving eight 1-hour sessions with 29 reflection sheets. The process follows six stages: (1) establishing a mutual relationship with clear boundaries, (2) self-exploration, (3) self-understanding, (4) shared decision-making, (5) action, and (6) feedback. Mode: Group with parents. Personnel: Pediatric diabetes nurses, pediatric physicians, dieticians. Duration: 8 to 12 months. Delivery method: Face-to-face	No significant reduction in HBA1c values (P = 0.65)	No significant differences were found in glycemic complications (such as hypoglycemia, and hospitalization), insulin doses/regimens, well-being, or competency. However, there was an improvement in autonomy, self-regulation, and parental support.

No.	Study	Design / Duration	Sample	Setting	Intervention	Outcome (hba1c)	Additional outcome
25	Harris *et al.* [40] 2015 USA	Randomized control trial 7 months	90 46 T: 44 C 55% M:45%F 12-19 years	Tertiary diabetes clinic	Intervention: Family systems therapy for diabetes (BFST-D) via face-to-face or internet video conferencing (Skype) Description: The behavioral intervention (BFST-D) consists of four key components: 1) problem-solving training, 2) communication skills training, 3) cognitive restructuring (challenging ingrained beliefs), and 4) family therapy techniques, offered either in person or through virtual sessions. The sessions involve modeling, providing instructions and feedback, and guiding the practice of new skills through behavioral tasks. Mode: Group with caregiver Personnel: Research assistants, psychologists Duration: 12 weeks Delivery method: Face-to-face and Skype video call	Significant reduction in hba1c ($P = 0.01$)	Significant improvements in adherence were sustained for three months after the follow-up.
26	Fiallo-Scharer *et al.* [41] 2019 USA	Randomized control trial 24 months	214 106 T: 108 C Both genders (Not specified) 8-16 years	Diabetes clinics	Intervention: Family-centered approach Description: This behavioral intervention focuses on: 1) identifying barriers to family self-management using the validated problem recognition in illness self-management (PRISM) tool, 2) providing tailored self-management resources from the healthcare system to address these barriers, and 3) considering alternatives to existing behaviors (social, emotional, or financial). The intervention is conducted through four group sessions coordinated with diabetes clinic visits. Mode: Individual sessions with families Personnel: Trained nurses Duration: 9 months Delivery method: Face-to-face	Significant reduction in hba1c by -0.08 ($P < 0.05$), Large decline for patients with hba1c > 10 (-0.19) ($P < 0.05$).	The mean quality of life (QOL) for parents significantly increased during the intervention ($P < 0.05$).
27	Sarteau *et al.* [42] 2020 USA	Randomized control trial 18 months	127 ND 45.9%F:54.1% M 13-16 years	Children's Hospital/Medical Centre and virtually	Intervention: Flexible lifestyle empowering change trial (FLEX) Description: This behavioral intervention combines motivational interviewing (MI) and problem-solving skills training (PSST). It consists of four 40-60 minute coaching sessions, spaced one month apart. The sessions focus on (1) evaluating concerns related to managing T1DM, (2) engaging with young individuals, and (3) assigning behavioral tasks. Goal setting during each session includes aspects like blood glucose monitoring (BGM), continuous glucose monitoring (CGM), and insulin dosing. The sessions conclude by incorporating parents into discussions about how they can support the goals set by the youth. Mode: Group sessions with parents Personnel: Dietician, nurse, certified diabetes educator (CDE) Duration: 7 months Delivery method: Face-to-face, followed by phone calls/text messages	Significant reduction in hba1c by 0.4% ($P = 0.03$)	There was no statistically significant difference in the number of days with clinical hypoglycemia.

#	Study	Design / Duration	Sample	Setting	Intervention	HbA1c result	Other results
28	Bakir *et al.* [43] 2021 Turkey	RCT 6 months	50 25 T: 25 C 50%F:50%M 14 ±2 years	Home visits and virtually	Intervention: Information–motivation–behavioral skills model. Description: This behavioral intervention involves multiple phone calls and home visits, providing information on diet and exercise, fostering motivation through a positive attitude in applying this knowledge, offering support, and addressing health concerns. It also focuses on developing behavioral skills and facilitating behavior changes to meet daily goals. Mode: Group sessions. Personnel: Nurses. Duration: Approximately 2 months. Delivery method: Face-to-face and phone calls	Significant reduction in hba1c levels ($P < 0.001$) And sixth months ($P < 0.001$)	The study group showed significant improvements in knowledge levels ($P < 0.001$), personal motivation levels ($P = 0.001$), social motivation levels ($P = 0.004$), and behavioral skills ($P < 0.001$).
29	Lawson *et al.* [44] 2000 Canada	Retrospective cohort study 15 months	28 17T: 11C Both genders (unspecified) 11-20 years	Outpatient/hospital	Intervention: Intensive diabetes management (IDM) with intensive follow-up. Description: This individualized program provided 6 to 8 hours of education per family, where patients reviewed their meal plans and learned to adjust their insulin dosages. Incentives were offered when the HbA1c target was achieved. This approach was compared to group education with routine follow-up, which consisted of 2-hour sessions. Mode: Group with families. Personnel: Nurses, dieticians, diabetologists, and research fellows. Duration: 6 to 8 hours of education across 3 to 4 sessions (duration not specified). Delivery method: Face-to-face and phone-call follow-up	Significant reduction by mean of 2.5% in T ($P < 0.0001$) Vs -0.9% in C ($P = 0.05$) after 3 months. The mean hba1c one year later remained significantly lower than at the initiation of IDM in the T group ($P = 0.001$) and was not significantly different than that before the initiation of IDM in the C group ($P = 0.8$).	Two patients in the T group experienced severe hypoglycemic reactions, while no such cases were reported in the C group.
30	Kumar *et al.* [45] 2004 USA	Prospective randomized clinical trial 4 months	39 19 T: 20 C 48.7%F:51.3%M 8-18 years	Virtually	Intervention: A wireless, portable system to enhance adherence and glycemic control. Description: The intervention involved providing the experimental group with a handheld device equipped with diabetes data management software, a wireless modem, and a wireless-enabled blood glucose monitor. Additionally, an integrated motivational game was included, where participants guessed their blood glucose levels based on the last three readings. This was compared to the control group, who only received the new technologies without the game element. Mode: Group with parents. Personnel: Trained research assistants. Duration: 4 weeks. Delivery method: Motivational game/virtual	No significant difference ($P = 0.06$)	Enhanced diabetes knowledge, increased frequency of blood glucose monitoring, and a reduction in glycemic complications.

No.	Study	Design / Duration	Sample	Sex / Age	Setting	Intervention	Outcomes
31	Von Sengbusch et al. [46] 2006 Germany	Cohort study (pre-/post- test) 24 months	107	56.1%F:43.9%M 8-16 years	Virtually	Intervention: Mobile diabetes education Description: Parents undergo a 5-day training program, either in a group or one-on-one setting, focused on insulin function, insulin adjustment, managing sick days, and addressing daily challenges. This training is followed by 24 mobile-based follow-up sessions annually. Mode: One-to-one or group with families Personnel: Pediatric nurses and diabetologists Duration: 5-day yearly courses Delivery method: Mobile phone	No significant difference in the overall hba1c Levels. Although Patients with high hba1c (> 8%); showed significant reduction (P < 0.01), while patients with low < 6.8% showed a significant increase (P < 0.05). Both were exposed to DM complications. No change in the frequency or number of severe hypoglycemic episodes. A significant decrease in hospital admissions was observed, along with improved knowledge and pediatric quality of life (PedQOL).
32	Channon et al. [47] 2007 UK	Multi-center randomized controlled trial 12 months	66 38 T: 28 C	28.8%F:71.2%M 14-17 years	Diabetes clinic	Intervention: A multicenter motivational interviewing program Description: Participants engaged in individual, patient-centered motivational interviewing sessions aimed at increasing awareness of diabetes and exploring alternatives to existing behaviors, considering social, emotional, and financial factors. The sessions focused on problem-solving, decision-making, goal-setting, and reducing resistance to therapy. Mode: Individual Personnel: Psychologists and nurses Duration: 12 months Delivery method: Face-to-face	Significant reduction (9.3 to 8.7% (T): 9 to 9.2%(C), P = 0.04) and maintained at 24 months (9.3 to 8.7% (T): 9 to 9.1%(C), (P = 0.003). A significant improvement in quality of life (QOL) was observed (P = 0.001).
33	Lafusco et al. [48] 2011 Italy	Randomized control trial 2 years	396 193 T: 203 C	56% F: 44% M 10-18 years	Virtually	Intervention: Chat line as a tool to improve coping with diabetes Description: Weekly sessions were conducted for a minimum of two years, lasting 90 minutes each, focusing on diabetes management, anxiety about the future, and addressing interpersonal and social relationships. Mode: Group with parents Personnel: Research assistant, physician, and psychologist Duration: Weekly sessions with a 2-year follow-up Delivery method: Chat line	No significant difference in hba1c between the two groups (P = 0.056). There was a significant improvement in diabetes-specific quality of life (QOL), with reduced worries about diabetes. Adherence to injection frequency and therapy type improved, although this was not statistically significant.

#	Study	Design / Duration	Sample	Setting	Intervention	HbA1c result	Other results
34	Pinsker *et al.* [49] 2011 USA	Pilot study 6 months	32 16T:16C Both genders (not specified) <18 years	Virtually	Intervention: Pediatric diabetes education portal Description: A website designed for patients and their families to access clinic test results, view educational content related to these results and interact with their diabetes educator. It includes fingerstick, hemoglobin A1c (HbA1c) testing, and regular use of a continuous glucose monitoring system (CGMS), with results uploaded after each clinic visit. Patients and families were categorized as either website users or non-users. Mode: Group with families Personnel: Diabetes care team, including endocrinologists and educators Duration: 3-5 days Delivery method: Online-based	Significant reduction in hba1c among website users (P = 0.03)	There was an improvement in patient compliance and diabetes knowledge, though the latter was not statistically significant, along with increased monitoring by physicians.
35	Froisland *et al.* [50] 2012 Norway	Pilot mixed-method study (pre-/post intervention) 3 months	12 58.3%F:41.7%M 13-19 years	Virtually	Intervention: Visual learning on mobile phones Description: Two mobile phone applications were used: (1) a picture-based diabetes diary app that allowed users to log physical activities and take photos of their food intake, with Bluetooth connectivity to a glucometer to track blood glucose levels, and (2) a web-based, encrypted short message service (SMS) that was password-protected for secure communication. Mode: Group with parents Personnel: Researchers and physicians Duration: 3 months Delivery method: Mobile apps	No significant difference in hba1c (P = 0.38)	There was no significant change in diabetes knowledge (P = 0.82), but satisfaction levels were higher (although not statistically significant), and there were subjective improvements in diabetes management.
36	Peña *et al.* [51] 2013 Germany	RCT (pre-/post intervention) 7 months	13 61.5%F:38.5%M 6-10 years	Pediatric Diabetes Unit and virtually	Intervention: Impact of telemedicine assessment on glycemic variability Description: Training on the Accu-Chek (Roche) Smart Pix software was provided, followed by the measurement of glucose values for 3 months. These values were then compared with those from a subsequent 4-month period where telemedicine support was not used. Mode: Group with families Personnel: Researchers and diabetes specialists Duration: 3 months Delivery method: Online-based	Significant reduction in mean hba1c levels (P = 0.012)	There was no notable decrease in mean blood glucose (MBG) or the High Blood Glucose Index (HBGI).

No.	Study	Design (Duration)	Participants	Setting	Intervention	HbA1c Result	Outcome
37	Bin-Abbas *et al.* [52] 2014 KSA	Prospective experimental trial (pre-/post intervention test) 6 months	200 Both genders (unspecified) 11 years	Virtually	Intervention: Mobile phone messaging service. Description: Children received daily informational texts, weekly interactive messages, and multimedia video messages through their parents. These communications covered essential diabetes care knowledge, including symptoms, signs, pathophysiology, etiology, diagnosis, and management, such as insulin therapy, dietary therapy, psychotherapy, and updates on the latest diabetes-related news. Mode: Group with parents. Personnel: Pediatricians and research assistants. Duration: 6 months. Delivery method: Text messaging and phone calls	Sig. reduction in hba1c P = 0.0001	There was an enhancement in knowledge, blood glucose monitoring, a decrease in glycemic complications, and a reduction in missed insulin doses to 0%.
38	Kassai *et al.* [53] 2015 France	Parallel-group randomized controlled trial 12 months	77 39 T: 38 C 36% F: 41% M 12-17 years	Multi-center	Intervention: Pediatrician and nurse counseling. Description: Participants in the intervention group received three-monthly doctor visits, monthly nurse visits, and biweekly phone calls, while the control group had three-monthly doctor visits. The intervention provided information on general diabetes management, strategies to minimize complications and disease control techniques. Mode: Group. Personnel: Pediatricians and nurses. Duration: One year. Delivery method: Face-to-face and phone calls	No significant reduction -0.04% (T) (P = 0.61) Versus -0.03% (C) (P = 0.54)	There were no notable differences in diabetes-related side effects, except for ketoacidosis, which was observed more often in the intervention group compared to the control group.
39	Ng [54] 2015 UK	Cohort study (pre-/post- test) 5 years	The number and gender of participants were not specified; 12-25 years	Virtually	Intervention: Technology and social media Intervention. Description: The intervention utilized three digital techniques: 1) Facebook, a social media platform, for interactive communication providing diabetes support and education; 2) Twinkle.Net, an integrated pediatric diabetes electronic management system for monthly audits and more frequent follow-ups with patients exhibiting poor control; and 3) Diasend®, a blood glucose and insulin pump data management system that allows quick access to and analysis of glucose data, enabling tailored treatment adjustments. Mode: Group with families. Personnel: Pediatric diabetes team. Duration: 1 year. Delivery method: Social media technology	Significant reduction in hba1c (P < 0.05)	The length of hospital stays and admissions were reduced. Over 81% of participants felt that the technology for downloading data from glucose meters and insulin pumps was beneficial, and 87% believed it enhanced clinical decision-making for patient management.
40	Joubert *et al.* [55] 2016 France	Prospective multicenter-pilot study (pre-/post- test) 6 months	47 58% F: 42% M 11-18 years	Virtually	Intervention: Serious videogame for flexible insulin therapy. Description: In the game "L'Affaire Birman," players tackle diabetes-related issues such as hypoglycemia or hyperglycemia by adjusting insulin doses. No supplementary education was provided beyond what was based on the player's blood glucose levels, physical activity, and carbohydrate intake. Mode: Group with families. Personnel: Physicians, nurses, dietitians, and expert diabetic patients (academic diabetes care team). Duration: Approximately 3 months. Delivery Method: Web-based game sessions	No significant reduction in hba1c but remained stable throughout the study	There was an improvement in knowledge without corresponding changes in therapeutic behavior. A significant enhancement was observed in insulin titration and carbohydrate (CHO) quantification.

#	Author / Year / Country	Study design / Duration	Sample	Setting	Intervention	HbA1c Outcome	Other Outcomes
41	La Banca et al. [56] 2021 Brazil	Pilot randomized trial 8 - 12 months	20 10 T: 10 C 60% F: 40% M 7-12 years	Diabetes clinics	Intervention: Therapeutic play intervention (ITP) Description: Children in the intervention group first watched a video of other children injecting insulin into a doll, followed by a narrative about a child with T1DM self-injecting insulin at school. Afterward, the children recorded themselves injecting the doll again. In contrast, the control group received standard clinic-based education. Mode: Group with families Personnel: Trained nurses and the research team Duration: 1 month Delivery Method: Face-to-face	No significant reduction Mean HBA1c was 8.8 ± 1.2% T:9.3 ±2.6% C; (P = 0.6)	There was a statistically significant improvement in injection technique scores, and 90% of participants reported high levels of satisfaction with their quality of life (QOL).
42	Dłużniak-Gołaska et al. [57] 2019 Poland	Randomized control trial 6 months	196 98 T: 98 C Both genders (not specified) 8-17 years	Hospital-diabetology clinic and virtually	Intervention: Interactive nutrition education Description: Participants, all with poorly controlled type 1 diabetes managed using insulin pumps, were randomly assigned to one of two groups: the experimental group (E), which utilized interactive techniques such as quizzes and multimedia applications, or the control group (C), which only received traditional lecture-based instruction. The educational content focused on carbohydrate counting, blood glucose response to food, and healthy eating practices. Mode: Group with parents Personnel: Trained dietitian Duration: 3 months Delivery Method: Face-to-face sessions followed by interactive mobile apps	Significant reduction in hba1c in Group E By −0.47%, (P < 0.01) The positive effect Was no longer present after 6 months.	At the 6-month follow-up, clinical outcomes showed a non-significant improvement in both groups. Group C experienced a greater increase in obesity rates compared to Group E. A notable difference was found in the knowledge scores related to " blood glucose response to food."
43	Döğer et al. [58] 2019 Turkey	Cohort study (pre-/post- test) 6 months	82 53% F: 47.6% M 10.89 ±4 years	Virtually	Intervention: Telehealth system Description: Patients and parents were categorized into frequent callers, who contacted the system daily, 5–6 times per week, 1–2 times a week, or once every 15 days, and infrequent callers, who called less often. Counseling sessions were conducted through communication networks to discuss the current treatment plan and address diabetes-related questions, including insulin dosing, blood glucose regulation, carbohydrate counting, and the appropriate actions for managing hyperglycemia and hypoglycemia. Mode: Group with families Personnel: Diabetes team (nurses, dietitians, psychologists, and physicians) Duration: 3 months Delivery Method: Internet and smartphones	Significant reduction in hba1c (P < 0.001)	None
44	Jaser et al. [59] 2020 USA	Randomized controlled trial 6 months	120 60 T: 60 C 52.5%F:47.5%M 13-17 years	Virtually	Intervention: Positive psychology intervention Description: Every two weeks, the control group (EDU) received educational materials, which included information on adherence, HbA1c, and hypoglycemia. The intervention group, Positive Affect (PA), received the same materials as the EDU group, along with additional reminders focused on gratitude, self-affirmation, parental affirmation, and small gifts. Mode: Group with caregivers Personnel: Trained research assistants Duration: 2 months (8 weeks) Delivery Method: Text message or phone call	No significant difference post 3 months (P = 0.86), and no sig difference after 6 months (P = 0.557)	Positive affect (PA) intervention significantly enhanced the quality of life (QOL).

#	Study	Design / Duration	Sample	Setting	Intervention	HbA1c result	Other outcomes
45	Alfonsi *et al.* [60] 2020 Canada	Randomized control trial 3 months	46 23 T: 23 C Both Genders (not specified) 8-17 years	Virtually	Intervention: Carbohydrate counting App using image recognition. Description: The iSpy app, an advanced mobile application designed to assist young people with T1DM in counting carbohydrates by identifying food through images, was provided to participants on their mobile devices. Participants were tasked with using the app to complete various activities. Mode: Group. Personnel: Registered dietitians and educators. Duration: 3 months. Delivery Method: Mobile app	Significant reduction in hba1c Levels ($P = 0.03$)	The accuracy of carbohydrate (CHO) counting improved ($P = 0.008$), with a decrease in the frequency of counting errors, along with positive scores for quality of life (QOL) in terms of acceptability and engagement.
46	Otis *et al.* [61] 2020 USA	Mixed-phase pilot study 5 months	42 22 phase 1: 20 phase 2 64%F:36% M 5-14 years	Virtually	Intervention: Mobile educator tool/program. Description: The mobile diabetes educator (MDE) includes eight animated, interactive modules featuring a preadolescent with T1DM of uncertain ethnicity. These modules cover topics such as the etiology of diabetes, blood sugar control, and recommended diet and exercise plans. A tablet with information on diet, glucose testing, glucose responses, and insulin management was provided to parent-child pairs. Mode: Group with parents. Personnel: Children's educational media consultants. Duration: One hour. Delivery Method: Interactive electronic book (mobile)	No significant difference in hba1c ($P = 0.71$)	No notable changes were observed in diabetes knowledge, attitudes, or behavioral measures. Additionally, there were no significant changes in diabetes self-management, self-efficacy, or parental communication.
47	Whittemore *et al.* [62] 2020 USA	Randomized control trial 6 months	162 81 T: 81 C 98% F: 2% M 11-16 years	Virtually	Intervention: eHealth program. Description: Participants were randomly assigned to either the wait-list control group or the type 1 teamwork website. They received access to the eHealth program via email, along with instructions on how to navigate it. The program included information on adolescent challenges, fostering positive partnerships between parents and adolescents, encouraging positive communication, gradually increasing adolescent responsibility, understanding parental emotions, and the importance of self-care. Type 1 Teamwork consisted of six interactive sections. Mode: Group of parents of adolescents. Personnel: Pediatric diabetes endocrinologists. Duration: 6 months. Delivery Method: Web-based sessions	No significant reduction in hba1c but remained stable throughout the study ($P = 0.089$)	Parenting stress significantly decreased, with improved coping observed as parents spent more time in the program.
48	Pais *et al.* [63] 2021 Canada	Randomized, controlled, parallel-group trial 4 months	50 24 T: 26 C 54%F:46%M 12-18 years	The hospital for sick children (SickKids) and virtually	Intervention: Counting carbs to be in charge. Description: This intervention aimed to assess the effectiveness of teaching carbohydrate counting principles. It began with an evaluation of participants' knowledge, followed by either an online or in-person session conducted by a dietitian, and concluded with a post-intervention evaluation. Mode: Group. Personnel: Dietitians. Duration: Approximately 1 month. Delivery Method: Face-to-face and online	Significant reduction in hba1c after 3 months by 1% in both C & T groups ($P = 0.01$)	The frequency of carbohydrate (CHO) calculation improved, leading to increased efficiency and knowledge in both methods, although no significant difference was observed.

| 49 | Tong *et al*. [64] 2021 China | Quasi-experimental prospective study 9 months | 102 52 T: 50C 56.9%F:43.1%M <14 years | hospital of China Medical University and virtually | Intervention: Hospital discharge education plan Description: During hospitalization, a multidisciplinary team delivered diabetes education, skill development, psychological support, telephone follow-up, and WeChat-based interventions. The educational sessions for children and their families emphasized problem-solving, coping strategies, self-management techniques, and decision-making skills. Mode: Group with families Personnel: Nurse, nutritionist, endocrinologist, pharmacist, and psychologist Duration: 4 months Delivery Method: Face-to-face and phone call follow-up | Significant reduction in hba1c post-intervention (P = 0.012) | The intervention group showed higher discharge readiness and education scores compared to the control group. |

Results and Discussion

Characteristics of Studies

The 49 studies included in this review were published from 2000 to 2021, with research spanning across 18 different countries. Most of the studies (33 out of 49) were published after 2011. Among these, 12 (24%) used qualitative designs, while 37 (76%) utilized mixed-methods approaches. The quantitative studies included 6 randomized controlled trials (RCTs) and four observational studies (case-control or cohort). Furthermore, 36 (73.5%) of the studies compared outcomes between participants receiving educational interventions and those in control groups, who continued their usual care. Other studies focused on comparing different educational interventions or analyzing pre- and post-test data.

The studies varied considerably in terms of intervention types, study designs, and outcome measures. For classification purposes, the duration of the educational intervention was grouped into three categories: 24 (49%) studies had interventions lasting ≤ 3 months, 15 (30.6%) lasted between three and 6 months, and 10 (20.4%) ranged from 6 to 12 months. A significant reduction in HbA1c was observed in 28 out of 49 studies (57%). Specifically, 16 studies showed a notable decline in HbA1c between three and six months post-intervention, while three studies measured HbA1c levels ≥ 1 year after the intervention.

Population Characteristics

The scoping review included 5,874 patients across all 49 studies, with ages ranging from 10.3 to 17.3 years. Several studies [31, 32, 38, 39, 49, 53, 59, 63] also targeted young adults aged 18 to 25 years, who had been diagnosed with T1DM for at least a year. Of the 49 studies, 42 (85.7%) had an average gender distribution of 44% male and 56% female participants.

Characteristics of Interventions

The patient education interventions across the studies varied in terms of goals, target populations, delivery methods, and locations, which are detailed in the supplementary information (Table 1). These interventions were designed to enhance coping skills and knowledge for both patients (children and adolescents) and their caregivers (families) to improve T1DM management and patients' daily lives. A total of seventeen (34.7%) interventions were conducted face-to-face, 17 (34.7%) were delivered virtually (via mobile devices, video calls, or online platforms), and 15 (30.6%) combined both face-to-face and virtual methods. Additionally, 26 (53.1%) of the interventions were held in person at hospitals, clinics, or health centers, while 5 (10.2%) took place in summer camps.

Among the 46 group-based interventions, 33 (67.3%) involved family members or support persons, while 13 (26.5%) did not. Three interventions were individually delivered to patients. A significant proportion of interventions (42 or 85.7%) were led by healthcare providers, while 7 (14.3%) were facilitated by researchers and trained assistants. Additionally, 22 interventions (44.9%) were managed by multidisciplinary teams.

The interventions varied in format, with 7 (14.3%) structured as session-based educational programs, 5 (10.2%) implemented in summer camp settings, 5 (10.2%) focusing on behavioral and coping skills, and 4 (8.2%) utilizing peer education approaches involving

group discussions. Other methods included motivational interviews, game-based interventions, therapeutic play, psychological support, dietary education focusing on carbohydrate counting, and intensive diabetes education programs that incorporated regular blood glucose monitoring, self-management techniques, and hospital discharge plans. Most interventions included education on T1DM pathophysiology, carbohydrate counting, insulin adjustments, managing complications, and sick-day management.

Study Outcomes

The primary outcome of this review was the change in HbA1c levels. Nearly all interventions, or 48 out of 49 studies (98%), reported a reduction in HbA1c levels following the intervention, with 28 (58%) of these reductions being statistically significant. Additional outcomes examined included knowledge acquisition, behavioral changes, psychological outcomes, quality of life (QOL), and overall health status. Specifically, 16 studies assessed diabetes-related knowledge as a learning outcome, with 12 studies (75%) showing significant improvements. Behavioral outcomes, including dietary habits, self-care practices, blood glucose monitoring, self-management, problem-solving, and adherence to insulin therapy, were evaluated in 23 studies (46.9%), with 22 studies reporting positive changes in at least one of these areas.

In terms of psychological and socio-psychological impacts, 10 studies identified improvements in self-esteem, self-efficacy, coping abilities, discharge readiness, motivation, stress reduction, and treatment satisfaction. Additionally, 16 studies out of 49 reported improvements in QOL, with 5 of these showing statistically significant results. Health outcomes, including reductions in diabetes-related complications (such as hypo- and hyperglycemia) and fewer hospital admissions, were documented in eight studies.

Education is a critical component of diabetes management, providing tailored care that enhances treatment adherence and helps prevent complications, ultimately improving overall management [65]. According to Lorig and Holman [9], education empowers patients to better understand their condition, develop the necessary skills to handle challenges, personalize their treatment, and maintain a high QOL. This study contributes valuable insights to the ongoing scientific discussion regarding the effectiveness of various

interventions aimed at improving the well-being of children and adolescents with diabetes.

Overall, most educational interventions led to improved glycemic control, as evidenced by reductions in HbA1c levels. This suggests that educational interventions can be effective in managing T1DM in children and adolescents. However, many studies did not address critical factors such as the sustainability of glycemic control, even though prolonged glycemic control is a key factor in preventing both acute and chronic complications in young patients with type 1 diabetes [66].

Educational interventions must be tailored to the individual patient, considering their age, cultural background, stage of diabetes, lifestyle, and maturity [67]. For example, data from over 15,000 participants in the T1DM Exchange registry in the United States highlighted a concerning increase in HbA1c levels between the ages of 13 and 25 years, with the highest average of 9.2% among 19-year-olds, showing the need for targeted efforts to optimize glycemic control in this age group [68].

When examining the best models for educational interventions, a positive trend was observed in 13 out of 22 (59.1%) studies involving multidisciplinary teams composed of doctors, nurses, dietitians, and psychologists. These collaborative interventions proved to be effective in managing T1DM in children and adolescents, leading to significant improvements in glycemic control. Wigert et al. [69] identified three critical outcomes associated with effective multidisciplinary teams in diabetes care: 1) fostering long-term relationships, 2) integrating diverse knowledge through teamwork, and 3) ensuring proper documentation.

The ability of healthcare providers to communicate effectively with each other and with patients is essential for building trust and shared responsibilities, and ensuring the success of the intervention. Additionally, proper documentation is key to patient follow-up and maintaining the effectiveness of the team [69]. Likitmaskul et al. [20] emphasized that a multidisciplinary approach is crucial for supporting diabetic children and their families in managing blood sugar levels, addressing emerging issues, and ensuring long-term self-care.

Most studies reporting significant improvements in glycemic control measured HbA1c levels between three and six months post-intervention, while few studies tracked HbA1c levels for more than a year. This suggests

that many effective interventions cannot sustain long-term glycemic control. However, studies that included regular follow-up consultations over a year or more demonstrated long-term improvements in HbA1c and a reduction in severe hypoglycemia episodes [70]. Feedback from participants indicated that the interventions were beneficial, resulting in improved health outcomes, such as fewer diabetes-related complications and reduced hospital admissions and lengths of stay [38, 54, 55, 58, 61, 62]. Evaluating patient feedback is essential to refine intervention content, design, and delivery, and ensure targeted patient care [71].

QOL is a multidimensional measure that reflects a patient's overall well-being, including physical, psychological, and social functioning [72]. Sixteen education interventions measured QOL, with five reporting statistically significant improvements. Peer-based interventions, in particular, showed that sharing experiences and management strategies for T1DM not only helped patients learn from one another but also raised awareness about their condition [73].

Conclusion

The findings of this study highlight that the effectiveness of educational interventions is influenced by the duration of the intervention. This underscores the importance of embedding continuous educational programs within all diabetes management frameworks, rather than restricting them to a specific timeframe or initiating them only at the onset of a patient's follow-up care. Furthermore, it is advised that an organized, multidisciplinary approach to education be implemented in two stages: 1) an introductory phase providing a broad understanding of T1DM management for both patients (children and adolescents) and their families, and 2) a personalized, patient-specific phase where the unique needs and characteristics of each individual are considered, and the educational materials are customized accordingly. This dual-phase approach is expected to foster more effective, long-lasting, and possibly cost-efficient improvements in managing glycemic control.

References

1. Patterson CC, Karuranga S, Salpea P, Saeedi P, Dahlquist G, Soltesz G, et al. Worldwide estimates of incidence, prevalence and mortality of type 1 diabetes in children and adolescents: results from the International Diabetes Federation Diabetes Atlas, 9th edition. Diabetes Res Clin Pract. 2019;157:107842.

2. Lin CH, Chang CH, Chuang LM. Commentary on risk factors for first and subsequent cardiovascular disease events in type 1 diabetes: The diabetes control and complications trial/epidemiology of diabetes interventions and complications study. J Diabetes Investig. 2021;12(3):313-6.

3. Hood KK, Peterson CM, Rohan JM, Drotar D. Association between adherence and glycemic control in pediatric type 1 diabetes: A meta-analysis. Pediatrics. 2009;124(6):e1171-9.

4. Kyokunzire C, Matovu N. Factors associated with adherence to diabetes care recommendations among children and adolescents with type 1 diabetes: A facility-based study in two urban diabetes clinics in Uganda. Diabetes Metab Syndr Obes. 2018;11:93-104.

5. Silverstein J, Klingensmith G, Copeland K, Plotnick L, Kaufman F, Laffel L, et al. Care of children and adolescents with type 1 diabetes: A statement of the American Diabetes Association. Diabetes Care. 2005;28(1):186-212.

6. Liu B, Huang F, Wu X, Xie Y, Xu R, Huang J, et al. Poor guideline adherence in type 1 diabetes education in real-world clinical practice: Evidence from a multicentre, national survey. Patient Educ Couns. 2021;104(11):2740-7.

7. Patient Engagement: Technical Series on Safer Primary Care. World Health Organization; 2016.

8. Graffigna G, Barello S. Spotlight on the patient health engagement model (PHE model): A psychosocial theory to understand people's meaningful engagement in their own health care. Patient Prefer Adherence. 2018;12:1261-71.

9. Lorig KR, Holman HR. Self-management education: History, definition, outcomes, and mechanisms. Ann Behav Med. 2003;26(1):1-7.

10. Campbell F, Biggs K, Aldiss SK, O'Neill PM, Clowes M, McDonagh J, et al. Transition of care for

adolescents from paediatric services to adult health services. Cochrane Database Syst Rev. 2016;4:CD009794.

11. Steinsbekk A, Rygg LO, Lisulo M, Rise MB, Fretheim A. Group based diabetes self-management education compared to routine treatment for people with type 2 diabetes mellitus. A systematic review with meta-analysis. BMC Health Serv Res. 2012;12:213.

12. Stenberg U, Haaland-Overby M, Fredriksen K, Westermann KF, Kvisvik T. A scoping review of the literature on benefits and challenges of participating in patient education programs aimed at promoting self-management for people living with chronic illness. Patient Educ Couns. 2016;99(11):1759-71.

13. Kristiansen TM, Antoft R. Patient education as a status passage in life – An ethnographic study exploring participation in a Danish group-based patient education programme. Soc Sci Med. 2016;158:34-42.

14. Arksey H, O'Malley L. Scoping studies: Towards a methodological framework. Int J Soc Res Methodol. 2005;8(1):19-32.

15. Mays N, Pope C, Popay J. Systematically reviewing qualitative and quantitative evidence to inform management and policy-making in the health field. J Health Serv Res Policy. 2005;10(Suppl 1):6-20.

16. Afshar M, Memarian R, Mohammadi E. The effect of group discussion on the quality of life and HbA1c levels of adolescents with diabetes. Iran Red Crescent Med J. 2014;16(8):e21110. doi:10.5812/ircmj.21110

17. Altundag S, Bayat M. Peer interaction and group education for adaptation to disease in adolescents with Type 1 diabetes mellitus. Pak J Med Sci. 2016;32(4):1010-4. doi:10.12669/pjms.324.9809

18. Edraki M, Zarei A, Soltanian M, Moravej H. The effect of peer education on self-care behaviors and the mean of glycosylated hemoglobin in adolescents with Type 1 diabetes: A randomized controlled clinical trial. Int J Community Based Nurs Midwifery. 2020;8(3):209-19. doi:10.30476/ijcbnm.2020.82296.1051

19. Walker AF, Haller MJ, Gurka MJ, Morris HL, Bruggeman B, Miller K, et al. Addressing health disparities in type 1 diabetes through peer mentorship. Pediatr Diabetes. 2020;21(1):120-7. doi:10.1111/pedi.12935

20. Likitmaskul S, Wekawanich J, Wongarn R, Chaichanwatanakul K, Kiattisakthavee P, Nimkarn S, et al. Intensive diabetes education program and multidisciplinary team approach in management of newly diagnosed type 1 diabetes mellitus: a greater patient benefit, experience at Siriraj Hospital. J Med Assoc Thail. 2002;85(Suppl 2):S488-95.

21. Wang YC, Stewart SM, Mackenzie M, Nakonezny PA, Edwards D, White PC. A randomized controlled trial comparing motivational interviewing in education to structured diabetes education in teens with type 1 diabetes. Diabetes Care. 2010;33(8):1741-3. doi:10.2337/dc10-0019

22. Abolfotouh MA, Kamal MM, El-Bourgy MD, Mohamed SG. Quality of life and glycemic control in adolescents with type 1 diabetes and the impact of an education intervention. Int J Gen Med. 2011;4:141-52. doi:10.2147/IJGM.S16951

23. Coates V, Chaney D, Bunting B, Shorter GW, Shevlin M, McDougall A, et al. Evaluation of the effectiveness of a structured diabetes education programme (CHOICE) on clinical outcomes for adolescents with type 1 diabetes: A Randomised controlled trial. J Diabetes Metab. 2013;4(6):1000280. doi:10.4172/2155-6156.1000280

24. Christie D, Thompson R, Sawtell M, Allen E, Cairns J, Smith F, et al. Structured, intensive education maximising engagement, motivation and long-term change for children and young people with diabetes: A cluster randomised controlled trial with integral process and economic evaluation - the CASCADE study. Health Technol Assess. 2014;18(20):1-202. doi:10.3310/hta18200

25. Hawkes CP, Willi SM, Murphy KM. A structured 1-year education program for children with newly diagnosed type 1 diabetes improves early glycemic control. Pediatr Diabetes. 2019;20(4):460-7. doi:10.1111/pedi.12849

26. Ramírez-Mendoza F, González JE, Gasca E, Camacho M, Cruz MV, Caraveo D, et al. Time in range and HbA1C after 6 months with a multidisciplinary program for children and adolescents with diabetes mellitus, real world data from Mexico City. Pediatr Diabetes. 2020;21(1):61-8. doi:10.1111/pedi.12921

27. D'Souza RS, Ryan M, Hawkes E, Baker C, Davies Y, Judith R, et al. Questionnaire-based service evaluation of the efficacy and usefulness of SEREN:

A structured education programme for children and young people diagnosed with type 1 diabetes mellitus. BMJ Open Qual. 2021;10(3):e001337. doi:10.1136/bmjoq-2021-001337

28. Karagüzel G, Bircan I, Erişir S, Bundak R. Metabolic control and educational status in children with type 1 diabetes: effects of a summer camp and intensive insulin treatment. Acta Diabetol. 2005;42(4):156-61. doi:10.1007/s00592-005-0196-9

29. Santiprabhob J, Likitmaskul S, Sriwijitkamol A, Peerapatdit T, Sawathiparnich P, Nitiyanant W, et al. Improved glycemic control among Thai children and young adults with type 1 diabetes participating in the diabetes camp. J Med Assoc Thai. 2005;88(Suppl 8):S38-S43.

30. Santiprabhob J, Likitmaskul S, Kiattisakthavee P, Weerakulwattana P, Chaichanwattanakul K, Nakavachara P, et al. Glycemic control and the psychosocial benefits gained by patients with type 1 diabetes mellitus attending the diabetes camp. Patient Educ Couns. 2008;73(1):60-6. doi:10.1016/j.pec.2008.05.023

31. Wang YC, Stewart S, Tuli E, White P. Improved glycemic control in adolescents with type 1 diabetes mellitus who attend diabetes camp. Pediatr Diabetes. 2008;9(1):29-34. doi:10.1111/j.1399-5448.2007.00285.x

32. Troncone A, Chianese A, Cascella C, Zanfardino A, Iafusco D. Psychological outcomes in children and early adolescents with type 1 diabetes following pediatric diabetes summer camp: A 3-month follow-up study. Front Pediatr. 2021;9:650201. doi:10.3389/fped.2021.650201

33. Cook S, Herold K, Edidin DV, Briars R. Increasing problem solving in adolescents with type 1 diabetes: The choices diabetes program. Diabetes Educ. 2002;28(1):115-24. doi:10.1177/014572170202800113

34. Lehmkuhl HD, Storch EA, Cammarata C, Meyer K, Rahman O, Silverstein J, et al. Telehealth behavior therapy for the management of type 1 diabetes in adolescents. J Diabetes Sci Technol. 2010;4(1):199-208. doi:10.1177/193229681000400125

35. Whittemore R, Grey M, Lindemann E, Ambrosino J, Jaser S. Development of an Internet coping skills training program for teenagers with type 1 diabetes. Comput Inform Nurs. 2010;28(2):103-11. doi:10.1097/NCN.0b013e3181cd8199

36. Mulvaney SA, Anders S, Smith AK, Pittel EJ, Johnson KB. A pilot test of a tailored mobile and web-based diabetes messaging system for adolescents. J Telemed Telecare. 2012;18(2):115-8.

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

38. Grey M, Whittemore R, Jeon S, Murphy K, Faulkner MS, Delamater A, et al. Internet psycho-education programs improve outcomes in youth with type 1 diabetes. Diabetes Care. 2013;36(9):2475-82. doi:10.2337/dc12-2199

39. Husted GR, Thorsteinsson B, Esbensen BA, Gluud C, Winkel P, Hommel E, et al. Effect of guided self-determination youth intervention integrated into outpatient visits versus treatment as usual on glycemic control and life skills: A randomized clinical trial in adolescents with type 1 diabetes. Trials. 2014;15(1):321. doi:10.1186/1745-6215-15-321

40. Harris MA, Freeman KA, Duke DC. Seeing is believing: Using Skype to improve diabetes outcomes in youth. Diabetes Care. 2015;38(8):1427-34.

41. Fiallo-Scharer R, Palta M, Chewning BA, Rajamanickam V, Wysocki T, Wetterneck TB, et al. Impact of family-centered tailoring of pediatric diabetes self-management resources. Pediatr Diabetes. 2019;20(7):1016-24. doi:10.1111/pedi.12899

42. Cristello Sarteau A, Crandell J, Seid M, Kichler JC, Maahs DM, Wang J, et al. Characterization of youth goal setting in the self-management of type 1 diabetes and associations with HbA1c: The flexible lifestyle empowering change trial. Pediatr Diabetes. 2020;21(7):1343-52. doi:10.1111/pedi.13099

43. Bakır E, Çavuşoğlu H, Mengen E. Effects of the information-motivation-behavioral skills model on metabolic control of adolescents with type 1 diabetes in Turkey: Randomized controlled study. J Pediatr Nurs. 2021;58:e19-e27. doi:10.1016/j.pedn.2020.11.019

44. Lawson ML, Frank MR, Fry MK, Perlman K, Sochett EB, Daneman D. Intensive diabetes management in adolescents with type 1 diabetes: The importance of intensive follow-up. J Pediatr

Endocrinol Metab. 2000;13(1):79-84. doi:10.1515/jpem.2000.13.1.79

45. Kumar VS, Wentzell KJ, Mikkelsen T, Pentland A, Laffel LM. The DAILY (Daily Automated Intensive Log for Youth) trial: A wireless, portable system to improve adherence and glycemic control in youth with diabetes. Diabetes Technol Ther. 2004;6(4):445-53.

46. von Sengbusch S, Müller-Godeffroy E, Häger S, Reintjes R, Hiort O, Wagner V. Mobile diabetes education and care: intervention for children and young people with Type 1 diabetes in rural areas of northern Germany. Diabet Med. 2006;23(2):122-7. doi:10.1111/j.1464-5491.2005. 01754.x

47. Channon SJ, Huws-Thomas MV, Rollnick S, Hood K, Cannings-John RL, Rogers C, et al. A multicenter randomized controlled trial of motivational interviewing in teenagers with diabetes. Diabetes Care. 2007;30(6):1390-5. doi:10.2337/dc06-2260

48. Iafusco D, Galderisi A, Nocerino I, Cocca A, Zuccotti G, Prisco F, et al. Chat line for adolescents with type 1 diabetes: a useful tool to improve coping with diabetes: A 2-year follow-up study. Diabetes Technol Ther. 2011;13(5):551-5. doi:10.1089/dia.2010.0188

49. Pinsker JE, Nguyen C, Young S, Fredericks GJ, Chan D. A pilot project for improving paediatric diabetes outcomes using a website: The Pediatric Diabetes Education Portal. J Telemed Telecare. 2011;17(5):226-30.

50. Frøisland DH, Arsand E, Skårderud F. Improving diabetes care for young people with type 1 diabetes through visual learning on mobile phones: mixed-methods study. J Med Internet Res. 2012;14(4):e111.

51. Peña NV, Torres M, Cardona JA, Iniesta R. Impact of telemedicine assessment on glycemic variability in children with type 1 diabetes mellitus. Diabetes Technol Ther. 2013;15(2):136-42. doi:10.1089/dia.2012.0243

52. Bin-Abbas B, Jabbari M, Al-Fares A, El-Dali A, Al-Orifi F. Effect of mobile phone short text messages on glycaemic control in children with type 1 diabetes. J Telemed Telecare. 2014;20(3):153-6. doi:10.1177/1357633X14529244

53. Kassai B, Rabilloud M, Bernoux D, Michal C, Riche B, Ginhoux T, et al. Management of adolescents with very poorly controlled type 1 diabetes by nurses: a parallel group randomized controlled trial.

Trials. 2015;16:399. doi:10.1186/s13063-015-0923-7

54. Ng SM. Improving patient outcomes with technology and social media in paediatric diabetes. BMJ Qual Improv Rep. 2015;4(1):u209396.w3846. doi:10.1136/bmjquality. u209396.w3846

55. Joubert M, Armand C, Morera J, Tokayeva L, Guillaume A, Reznik Y. Impact of a serious videogame designed for flexible insulin therapy on the knowledge and behaviors of children with type 1 diabetes: The LUDIDIAB pilot study. Diabetes Technol Ther. 2016;18(2):52-8.

56. La Banca RO, Laffel LMB, Volkening LK, Sparapani VC, de Carvalho EC, Nascimento LC. Therapeutic play to teach children with type 1 diabetes insulin self-injection: A pilot trial in a developing country. J Spec Pediatr Nurs. 2021;26(1):e12309. doi:10.1111/jspn.12309

57. Dłużniak-Gołaska K, Panczyk M, Szypowska A, Sińska B, Szostak-Węgierek D. Interactive nutrition education is more effective in terms of improved levels of glycated hemoglobin in adolescent patients with poorly controlled type 1 diabetes - A randomized study. Diabetes Metab Syndr Obes. 2019;12:2619-31. doi:10.2147/DMSO.S229246

58. Döğer E, Bozbulut R, Acar AŞ, Ercan Ş, Uğurlu AK, Akbaş ED, et al. Effect of telehealth system on glycemic control in children and adolescents with type 1 diabetes. J Clin Res Pediatr Endocrinol. 2019;11(1):70-5. doi:10.4274/jcrpe.galenos.2018.2018.0017

59. Jaser SS, Datye K, Morrow T, Sinisterra M, LeStourgeon L, Abadula F, et al. THR1VE! Positive psychology intervention to treat diabetes distress in teens with type 1 diabetes: Rationale and trial design. Contemp Clin Trials. 2020;96:106086. doi:10.1016/j.cct.2020.106086

60. Alfonsi JE, Choi EE, Arshad T, Sammott SA, Pais V, Nguyen C, et al. Carbohydrate Counting app using image recognition for youth with type 1 diabetes: Pilot randomized control trial. JMIR Mhealth Uhealth. 2020;8(10):e22074.

61. Otis M, Zhu J, Mustafa-Kutana SN, Bernier AV, Shum JM, Dupre AA, et al. Testing usability and feasibility of a mobile educator tool for pediatric diabetes self-management: Mixed methods pilot study. JMIR Form Res. 2020;4(5):e16262.

62. Whittemore R, Coleman J, Delvy R, Zincavage R, Ambrosoli JA, Shi L, et al. An eHealth program for

parents of adolescents with T1DM improves parenting stress: A randomized control trial. Diabetes Educ. 2020;46(1):62-72.

63. Pais V, Patel BP, Ghayoori S, Hamilton JK. "Counting carbs to be in charge": A comparison of an internet-based education module with in-class education in adolescents with type 1 diabetes. Clin Diabetes. 2021;39(1):80-7. doi:10.2337/cd20-0060

64. Tong HJ, Qiu F, Fan L. Effect of hospital discharge plan for children with type 1 diabetes on discharge readiness, discharge education quality, and blood glucose control. World J Clin Cases. 2021;9(4):774-83. doi:10.12998/wjcc. v9.i4.774

65. Swiatoniowska N, Sarzynska K, Szymanska-Chabowska A, Jankowska-Polanska B. The role of education in type 2 diabetes treatment. Diabetes Res Clin Pract. 2019;151:237-46. doi:10.1016/j.diabres.2019.04.004

66. Nordwall M, Arnqvist HJ, Bojestig M, Ludvigsson J. Good glycemic control remains crucial in prevention of late diabetic complications–the Linköping Diabetes Complications Study. Pediatr Diabetes. 2009;10(3):168-76.

67. Marshall SL, Edidin DV, Arena VC, Becker DJ, Bunker CH, Gishoma C, et al. Glucose control in Rwandan youth with type 1 diabetes following establishment of systematic, HbA1c based, care and education. Diabetes Res Clin Pract. 2015;107(1):113-22.

68. Miller KM, Foster NC, Beck RW, Bergenstal RM, DuBose SN, DiMeglio LA, et al. Current state of type 1 diabetes treatment in the U.S.: Updated data from the T1D Exchange clinic registry. Diabetes Care. 2015;38(6):971e8.

69. Wigert H, Wikström E. Organizing person-centred care in paediatric diabetes: Multidisciplinary teams, long-term relationships and adequate documentation. BMC Res Notes. 2014;7(1):1-8. doi:10.1186/1756-0500-7-72

70. Plank J, Köhler G, Rakovac I, Semlitsch BM, Horvath K, Bock G, et al. Long-term evaluation of a structured outpatient education programme for intensified insulin therapy in patients with type 1 diabetes: A 12-year follow-up. Diabetologia. 2004;47(8):1370-5.

71. Monaghan M, Sanders RE, Kelly KP, Cogen FR, Streisand R. Using qualitative methods to guide clinical trial design: Parent recommendations for intervention modification in Type 1 diabetes. J Fam Psychol. 2011;25(6):868-72.

72. Hilliard ME, Minard CG, Marrero DG, de Wit M, Thompson D, DuBose SN, et al. Assessing health-related quality of life in children and adolescents with diabetes: Development and psychometrics of the type 1 diabetes and life (T1DAL) measures. J Pediatr Psychol. 2020;45(3):328-39.

73. Kazemi S, Parvizy S, Atlasi R, Baradaran HR. Evaluating the effectiveness of peer-based intervention in managing type I diabetes mellitus among children and adolescents: A systematic review. Med J Islam Repub Iran. 2016;30:442.