Impacts of Educational Interventions on Glycemic Control in Children and Adolescents with Type 1 Diabetes Mellitus

Sasha Muhammed Elamin¹, Adyani Md Redzuan¹, Siti Azdiah Abdul Aziz², Syazwani Hamdan¹, Masyarah Zulhaida Masmuzidin², Noraida Mohamed Shah¹*¹

¹Centre for Quality Management of Medicines, Faculty of Pharmacy, Universiti Kebangsaan Malaysia, Malaysia. ²Edutainment Industrial Revolution 4.0 (EIR 4.0), Creative Multimedia and Animation Section, Malaysian Institute of Information Technology, Universiti Kuala Lumpur, Malaysia.

Abstract

Although insulin treatment has been proven effective in controlling blood glucose among type 1 diabetes mellitus (T1DM) children and adolescents, treatment adherence remains suboptimal throughout the years. Therefore, education intervention is a promising approach to improve insulin therapy adherence, thus improving glycemia control in children with T1DM. This review summarized the findings of available interventions and potential outcomes of education interventions among children and adolescents living with T1DM. The scoping study framework developed by Arksey and O'Malley was used in retrieving and reviewing relevant publications (2000 – 2021), thus, emphasizing the variations in studies, interventions, and patient characteristics. This scoping review comprised 49 papers after the screening of 5015 articles. Most of the education interventions were multidisciplinary and reported improvements in patients’ glycated hemoglobin (HbA1c), with or without enhancements in other areas. In conclusion, various patient education interventions positively impact children and adolescents living with T1DM. The findings highlighted the efficacy of patient education interventions in ameliorating glycemic control, by reducing HbA1c, enhancing behavioral outcomes, improving psychological outcomes, patients’ health state and quality of life (QOL).

Keywords: Children, Adolescents, Type 1 diabetes, Education

INTRODUCTION

In 2019, approximately 600,900 children below the age of 15 were diagnosed with type 1 diabetes (T1DM) worldwide. Furthermore, T1DM among these particular populations could increase globally to 98,200 cases annually [1]. T1DM therapy aims to prevent cardiovascular morbidity and mortality through intensive glycemic control [2]. Moreover, adherence to diabetes management improves glycemic control independent of age, sociodemographic, or disease characteristics [3]. Nevertheless, adherence to treatment among T1DM children and adolescents is only 30% to 70% [4].

Previous T1DM studies among children have revealed that educating the patient and family, apart from being more cost effective for the patient's caregivers, intensive diabetes care management and close communication with health care professionals were associated with a decrease in hospitalisations and emergency department visits [5]. Notably, the information provided and delivery style should be pediatric-friendly, where the content ranges from basic diabetes management skills that address the family dynamics and concerns involving the whole family [5]. Several contributing factors concerning gaps between guidelines and clinical practice have been identified, including the lack of medical training, educational tools familiarity with guidelines, and time constraints [6].

Patient engagement describes the process where patients are actively involved in deciding their course of treatment, identifying factors influencing their lives, and taking action towards positive changes [7]. This concept is primary in patients’ self-management and realizing medical communication and relationship goals [8]. Therefore, patient education is crucial in the patient engagement intervention to support children and adolescents living with diseases [9]. In addition, various studies have reported a high interest in obtaining knowledge about diseases and their impacts on daily life among Children and adolescents with chronic medical conditions such as T1DM [10].

Address for correspondence: Noraida Mohamed Shah, Centre for Quality Management of Medicines, Faculty of Pharmacy, Universiti Kebangsaan Malaysia, Malaysia. noraida_mshah@ukm.edu.my

This is an open-access article distributed under the terms of the Creative Commons Attribution-Non Commercial-Share Alike 4.0 Licensor, which allows others to remix, tweak, and build upon the work non commercially, as long as the author is credited and the new creations are licensed under the identical terms.

How to cite this article: Elamin SM, Redzuan AM, Abdul Aziz SA, Hamdan S, Masmuzidin MZ, Mohamed Shah N. Impacts of Educational Interventions on Glycemic Control in Children and Adolescents with Type 1 Diabetes Mellitus. Arch Pharm Pract. 2023;14(4):13-31. https://doi.org/10.51847/4PWgp3vYN3
There are multiple forms of education interventions intended for children and adolescents, often recognized as complex interventions [11], led by healthcare providers or peers for groups or individuals [12]. Group sessions are effective in promoting health policies in many Western countries and essential in improving patients’ self-management of chronic disease [13].

It is deemed urgent to clarify and assess the key components and impacts of patient education interventions to establish a successful program. Several publications have highlighted the evidence concerning the potential benefits of this intervention for children and adolescents with diabetes [9], but none of these studies specifically reported how the program affects young individuals with T1DM. Therefore, this review provides a comprehensive summary of published assessments and potential outcomes of patient education interventions among children and adolescents with T1DM.

This review assessed the literature in order to address the following questions:

1. What study design, type of participants, and interventions are suitable for patient education programs involving T1DM children and adolescents?
2. What are the possible outcomes of patient education interventions for children and adolescents living with T1DM?

**MATERIALS AND METHODS**

**Search Strategy**

Intervention studies from 2000 to 2021 that assessed glycemic control as glycated hemoglobin (hba1c) and/or other diabetes-related outcomes among children or adolescents with T1DM were identified from six databases: pubmed, Scopus, Scholar, Science Direct, Cochrane, and CINAL. The Arksey and O’Malley approach was used as a systematic method to identify the effects of patient education interventions on glycemic control in children and adolescents with T1DM [14]. This paper selected the scoping review approach, where various study designs were considered to answer the research questions and ultimately achieve a thorough review of the available literature [15].

First, 5015 articles were identified, and 4900 studies that did not fulfill the requirements for inclusion were omitted (Figure 1). A total of 66 articles were later excluded. In addition, assessments of previous systematic reviews on similar topics led to the inclusion of six more studies in the current review. The disagreements about article inclusion were resolved via group discussion to reach a consensus. For example, five studies that included patients above 18 years old were considered in this review since the overall sample population consisted of children, adolescents, and young adults up to the age of 25. A total of 49 articles were included in this review.

![Figure 1. Flow diagram of identified, screened, and extracted studies](image-url)
The literature search was performed based on the patient, intervention, comparison, and outcomes (PICO) principles. The following keywords were selected for the literature search: “children”, “intervention”, “education”, “type 1 diabetes mellitus”, “glycemic control”, and “insulin”.

This scoping review was conducted according to the following specifications:

- **Population**: Children and adolescents
- **Intervention**: Physical or virtual patient education intervention led by healthcare professionals and/or trained participants focusing on enhancements of patients’ self-management, glycemic control, and general welfare.
- **Comparisons**: Routine treatment, different interventions, or pre/post-intervention effects.
- **Outcomes**: Glycemic control reflected by HbA1c and other impacts on patients’ learning, behavioral, psychological, health status, and QOL.

The inclusion criteria for this review are presented as follows: 1) qualitative and quantitative studies, 2) published in English, and 3) focused on interventions to improve HbA1c in children and/or adolescents with T1DM (at least one year before intervention). Meanwhile, the exclusion criteria were studies that did not include children or adolescents, included children in critical care or comorbidities, and did not consider HbA1c as an outcome.

### Data Extraction

This review highlighted how patient education interventions influence patients’ HbA1c levels. The studies included in this review conducted education interventions to improve diabetes outcomes in children and adolescents with type 1 diabetes, including their clinical, behavioral, psychological, health status, and QOL.

First, a data extraction sheet was prepared after deliberation among the authors. Two authors were then assigned to extract the relevant information according to the datasheet: general details [author(s), publication year, and country]; study population (age, gender); type of study (study design, duration); intervention program (type and description of intervention) and study findings (HbA1c, learning, behavioral, psychological, patients’ QOL, and health status). Finally, the findings were validated by another co-author and organised in accordance with the review’s main questions (Table 1).

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

<table>
<thead>
<tr>
<th>Study No.</th>
<th>Author Year</th>
<th>Country</th>
<th>Study design</th>
<th>Study duration</th>
<th>Sample description (ND: No data)</th>
<th>Setting</th>
<th>Intervention Description</th>
<th>Clinical outcome Glycated hemoglobin (HbA1c) (p-value)</th>
<th>Other outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>M. Afshar et al. [16] 2014 Iran</td>
<td>Pre- and post-test control groups 6 months</td>
<td>Diabetes Center/Out-patient clinic</td>
<td>56 75%F:25%M</td>
<td>12 - 18 Years</td>
<td>Intervention: Peer-education education-based intervention Description: Group discussion sessions on QOL with DM, the group’s members shared their problems and experiences with each other and followed the discussed instructions by diabetic specialists. Mode: group with parents Personnel: specific technician, DM specialist Duration: 6 months Delivery method: face-to-face and phone calls</td>
<td>Significant reduction by 1% Mean of 8% to 7% (p=0.001)</td>
<td>Improved quality of life (QOL) and fasting blood glucose (FBG)</td>
<td></td>
</tr>
<tr>
<td>Study</td>
<td>Design</td>
<td>Intervention</td>
<td>Description</td>
<td>Mode</td>
<td>Personnel</td>
<td>Duration</td>
<td>Delivery Method</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------</td>
<td>--------</td>
<td>--------------</td>
<td>-------------</td>
<td>------</td>
<td>-----------</td>
<td>----------</td>
<td>----------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>RCT</td>
<td>Peer education-based intervention</td>
<td>Introductory information about T1DM in adolescents with diabetes training sessions (warm-up games, narrating, question-answer demonstration, discussion, and role-play) followed by providing a training guide.</td>
<td>group</td>
<td>dieticians, nurses, and child psychiatrist</td>
<td>9 months</td>
<td>face-to-face</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>RCT</td>
<td>Peer education-based intervention</td>
<td>4 peer-led workshops on diabetic self-care behaviours.</td>
<td>group</td>
<td>peer educators (Supervised by DM-specialists)</td>
<td>1 month</td>
<td>face-to-face</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>RCT</td>
<td>Peer mentorship program</td>
<td>Several key exposures were included in the All for ONE-Outreach, Network, and Education mentoring programme, including social events infused with diabetes education, daily SMS text reminders for mentors and mentees for blood glucose monitoring, weekly text exchanges between mentors and mentees, and clinic visits.</td>
<td>group</td>
<td>college student mentors</td>
<td>9 months</td>
<td>face-to-face and text-messages</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>RCT</td>
<td>Intensive diabetes education program</td>
<td>Multidisciplinary The multidisciplinary management team provides self-management training including information about T1DM, insulin therapy, diet and exercise, monitoring, interpretation, and self-management of hypoglycemia.</td>
<td>group</td>
<td>pediatric endocrinologists, dieticians, psychologists, and nurses</td>
<td>10-12 days</td>
<td>face-to-face and phone call</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>RCT</td>
<td>Motivational interviewing (MI)-based diabetes education versus structured diabetes education education (SDE) group educational-based program</td>
<td>2-day workshop with either SDE or MI recommended by the American Diabetes Association’s (ADA) core content on medication, monitoring, and acute complications use core content recommended by the American Diabetes Association (ADA) on medication, monitoring, acute complications, plus two intervention sessions on lifestylelifestyle two intervention sessions. And two phone follow-ups</td>
<td>group</td>
<td>diabetes educators/physicians</td>
<td>6 months</td>
<td>face-to-face and phone calls</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Study</th>
<th>Design</th>
<th>Intervention</th>
<th>Description</th>
<th>Mode</th>
<th>Personnel</th>
<th>Duration</th>
<th>Delivery Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>RCT</td>
<td>Peer education-based intervention</td>
<td>Improved psychosocial outcome, QOL (Satisfaction)</td>
<td>group</td>
<td></td>
<td></td>
<td>Early intervention social support</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Significant reduction from</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>8.02 ± 1.06</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(p&lt;0.001)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Improved Self-care</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Study</th>
<th>Design</th>
<th>Intervention</th>
<th>Description</th>
<th>Mode</th>
<th>Personnel</th>
<th>Duration</th>
<th>Delivery Method</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Peer education-based intervention</td>
<td>Significant reduction from</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Improved diabetes knowledge, self-esteem, &amp;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>social support</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Improved QOL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Study</td>
<td>Country</td>
<td>Type</td>
<td>Duration</td>
<td>Setting</td>
<td>Intervention</td>
<td>Description</td>
<td>Delivered by</td>
</tr>
<tr>
<td>-------</td>
<td>---------</td>
<td>------</td>
<td>----------</td>
<td>---------</td>
<td>--------------</td>
<td>-------------</td>
<td>-------------</td>
</tr>
<tr>
<td>D. Christie et al. [24]</td>
<td>UK</td>
<td>Pragmatic, clustered Randomized trial</td>
<td>12 - 24 Months</td>
<td>General hospital clinic or teaching hospital / tertiary clinic</td>
<td>Structured educational group program</td>
<td>Two one-day workshops were held to teach intervention delivery, adapted from the CASCADE intervention (Child and Adolescent Structured Competencies Approach to Diabetes Education). It included 4 modules: Module 1: The relationship between diet, insulin, and blood glucose, Module 2: Blood glucose testing, Module 3: Insulin adjusting—pros and cons, and Module 4: Living with diabetes.</td>
<td>Pediatricians and nurses</td>
</tr>
<tr>
<td>V. Coates et al. [23]</td>
<td>Ireland</td>
<td>Multi-centered pragmatic randomized controlled trial</td>
<td>5 months</td>
<td>Seven hospital sites</td>
<td>Structured diabetes educational program</td>
<td>Designed to allow adolescents to adjust their diets and insulin regimes, allowing them to live a more normal lifestyle close to their peers without diabetes. It consisted of 12 hours of interactive, group-based sessions.</td>
<td>Research secretary and assistants</td>
</tr>
<tr>
<td>M. A. Abolfotouh et al. [22]</td>
<td>Egypt</td>
<td>Cross-sectional / quasi-experimental study</td>
<td>10 months</td>
<td>Diabetes outpatient clinics</td>
<td>Education intervention program</td>
<td>Four 120-minute sessions with one session every month. The program covered: (i) short and long-term complications of diabetes, (ii) medication and glucose monitoring, (iii) dietary and exercise recommendations, and (iv) psychological and social aspects.</td>
<td>Pediatricians</td>
</tr>
<tr>
<td>Study</td>
<td>Authors</td>
<td>Country</td>
<td>Sample Size</td>
<td>Duration</td>
<td>Setting</td>
<td>Intervention</td>
<td>Description</td>
</tr>
<tr>
<td>-------</td>
<td>---------</td>
<td>---------</td>
<td>-------------</td>
<td>----------</td>
<td>---------</td>
<td>-------------</td>
<td>-------------</td>
</tr>
<tr>
<td>10</td>
<td>C.P. Hawkes et al. [21]</td>
<td>USA</td>
<td>Retrospective cohort, 2 years</td>
<td>2019</td>
<td>USA</td>
<td>Pediatric hospital</td>
<td>A 10-hour education curriculum was used to provide participants with intensive coaching targeted to their family lifestyle and readiness to take independence, discussed nutrition-related challenges, reinforced carbohydrate counting and dietary management.</td>
</tr>
<tr>
<td>11</td>
<td>F. Ramírez-Mendoza et al. [22]</td>
<td>Mexico</td>
<td>Pre-and-post (no control)</td>
<td>2020</td>
<td>Mexico</td>
<td>Local health centers, general hospitals, pediatric hospitals, children obesity clinics, and private hospitals referred patients.</td>
<td>Interventions: multidisciplinary educational program. Description: The PAANDA program (a program of care for adolescents and children with diabetes mellitus) educates the patient how to correct blood glucose levels and urges them to regularly test glucose levels. Mode: group with caregiver. Personnel: social workers, pediatric nurses, and endocrinologists.</td>
</tr>
<tr>
<td>13</td>
<td>G. Karagüzel et al. [24]</td>
<td>Turkey</td>
<td>Pre-and-post control groups</td>
<td>2005</td>
<td>Turkey</td>
<td>Camp</td>
<td>Interventions: Summer camp and intensive insulin treatment. Description: Techniques for injecting insulin, blood glucose monitoring, and recognition and management of hypoglycemia, hyperglycemia, and ketosis, insulin dose modification depending on food and exercise plans, diabetic nutrition, carb counting, complications of diabetes, the importance of controlling diabetes, and novel therapies to test glycoemic control. Mode: group. Personnel: pediatric endocrinologists, nurses, dieticians, interns, and psychologists.</td>
</tr>
</tbody>
</table>

**Intervention: Summer camp and intensive insulin treatment**
Description: Techniques for injecting insulin, blood glucose monitoring, and recognition and management of hypoglycemia, hyperglycemia, and ketosis, insulin dose modification depending on food and exercise plans, diabetic nutrition, carb counting, complications of diabetes, the importance of controlling diabetes, and novel therapies to test glycoemic control. Mode: group. Personnel: pediatric endocrinologists, nurses, dieticians, interns, and psychologists. Duration: 7 days. Delivery method: face-to-face.
Intervention: Camp-based diabetes education program
Description:
- 5-day camp including small-group discussions on a range of diabetic self-management topics consisting of small group discussions on various topics on diabetes self-management skills and lectures on: insulin therapy and injection techniques, the significance of diabetes control, blood glucose monitoring, exercise and diabetes, diabetic nutrition, complications of diabetes, how to handle special events, novel therapies for diabetes, and social programmes lectures on: insulin therapy and injection techniques, the importance of diabetes control, blood glucose monitoring, exercise and diabetes, diabetic nutrition, complications of diabetes, how to handle special occasions, new therapies for diabetes and social programs.
- Mode: group
- Personnel: endocrinologists, fellows, nurses, psychologists, dieters
- Duration: 5 days
- Delivery method: face-to-face

Intervention: Summer camp educational program
Description:
- With the daily educational lectures and discussions, the camp provided three 20-day programmes, four times daily and when needed glucose levels tests and insulin adjustment before each meal. The licensed dietician planned all meals and all insulin injections were supervised. The camp offers three sessions of 20 days each, with daily education lectures and discussions. Blood glucose is tested on four times a day and as needed. Insulin is adjusted before each meal. All insulin injections are supervised, and all meals are planned by the registered dietician.
- Mode: group
- Personnel: medical students and physicians
- Duration: 20 days
- Delivery method: camp-based (face-to-face)

Intervention: Diabetes Summer Camp-Educational-based program
Description:
- Activities that are didactic and interactive for children that focus on the cause of the disease, its symptoms, insulin therapy, blood glucose monitoring, diet, the recognition and management of complications, the relationship between exercise, food intake, and insulin doses, the significance of diabetes control, the management of T1DM on a daily basis, stress management and other challenges in life.
- Mode: group with parents
- Personnel: medical director, physician, dietician, and psychologist
- Duration: 1 week
- Delivery method: camp-based (face-to-face)
<table>
<thead>
<tr>
<th>Study</th>
<th>Intervention</th>
<th>Description</th>
<th>Mode</th>
<th>Delivery method</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>Choices Diabetes Program</td>
<td>Behavioral intervention- 2-hours six-weekly behavioral sessions included: 1. Making decisions and maintaining a record 2. Making food planning 3. Insulin timing; getting back on track 5. Decision-making; and 6. Handling the psychological impacts of DM.1. Making choices and keeping records 2. Planning meals 3. Timing insulin 4. Getting back on track 5. Making decisions and 6. Dealing psychologically with the impact of DM.</td>
<td>Group w/parents</td>
<td>Face-to-face</td>
<td>Significant reduction in HbA1c by 0.74% compared to 0.09% in the waitlist group (p &lt; 0.01)</td>
</tr>
<tr>
<td>19</td>
<td>Telehealth Behavior Therapy</td>
<td>Behavioral intervention- Phone calls (sessions) with the therapist, discussing self-care activities which encourage adaptive self-care (goals for managing diabetes) and identifying potential obstacles to management and education. Discussing self-care activities and reinforcing adaptive self-care (diabetes goals), and identifying potential barriers to management and education.</td>
<td>Individual with families</td>
<td>Phone calls</td>
<td>Significant reduction in HbA1c by 0.74% compared to 0.09% in the waitlist group (p &lt; 0.01)</td>
</tr>
<tr>
<td>20</td>
<td>Internet Coping Skills Training Program (TEENCOPE)</td>
<td>Behavioral intervention- TEENCOPE is an intervention Web site consisting of managing diabetes sessions, which include four weekly sessions on glucose control, nutrition, exercise, sick days, and new technology, and five weekly sessions on self-talk, communication skills, social issue skills, stress management, and conflict resolution. Consisted of consisting of five weekly sessions on self-talk, communication skills, social problem skills, stress management, and conflict resolution and managing diabetes sessions which are four weekly sessions on glucose Control, nutrition, exercise, sick days, and new technology</td>
<td>Group w/parents</td>
<td>Web-based sessions</td>
<td>Increased Diabetes self-management profile (DSMP) (p&lt;0.01)</td>
</tr>
<tr>
<td>21</td>
<td>Tailored diabetes message system for mobile and the web</td>
<td>Tailored mobile and web-based diabetes messaging system Adolescents were motivated and reminded about diabetes self-care duties via the text messaging system whereby the text messaging system was designed to motivate and remind adolescents about diabetes self-care tasks, they received 10 texts per week, according AaCtterding to their individual ly-reported barriers to diabetes self-care, they received 10 text messages per week.</td>
<td>Individuals</td>
<td>Online-based</td>
<td>No significant differences in knowledge</td>
</tr>
</tbody>
</table>

**Study Details**

- **S. Cook et al. [33]**
  - **Mode**: Group w/parents
  - **Delivery method**: Face-to-face

- **Elamin et al. [36]**
  - **Mode**: Individual with families
  - **Delivery method**: Phone calls

- **Latham et al. [34]**
  - **Mode**: Group w/parents
  - **Delivery method**: Web-based sessions

- **Mohammadi et al. [38]**
  - **Mode**: Individuals
  - **Delivery method**: Online-based
<table>
<thead>
<tr>
<th>Study ID</th>
<th>First Author</th>
<th>Year</th>
<th>Country</th>
<th>Design</th>
<th>Duration</th>
<th>Setting</th>
<th>Intervention</th>
<th>Personnel</th>
<th>Delivery Method</th>
<th>Mode</th>
<th>Main Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>22</td>
<td>R. Fiallo Scharer et al.</td>
<td>2012</td>
<td>USA</td>
<td>Multisided randomized control trial</td>
<td>6 months</td>
<td>Pediatric diabetes clinics</td>
<td>Internet coping skills training (TEENCOPE) intervention Vs M vs. Managing Diabetes (MD) program</td>
<td>Nurses, psychologists, and PhD.D. Candidates</td>
<td>Face-to-face and web-based sessions</td>
<td>Both groups</td>
<td>No significant differences in HbA1c levels (p=0.144)</td>
</tr>
<tr>
<td>23</td>
<td>M. Grey et al.</td>
<td>2013</td>
<td>USA</td>
<td>Randomized controlled trial</td>
<td>6 months</td>
<td>Virtually</td>
<td>Internet Psycho-Education Programs</td>
<td>Trained Research Personnel</td>
<td>Web-based sessions</td>
<td>Both groups</td>
<td>No significant difference between the two groups (p&lt;0.05)</td>
</tr>
<tr>
<td>24</td>
<td>G. R. Hunger et al.</td>
<td>2014</td>
<td>Denmark</td>
<td>Randomized controlled trial</td>
<td>12 months</td>
<td>Pediatrics outpatient’s clinic</td>
<td>gguided self-determination youth (GSD-y) intervention</td>
<td>Group with parents</td>
<td>Face-to-face</td>
<td>Both groups</td>
<td>No significant differences in psychosocial outcomes (QOL, stress, depression, coping, family conflict) (p&lt;0.001)</td>
</tr>
<tr>
<td>25</td>
<td>A. Harris et al.</td>
<td>2015</td>
<td>USA</td>
<td>Randomized controlled trial</td>
<td>6 months</td>
<td>Tertiary diabetes clinic</td>
<td>Family Systems Therapy -Diabetes (BFST-D) via face-to-face OR Internet video conferencing (Skype)</td>
<td>Pediatric diabetes nurses, pediatricians, dieticians</td>
<td>Face-to-face and Skype video call</td>
<td>Both groups</td>
<td>Significant improvements in adherence, glycemic complications (hypoglycemia, hyperglycemia), and insulin doses (p&lt;0.05)</td>
</tr>
<tr>
<td>26</td>
<td>R. Fischer-Scharer et al.</td>
<td>2019</td>
<td>USA</td>
<td>Randomized controlled trial</td>
<td>24 months</td>
<td>Diabetes clinic</td>
<td>A family-centered approach</td>
<td>Trained nurses</td>
<td>Face-to-face</td>
<td>Both groups</td>
<td>Increased mean QOL during intervention for Parents (p&lt;0.05)</td>
</tr>
</tbody>
</table>

**Intervention:**
- Internet coping skills training (TEENCOPE) intervention
- Internet Psycho-Education Programs
- gguided self-determination youth (GSD-y) intervention
- Family Systems Therapy -Diabetes (BFST-D) via face-to-face OR Internet video conferencing (Skype)
- A family-centered approach

**Significant Reductions:**
- In HbA1c levels (p=0.01)
- In other glycaemic complications (p<0.05)
- In mean QOL during intervention for Parents (p<0.05)
- In adherence, glycemic complications (p<0.01)

**Main Findings:**
- No significant differences in HbA1c levels between both groups (p=0.144)
- No significant difference between the two groups (p<0.05)
- Significant improvements were observed in adherence, glycemic complications, and insulin doses (p<0.05)
<table>
<thead>
<tr>
<th>Study</th>
<th>Authors</th>
<th>Year</th>
<th>Country</th>
<th>Study Type</th>
<th>Duration</th>
<th>Intervention</th>
<th>Description</th>
<th>Mode</th>
<th>Personnel</th>
<th>Delivery Method</th>
<th>Outcome Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>27</td>
<td>A. C. Sarteau et al.</td>
<td>2020</td>
<td>USA</td>
<td>RCT</td>
<td>18 months</td>
<td>Intervention: The Flexible Lifestyle Empowering Change trial (FLEX)</td>
<td>Behavioral intervention - combine both strategies (motivational interviewing (MI) &amp; problem-solving skills training (PSST), four 40- to 60-minute introductory coaching sessions - One month apart, there was a (1) evaluation of what worried young people about their T1DM (2) interacting with youngsters; (3) assigning behavioral homework. Each session where youth goal setting integrated BGM, CGM, and insulin dosing concluded by integrating the parent into the discussion on how they support the objectives identified by the youth.</td>
<td>Group with parents</td>
<td>Dietician, nurse, certified diabetes educator (CDE)</td>
<td>Face-to-face and phone call</td>
<td>Significant reduction in hba1c levels (p&lt;0.001) And sixth months (p&lt;0.001) Improved knowledge levels (p&lt;0.001), Personal motivation levels (p = 0.001), Social motivation levels (p = 0.004) And Behavioral skills (p&lt;0.001) Of the study group.</td>
</tr>
<tr>
<td>28</td>
<td>E. Bakır et al.</td>
<td>2021</td>
<td>Turkey</td>
<td>RCT</td>
<td>6 months</td>
<td>Intervention: Information-motivation-behavioral skills model</td>
<td>Consist of a number of phone calls and home visits including information on diet and exercise, motivation applying a good attitude in practicing the information, support, and health alarm, behavioral skills, and behavioral changes for achieving daily goals.</td>
<td>Group</td>
<td>Nurses</td>
<td>Face-to-face and phone call</td>
<td>Significant reduction in hba1c levels (p&lt;0.001) And sixth months (p&lt;0.001) Improved knowledge levels (p&lt;0.001), Personal motivation levels (p = 0.001), Social motivation levels (p = 0.004) And Behavioral skills (p&lt;0.001) Of the study group.</td>
</tr>
<tr>
<td>29</td>
<td>M. L. Lawson et al.</td>
<td>2000</td>
<td>Canada</td>
<td>Retrospective cohort study</td>
<td>15 months</td>
<td>Intervention: Intensive Diabetes Management (IDM) with intensive follow-up</td>
<td>The individualized programme each family received 6 to 8 hours of education, during which time the patients reviewed their meal plans and insulin dosing, with incentives when the hba1c target was met. Compared to group education with routine follow-up (2-hour sessions).</td>
<td>Group with families</td>
<td>Nurses, dieticians, diabetologists, and research fellows</td>
<td>Face-to-face and phone call follow-up</td>
<td>Significant reduction by mean -2.5% in T (p&lt;0.0001) Vs -0.9% in C (p&lt;0.05) after 3 months - The mean hba1c one year later remained significantly lower than at initiation of IDM in the T group (p=0.001) and was not significantly different than that prior to initiation of IDM in the C group (p=0.8). 2 patients of in the T group, had severe hypoglycemic reactions, while no reported cases from the C group.</td>
</tr>
</tbody>
</table>
### Intervention: A Wireless, Portable System to Improve Adherence and Glycemic Control

**Description:** A handheld device with diabetes data management software and a wireless modem was given to the game group. The game group received a handheld device fitted with a wireless modem and diabetes data management software, in addition to a wireless-enabled blood glucose monitor (new technologies) and an integrated motivational game in which participants would guess a blood glucose level, after a collection of three previous readings plus a wireless-enabled BG monitor (new technologies) along with an integrated motivational game in which the participants would guess a BG level following a collection of three earlier readings versus the C group, who received the new technologies only.

**Mode:** group with parents

**Personnel:** trained research assistants

**Duration:** 4 weeks

**Delivery method:** motivational game/virtual

<table>
<thead>
<tr>
<th>Year</th>
<th>Country</th>
<th>Methodology</th>
<th>Intervention</th>
<th>Mode</th>
<th>Personnel</th>
<th>Duration</th>
<th>Delivery Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>USA</td>
<td>Randomized controlled trial</td>
<td>14, 18 years</td>
<td>39</td>
<td>10 T: 20 C, 48% F: 51% M</td>
<td>6-18 years</td>
<td>Virtually</td>
</tr>
</tbody>
</table>

### Intervention: Mobile Diabetes Education

**Description:** Parents receive 5-day training on insulin function in a group or one-on-one setting, encouraging them to handle insulin administration. Parents training in a group or one-to-one setting for 5 days, on insulin function and empowering them to cope with insulin adjustment, sickness, and the challenges in everyday daily life. And 24 mobile-based follow-ups every year.

**Mode:** one-to-one or group with families

**Personnel:** pediatric nurses and diabetologists

**Duration:** 5-day yearly courses

**Delivery method:** mobile phone

<table>
<thead>
<tr>
<th>Year</th>
<th>Country</th>
<th>Methodology</th>
<th>Intervention</th>
<th>Mode</th>
<th>Personnel</th>
<th>Duration</th>
<th>Delivery Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>Germany</td>
<td>Cohort study</td>
<td>10-18 years</td>
<td>39</td>
<td>8 T: 15.4% F: 34.6% M</td>
<td>1-6 months</td>
<td>Virtually</td>
</tr>
</tbody>
</table>

### Intervention: A Multicenter, motivational interviews

**Description:** The participants received individual, patient patient-driven, motivational interviewing sessions on DM awareness raising and alternatives to current behaviors were taken into consideration. Sessions on DM DM-related awareness building. Alternatives to the current behaviors were considered (social, emotional, or financial) Problem-solving, making decisions, setting goals, and lowering therapy resistance. Problem-solving, making choices, goal goal-setting, and reduce reducing resistance to therapy.

**Mode:** Individuals

**Personnel:** psychologists, and nurses

**Duration:** 12 months

**Delivery method:** face-to-face

<table>
<thead>
<tr>
<th>Year</th>
<th>Country</th>
<th>Methodology</th>
<th>Intervention</th>
<th>Mode</th>
<th>Personnel</th>
<th>Duration</th>
<th>Delivery Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>UK</td>
<td>Multi-center randomized controlled trial</td>
<td>6-12 months</td>
<td>39</td>
<td>3 T: 28% F: 12% M</td>
<td>14-17 years</td>
<td>Diabetes clinic</td>
</tr>
</tbody>
</table>

### Intervention: Chat Line as a tool Tool to Improve Coping with DM

**Description:** Sessions on a weekly basis for at least two years. Simultaneously, weekly chat line sessions for at least 2 years consecutively, lasted lasting 90 min about diabetes management, anxiety about the future, as well as interpersonal and societal interations. Anxiety about the future, and interpersonal and social relationship.

**Mode:** group with parents

**Personnel:** research assistant, physician, and psychologist

**Duration:** weekly sessions with 2-year follow-up

**Delivery method:** chat line

<table>
<thead>
<tr>
<th>Year</th>
<th>Country</th>
<th>Methodology</th>
<th>Intervention</th>
<th>Mode</th>
<th>Personnel</th>
<th>Duration</th>
<th>Delivery Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>Italy</td>
<td>Randomized controlled trial</td>
<td>10-18 years</td>
<td>39</td>
<td>19 T: 203 C, 56% F: 44% M</td>
<td>10-18 years</td>
<td>Virtually</td>
</tr>
</tbody>
</table>
Elamin et al.: Impacts of Educational Interventions on Glycemic Control in Children and Adolescents with Type 1 Diabetes Mellitus

**Intervention**: Pediatric Diabetes Education Portal

**Description:**
A website where patients and their family could check clinic test results, read educational materials about these results, and ask their diabetes educator questions on website for patients and families that allowed them to review clinic test results, review educational materials related to these results and post questions to their diabetes educator, Fingerstick, hemoglobin A1c (HbA1c) testing, and regular periodic use of a continuous glucose monitoring system (CGMS) with the results displayed posted to the website after each clinic visit. Patients and/or parents were categorised as website users or non-users. Patients and/or parents were classified as users or non-users of the website

**Mode**: group with families

**Personnel**: diabetes care team with endocrinologist and educators

**Duration**: 3-5 days

**Delivery method**: online-based

---

**Intervention**: Visual Learning on Mobile Phones

**Description:**
Two mobile phone apps: (1) one that is pictures-based diabetic diary to record physical activity and photos of food intake; the phone and glucometer were connected through Bluetooth; Two mobile phone applications: (1) an application that contained a picture-based diabetes diary to record physical activity, and photos of food eaten, the phone was communicated with the glucometer by Bluetooth technology to capture blood glucose values, and (2) a short message (SMS) service that is web-based, password-secured, and encrypted from the Web-based, password-secured and encrypted short message service (SMS)

**Mode**: group with parent

**Personnel**: researchers and pediatricians

**Duration**: 3 months

**Delivery method**: mobile apps

---

**Intervention**: Impact of Telemedicine Assessment on Glycemic Variability

**Description:**
The glucose values were measured for 3 months after training sessions on the Accu-Chek (Roche) Smart Pix software, and the results were compared to those from a following 4-month period without telemedical support.

Training sessions were held on Accu-Chek (Roche) Smart Pix software, then glucose values were assessed for 3 months, and compared to a subsequent 4-month period without telemedical support

**Mode**: group with families

**Personnel**: researchers with diabetes specialists

**Duration**: 3 months

**Delivery method**: online-based

---

**Intervention**: mobile Mobile phone messaging service

**Description**: Daily informational texts, interactive messages once a week, and multimedia video messages about diabetes care procedures were sent to the kids via their parents' children were provided – through their parents – with daily information messages, with weekly interactive messages, and on request, with multimedia video messages about procedures related to diabetes care, contained basic knowledge on diabetes care, including: pathophysiology, aetiology, diagnosis, and management covered general diabetes care knowledge, including diabetes symptoms, signs, pathophysiology, etiology, diagnosis, management including (insulin therapy, nutrition therapy, and psychotherapy), insulin therapy, diet therapy, psychotherapy and diabetes press news and recent information about diabetes.

**Mode**: group with parents

**Personnel**: pediatricians and research assistants

**Duration**: 6 months

**Delivery method**: text messaging and phone calls

---

**Intervention**: Blood glucose monitoring (HbA1c and the High Blood Glucose Index (HBGI))

**Description**: No significant reduction in mean HbA1c levels

**Mode**: group with families

**Personnel**: researchers with diabetes specialists

**Duration**: 3 months

**Delivery method**: online-based

---

**Intervention**: Improved knowledge, Decline glycemic management

**Description**: No significant change in diabetes knowledge (p = 0.82)

**Mode**: group with families

**Personnel**: researchers with diabetes specialists

**Duration**: 3 months

**Delivery method**: online-based

---

**Intervention**: Improved diabetes management

**Description**: Higher levels of satisfaction (statistically significant), and increased knowledge (statistically significant), and increased knowledge (statistically significant)

**Mode**: group with families

**Personnel**: researchers with diabetes specialists

**Duration**: 3 months

**Delivery method**: online-based

---

**Intervention**: Improved patient compliance, Diabetes knowledge monitoring by physicians

**Description**: No significant difference in HbA1c levels (p = 0.38)

**Mode**: group with families

**Personnel**: researchers with diabetes specialists

**Duration**: 3 months

**Delivery method**: online-based

---

**Intervention**: Improved effects in the management of diabetes subjectively.

**Description**: No significant reduction in mean blood glucose (MBG) and the High Blood Glucose Index (HBGI)

**Mode**: group with families

**Personnel**: researchers with diabetes specialists

**Duration**: 3 months

**Delivery method**: online-based

---

**Intervention**: Improved diabetes management

**Description**: No significant change in diabetes knowledge (p = 0.82)

**Mode**: group with families

**Personnel**: researchers with diabetes specialists

**Duration**: 3 months

**Delivery method**: online-based

---

**Intervention**: Improved effects in the management of diabetes subjectively.

**Description**: No significant reduction in mean blood glucose (MBG) and the High Blood Glucose Index (HBGI)

**Mode**: group with families

**Personnel**: researchers with diabetes specialists

**Duration**: 3 months

**Delivery method**: online-based

---

**Intervention**: Improved diabetes management

**Description**: No significant change in diabetes knowledge (p = 0.82)

**Mode**: group with families

**Personnel**: researchers with diabetes specialists

**Duration**: 3 months

**Delivery method**: online-based
Intervention: Pediatrician and nurses counseling

Description:
Either the intervention group (three-monthly doctor visits plus a monthly nurse visit and biweekly phone calls) or the control group (three-monthly doctor visits)
The content of the intervention included general information about diabetes, how to manage it, and how to minimize diabetes-related complications.

Mode: group

Personnel: pediatricians and nurses

Duration: One year

Delivery method: face-to-face and phone calls

Intervention: Technology and social media intervention

Description:
Three digital technology techniques 1) Facebook social media platform for interactive communications that provided diabetic support and education, 2) Twinkle.Net integrated paediatric diabetes electronic management system (which permit monthly audits and more intensive contacts with low controls patients, and 3) Diasend® blood glucose and insulin pump downloading system, which enables quick access to and joint analysis of patients' blood glucose data in a clinic and enables the team to individualize treatment regimens.

Mode: group with families

Personnel: pediatric diabetes team

Duration: 1 year

Delivery method: social media technology

Intervention: Serious Videogame Designed for Flexible Insulin Therapy

Description:
In “L’Affaire Birman” the player will start solving diabetes-related problems (hypoglycemia or hyperglycemia) and adapts insulin dose injection.

No additional education was provided to the participants during their participation beyond that which was based on their blood glucose level, degree of physical activity, and carbohydrate intake.

Mode: group with families

Personnel: physicians, nurses, dieticians, and expert diabetic patients (academic diabetes care team)

Duration: About 3 months

Delivery Method: web-based game sessions

Intervention: Therapeutic play intervention (ITP)

Description:
Following a video of children in the intervention group injecting a doll with insulin, a narrative about a T1DM child who self-injects insulin at school was read to the children. Children then videotaped injecting the doll once more, while the control group received standard clinic education.

Mode: group with families

Personnel: trained nurses with the research team

Duration: 1 month

Delivery method: face-to-face
<table>
<thead>
<tr>
<th>Study Code</th>
<th>Authors</th>
<th>Year</th>
<th>Country</th>
<th>Study Design</th>
<th>Participants</th>
<th>Mode</th>
<th>Delivery Method</th>
<th>Intervention</th>
<th>Duration</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>43</td>
<td>E. DJigler et al.</td>
<td>2019</td>
<td>Turkey</td>
<td>Randomized controlled trial</td>
<td>82</td>
<td>Group with families</td>
<td>Diabetes team, psychologists, physicians</td>
<td>Telehealth System</td>
<td>3 months</td>
<td>No significant difference in hba1c (p&lt;0.001)</td>
</tr>
<tr>
<td>44</td>
<td>M. Otis et al.</td>
<td>2020</td>
<td>USA</td>
<td>Randomized controlled trial</td>
<td>120</td>
<td>Group with caregivers</td>
<td>Trained research assistants</td>
<td>Positive psychology intervention</td>
<td>2 months (8 weeks)</td>
<td>No significant difference in hba1c (p=0.86)</td>
</tr>
<tr>
<td>45</td>
<td>J. E. Alfonsi et al.</td>
<td>2020</td>
<td>Canada</td>
<td>Randomized controlled trial</td>
<td>23</td>
<td>Both genders (not specified)</td>
<td>Children’s educational media consultants</td>
<td>Mobile Educator Tool/program</td>
<td>3 months</td>
<td>Significant reduction in hba1c (p&lt;0.03)</td>
</tr>
<tr>
<td>46</td>
<td>M. O. J. et al.</td>
<td>2020</td>
<td>USA</td>
<td>Mixed phase pilot study</td>
<td>46</td>
<td>Both genders (not specified)</td>
<td>Trained research assistants</td>
<td>eHealth program</td>
<td>3 months</td>
<td>No significant difference in hba1c (p=0.089)</td>
</tr>
<tr>
<td>47</td>
<td>R. Whitemore et al.</td>
<td>2020</td>
<td>USA</td>
<td>Randomized control trial</td>
<td>162</td>
<td>Group with parents</td>
<td>Pediatric diabetes endocrinologists</td>
<td>eHealth program</td>
<td>6 months</td>
<td>Significantly lower parenting stress (better coping while spending more time in the program)</td>
</tr>
</tbody>
</table>

Intervention: Telehealth System
Description: Patients/parents who called daily, 5–6 times per week, 1-2 times per week, or once every 15 days were classified as frequent callers, while those who called less frequently were classified as infrequent callers. Counselling was conducted via communication networks to discuss the current treatment plan and ask diabetes-related questions (about insulin dose and blood glucose regulation, carbohydrate counting, and appropriate actions to be taken in the case of hyperglycemia and hypoglycemia).
Mode: Group with families
Personnel: Diabetes team, psychologists, physicians
Duration: 3 months
Delivery method: Internet and smartphones

Intervention: Positive psychology intervention
Description: Every two weeks, educational materials were mailed to the control group (EDU). Included details like adherence, hba1c, and hypoglycemia. And the intervention group positive affect (PA) group, who received reminders (gratitude, self-affirmation, parental affirmation, and modest presents) in addition to the same materials as the EDU group.
Mode: Group with caregivers
Personnel: Trained research assistants
Duration: 2 months (8 weeks)
Delivery method: text message or phone call

Intervention: Carbohydrate Counting App Using Image Recognition
Description: The ispy app, a cutting-edge mobile application that allows food identification through images and is designed to help young people with T1DM count carbohydrates, was provided on participants’ mobile devices, and they were asked to complete tasks using it. Mode: Group with caregivers
Personnel: Registered dieticians and educators
Duration: 3 months
Delivery method: Mobile app

Intervention: Mobile Educator Tool/program
Description: The Mobile Diabetes Educator (MDE) comprises of eight animated, interactive modules with a paleoeducator with T1DM who is of uncertain ethnicity. The aetiology of diabetes, controlling blood sugar levels, and suggested diet and exercise regimens are all covered. A tablet with information on diet, glucose tests, glucose responses, and insulin was given to parent-child couples.
Mode: Group with parents
Personnel: Children’s educational media consultants
Duration: One hour
Delivery method: Interactive electronic book (mobile)

Intervention: eHealth program
Description: Participants were randomly assigned to the wait-list control group or the type 1 teamwork website. They were given access to the eHealth programme via email, along with instructions on how to access, and were given information on the challenges of adolescence, creating a positive partnership between parents and adolescents, communicating positively with adolescents, gradually assigning them more responsibility, understanding the emotions that parents experience, and the significance of taking care of oneself. Type 1 Teamwork included six interactive sections.
Mode: Group of parents of adolescents
Personnel: Pediatric diabetes endocrinologists
Duration: 6 months
Delivery method: Web-based sessions

Significant reduction in hba1c (p<0.03)
No significant difference in hba1c levels (p=0.03)
Significantly lower parenting stress (better coping while spending more time in the program)
No significant difference in hba1c levels (p=0.089)
Significantly lower parenting stress (better coping while spending more time in the program)
RESULTS AND DISCUSSION

Studies Characteristics

The 49 studies included in this review were published between 2000 and 2021. The research setting spans 18 different countries, with most articles (33/49) published after 2011. Furthermore, 12 (24%) studies utilized qualitative designs, while 37 (76%) adopted the mixed-method design. Six quantitative studies were randomized controlled trials (RCT), and four had observational analytical designs (case-control/cohort studies). Moreover, 36 out of 49 (73.5%) articles compared the outcomes between the participants in the educational interventions and the control group that adhered to their original course of treatment and care. Other research compared the outcomes of different patient education interventions or pre- and post-test studies.

A significant variation was detected in the types of patient education intervention, design, and outcome measures between studies. The studies were classified into three categories based on the duration of the educational intervention, where 24 (49%) studies lasted ≤ 3 months, 15 (30.6%) studies were conducted between three to six months, and 10 (20.4%) education interventions lasted for six to 12 months. Furthermore, 28 out of 49 (57%) studies showed that hba1c levels were substantially decreased over time. Meanwhile, 16 studies that reported a significant decrease in hba1c recorded the measurements between three to six months post-intervention, while only three were measured in ≥ 1 year of intervention.

Sample Population Characteristics

A total of 5874 patients were comprised in this scoping review (Table 1), with an age range of 10.3 to 17.3 years. Nonetheless, several studies [31, 32, 38, 39, 49, 53, 59, 63] had a target population consisting of children, adolescents, and young adults between 18 and 25 years old, having type T1DM for at least a year. In addition, 42 out of the 49 studies (85.7%) had an average of 44% male and 56% female participants.

Intervention Characteristics

The patient education interventions vary between studies (objectives, participants, locality, and delivery methods) and are detailed in the supplementary information (Table 1). The interventions were conducted physically or virtually, focusing on the patients’ (children and adolescents) and caregivers’ (patients’ families) coping skills and knowledge provided to improve T1DM management, patients’ health, and daily life. A total of 17 (34.7%) interventions were held face-to-face, 17 (34.7%) were conducted virtually (via mobile phones, video conferencing, or web-based), and 15 (30.6%) combined both techniques. In addition, 26 (53.1%) interventions were conducted in person at hospitals (clinics or centers), while five (10.2%) were in summer camps.

Among the 46 group-based interventions, 33 (67.3%) included family or support persons, while the other 13 (26.5%) did not. On the other hand, three interventions were conducted individually with patients. Furthermore, 42 (85.7%) interventions were led by health care providers and seven interventions involved researchers and trained research assistants as the main facilitators. Multidisciplinary teams directed another 22 (44.9%) interventions.

Seven (14.3%) interventions were designed as session-based, structured education programs, five (10.2%) were camp-based interventions with training and activities, five (10.2%) involved behavioral and coping skills training, and four (8.2%) were peer-education that consisted of problem sharing and discussion. The remaining interventions were...
motivational interviews, game-based and therapeutic play interventions, psychological interventions, dietary interventions with carb calculation training, and an intensive diabetes education program involving frequent blood glycemia monitoring, self-management, and a hospital discharge education plan. Most education interventions included educational materials on T1DM pathophysiology, carbohydrate counting, insulin dose adjustment, diabetic complications management, and sick-day rules.

**Study Outcomes**

The hba1c level is the primary outcome of this study. Most interventions or 48 (98%) studies reported reduced hba1c levels post-intervention, among which 28 (58%) were statistically significant. Other outcomes include learning, behavioral, psychological, QOL, and health status. Notably, 16 interventions evaluated diabetes-related knowledge as learning outcomes, of which 12 studies (75%) demonstrated improvements and were statistically significant. A total of 23 studies (46.9%) assessed behavioral outcomes, such as dietary practice, self-care, self-management, problem-solving, blood glycemia monitoring, and adherence to insulin, where 22 reported enhancements in at least one of the measured parameters.

Another 10 studies reported improvements in psychological and socio-psychological outcomes, including self-esteem, self-efficacy, coping with T1DM, discharge readiness, motivation, reduced stress, and treatment satisfaction. Meanwhile, 16 out of 49 studies exhibited better QOL, of which five were statistically significant. Improved health status outcomes were indicated by decreased diabetes-related complications (hypo/hyperglycemia) and hospital admissions, which were recorded in eight studies.

Education is a vital process in diabetes management that allows for patient-specific care, improving treatment adherence and prevent-diabetes related complications, thus, leading to optimized management [65]. Lorig and Holman [9] stated that education enables patients to understand their illnesses, hone relevant skills and knowledge to manage challenges, customize treatments, and maintain a good QOL. This study provided the necessary information for the scientific debate about the efficacy of various interventions to improve the welfare of diabetic children and adolescents.

Generally, most educational interventions effectively improved glycemia control and reflected a reduction in hba1c. This finding suggested that education intervention effectively controls T1DM in children and adolescents. Nevertheless, most studies did not explore the key factors, such as the sustainability of glycemia control, despite the level of sustained glycemic control in young patients with type 1 diabetes being the leading cause of chronic and acute complications [66].

It is highly recommended for an educational intervention to be patient-specific, depending on their age, culture, diabetes stage, lifestyle, and maturity to suit the individual needs [67]. For example, more than 15000 participants whose data were retrieved from the T1DM Exchange registry across the United States of America (USA) demonstrated that hba1c levels skyrocketed between ages 13 and 25 and did not stabilize until after 30 [68]. Furthermore, hba1c in this age range has worsened since 2010, charting the highest average of 9.2% among 19-year-old patients [68]. These findings indicated the urgency of optimizing glycemic levels specifically in younger populations.

In the search for the best education intervention, a trend toward significant glycemic improvements were observed in 13 out of 22 (59.1%) studies associated with multidisciplinary interventions by teams of doctors, nurses, dietitian, and psychologists. The collaboration between health care providers with different expertise demonstrated a synergistic effect in managing children and adolescents with T1DM, resulting in significant outcomes and better glycemic control. Wigert et al. [69] explained three significant outcomes of an effective multidisciplinary team when caring for children and adolescents with T1DM: 1) building a long-term relationship, 2) integrating knowledge through multidisciplinary teamwork, and 3) ensuring adequate documentation.

Effective communication between patients and health care providers is essential in building a long-term relationship based on trust, shared responsibilities, and ethical considerations. Furthermore, the multidisciplinary team must be able to communicate effectively with one another in disseminating knowledge required by the patients, besides ensuring adequate documentation crucial for patient follow-ups and in maintaining the functioning and stability within the team [69]. Moreover, Likitmaskul et al. [20] emphasized the importance of a multidisciplinary team for an effective education program and for helping diabetic children and their families manage their glycemia, arising problems, and long-term self-care.

Most interventions that reported significant improvements in glycemia control measured the glycated hemoglobin between three- and six-months post-intervention. In contrast, few interventions with significant improvements measured the patients' hba1c levels regularly for more than a year. These findings suggested that most effective interventions lack sustainable glycemia control. Regular consultations and follow-ups with T1DM patients for more than a year post-intervention resulted in long-term improvements in hba1c and reduced incidence of severe hypoglycemia [70]. Additionally, post-intervention feedback was reported in several reviewed studies. The participants found the interventions beneficial, reporting better health status reflected by fewer diabetes-related complications (hypoglycemia, hyperglycemia, hospital admissions, and length of stay in hospital) [38, 54, 55, 58, 61, 62]. Intervention evaluation and participants’ feedback are vital in evaluating and modifying intervention content, design, and delivery and are valuable for patient targeting [71].
The QOL is a multidimensional concept that measures patients’ well-being, and physical, psychological, and social functioning [72]. This concept was selected as an outcome of several education interventions (n = 16) with positive results, where five were statistically significant. Meanwhile, the peers-based intervention studies demonstrated that sharing knowledge, experiences, and management strategies in dealing with T1DM-related challenges allowed the young patients to learn from each other besides promoting awareness about their illness [73].

CONCLUSION

In conclusion, the study findings demonstrated that the outcomes from education interventions were related to intervention duration. Therefore, it is essential to integrate education intervention programs into all diabetic management settings instead of limited duration or teaching at the beginning of the patient’s follow-up. In addition, it is recommended that a well-structured multidisciplinary education intervention program should be divided into two phases: 1) comprehensive education intervention phase in which the participants (children or adolescents and their families) are exposed to the general knowledge and management strategies of T1DM, and 2) individualized, patient-centered phase, in which each patient subjective characteristics are considered, and the educational materials are tailored to their individual needs. Both phases are predicted to contribute to effective, sustainable, and potentially cost-effective improvements in glycaemia control.

ACKNOWLEDGMENTS: None

CONFLICT OF INTEREST: None

FINANCIAL SUPPORT: None

ETHICS STATEMENT: None

REFERENCES


50. Ng SM. Improving patient outcomes with technology and social media in paediatric diabetes. BMJ Qual Improv Rep. 2015;4(1):u200396.w3846. doi:10.1136/bmjquality.u200396.w3846


54. Ng SM. Improving patient outcomes with technology and social media in paediatric diabetes. BMJ Qual Improv Rep. 2015;4(1):u200396.w3846. doi:10.1136/bmjquality.u200396.w3846
Elamin et al.: Impacts of Educational Interventions on Glycemic Control in Children and Adolescents with Type 1 Diabetes Mellitus

Archives of Pharmacy Practice ¦ Volume 14 ¦ Issue 4 ¦ October – December 2023