




# Educational Interventions for Individuals with Insulin-Treated Type 2 Diabetes Mellitus: A Systematic Review

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**Objective:** To evaluate and synthesize evidence on the impact of educational interventions for individuals with insulin-treated type 2 diabetes mellitus (T2DM).

**Methods:** Following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, five electronic databases (Scopus, PubMed, Medline, CINAHL Plus with Full Text, and Web of Science) were systematically searched in February 2024. The search focused on studies published between 2019 and 2024 that investigated the impact of educational interventions on individuals with insulin-treated T2DM. Reference lists of the included studies were also manually searched. Titles and abstracts were screened for eligibility, and relevant full texts were assessed.

**Results:** Out of 1,032 identified records, 11 studies met the inclusion criteria. According to the data synthesized using a convergent integrated analysis framework, five major themes have emerged: 1) Glycemic control (including subthemes improving HbA1C, decreasing postprandial plasma glucose, and decreasing fasting plasma glucose), 2) Insulin-related complications (including subthemes reducing hypoglycemic events and reducing the size of lipohypertrophy), 3) Knowledge, Attitude, and Practice (including subthemes engaging in self-management, improving insulin injection technique, improving knowledge, and improving attitude toward insulin treatment), 4) Optimal dose of insulin, and 5) Improving quality of life.

**Conclusion:** Educational interventions are crucial for improving diabetes-related outcomes and reducing complications in individuals with insulin-treated T2DM. These interventions enhance knowledge, attitudes, and self-management practices, leading to better glycemic control and quality of life. Healthcare settings should develop and provide tailored educational programs for individuals with insulin-treated T2DM to optimize outcomes and minimize complications.

**Keywords:** type 2 diabetes, insulin-treated, education, health management

## Background

The prevalence and incidence of type 2 diabetes mellitus (T2DM) are increasing worldwide.<sup>1,2</sup> Type 2 diabetes mellitus is predominantly caused by insulin resistance; cells do not respond well to insulin to take up glucose from the blood.<sup>3</sup> In 2017, more than 400 million people suffered from T2DM, which accounted for 6.28% of the global population.<sup>2</sup> Moreover, the prevalence rate of individuals with T2DM in 2017 was 6,059 cases per 100,000 people, and it would rise to 7,079 cases per 100,000 people in 2030.<sup>4</sup> Thus, it could be implied that the number of individuals with T2DM will increase.

Diabetes mellitus is a chronic condition associated with increasing healthcare expenses and a 2–4 times higher risk of cardiovascular disease.<sup>5</sup> Individuals with T2DM encounter numerous challenges in managing their blood glucose levels,<sup>6,7</sup> including access to healthcare services, adherence to medication regimens and lifestyle modifications, as well as coping with the complexity of treatment regimens. Managing T2DM requires a comprehensive strategy that includes both non-pharmacological interventions, such as lifestyle changes, and pharmacological treatments.<sup>3</sup> In terms of pharmacological

treatments, various types of medication are available for treating diabetes, and the choice of treatment depends on the underlying mechanisms of the disease.

Insulin is a widely used medication for controlling plasma glucose levels and achieving glycemic targets.<sup>3</sup> Insulin administration as part of diabetes treatment requires a considerable degree of patient engagement and cooperation, as individuals are responsible for self-administering the insulin. Challenges may arise from inadequate insulin management, such as incorrect dosing and inappropriate insulin injection techniques resulting in lipohypertrophy or inadvertent injection into muscle tissue.<sup>8</sup> Inappropriate insulin administration can precipitate adverse outcomes, including episodes of hypoglycemia or an inability to attain a glycemic target. Consequently, it is imperative to train patients regarding insulin management to achieve glycemic targets and optimize diabetes management.

Interventions for individuals with T2DM, especially educational intervention, were studied and implemented to help them overcome challenges in insulin management. Diabetes education is an essential component in insulin management and plays an important role in several aspects. Health education improves patients' knowledge, attitudes, and practices, particularly with regard to lifestyle modifications and dietary management, resulting in better glycemic control.<sup>9</sup> In addition, a low level of knowledge of diabetes demonstrates deficits in self-management and low quality of life. It is correlated with low satisfaction with treatment, which will help maintain patients' adherence to the treatment.<sup>10</sup> However, the education process is complex and affected by several factors, primarily patients' psychosocial and demographic characteristics, as well as educator-related issues. Given the importance of educational intervention for individuals with T2DM and the complex education process, the knowledge gap is a lack of understanding of the educational approach to educational interventions for individuals with insulin-treated T2DM.

This systematic review aims to contribute to the existing body of knowledge by comprehensively examining the available literature on educational interventions for individuals with insulin-treated T2DM. Understanding the effectiveness of different educational approaches is vital for healthcare professionals, educators, and policymakers seeking to optimize diabetes care. By synthesizing and critically evaluating the evidence, this review will provide insights into the strengths and limitations of current interventions, potentially identifying gaps in knowledge and areas for further research. Ultimately, the findings of this systematic review have the potential to inform the development of evidence-based guidelines and recommendations for healthcare providers, enhancing the quality of care and outcomes for individuals with insulin-treated T2DM.

## Objective

To evaluate and synthesize evidence on the impact of educational interventions for individuals with insulin-treated type 2 diabetes mellitus.

## Methods

### Identify Relevant Studies

We adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines<sup>11</sup> in this systematic review to illustrate the process of literature identification, screening, exclusion, and inclusion. In February 2024, we conducted a comprehensive search across five electronic databases—Scopus, PubMed, Medline, CINAHL Plus with Full Text, and Web of Science—to locate relevant studies published between 2019 and 2024 to capture the most recent advancements and innovations in educational interventions for diabetes care. This period reflects the latest practices, integrates new digital health tools, aligns with updated clinical guidelines, and ensures high-quality evidence, making our review relevant and comprehensive. As our aim was to examine the impact of educational interventions on individuals with insulin-treated T2DM, we utilized a combination of search terms (“Education” AND “Type 2 Diabetes” AND “Insulin”) with Boolean operators. Additionally, we manually reviewed the reference lists of included studies to find further relevant research. All identified references were managed using EndNote.

## Study Selection

Titles and abstracts were initially screened to identify eligible studies. Subsequently, the full texts of these studies were assessed for relevance. To ensure that only studies pertinent to our objective were included, we applied specific inclusion criteria. Conversely, exclusion criteria were utilized to discard literature that did not align with the scope of the review (see [Table 1](#)).

## Data Extraction

The standardized chart for data extraction will be developed for this review, including the following data for each study: Reference, Year, Country, Study Design, Sample Size, Focus Population, Age (Mean), Objective, Educational intervention included in the study, Professions Involved, Main results describing the impact of educational intervention in individuals with insulin-treated T2DM, The impact of educational intervention in individuals with insulin-treated T2DM (Theme), and Suggestions for future research ([Supplementary Table 1](#)).

## Data Synthesis

In this review, we employed the convergent integrated analysis framework recommended by the Joanna Briggs Institute for systematic reviews to synthesize data from the included studies.<sup>12</sup> During the data synthesis process, we extracted themes from the key findings by analyzing the similarities and differences between these main findings. Additionally, sub-themes were abstracted as necessary, focusing on the more specific targets of the corresponding findings, in a manner akin to the approach used by qualitative researchers to generate theme.

## Results

### Search Results

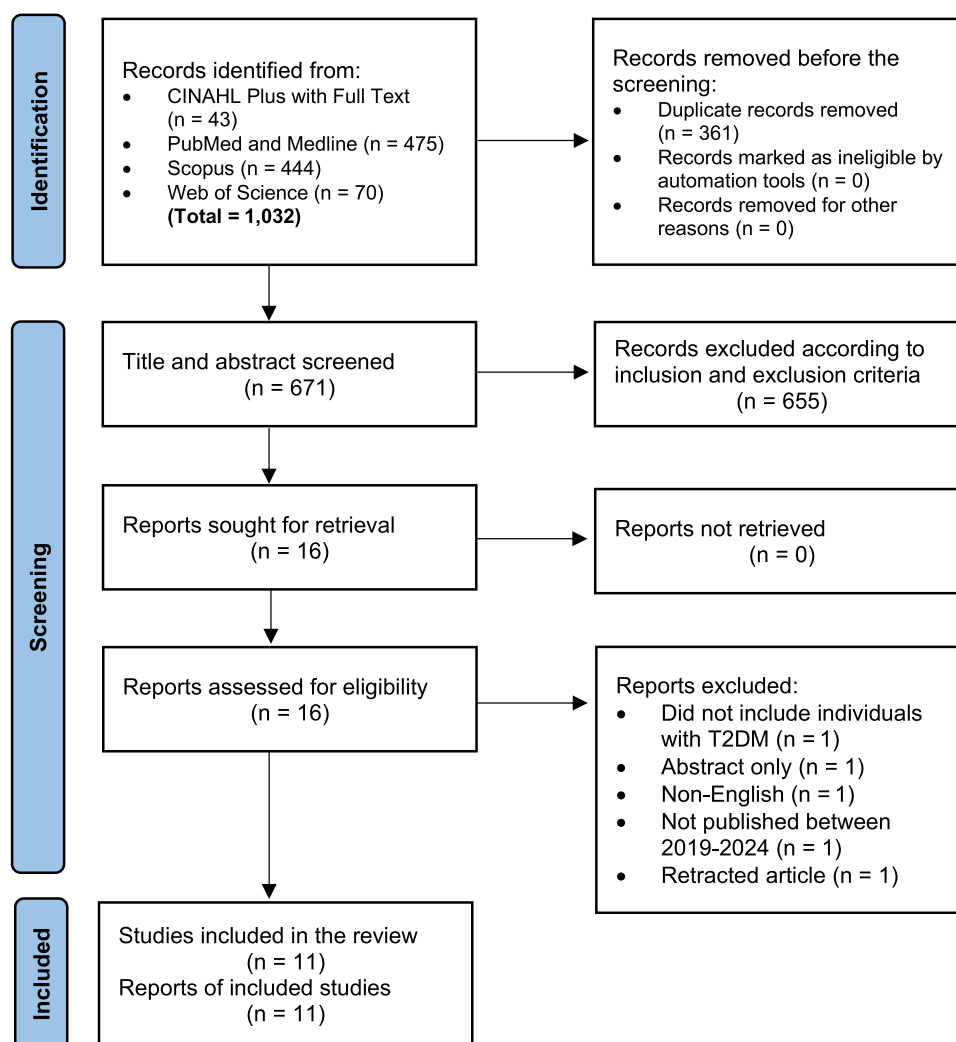
A total of 1,032 records were identified from CINAHL Plus with Full Text (N = 43), PubMed, and Medline with full text (N = 475), Scopus (N = 444), and Web of Science (N = 70). No additional records were identified through other resources. Results with abstracts were subsequently exported into Endnote. Of the 1,032 articles, 361 duplicates were removed, and 671 records were screened for eligibility. After applying the inclusion and exclusion criteria, 655 articles were excluded as they were irrelevant to the topic of interest, leaving 16 articles eligible for full-text screening. Subsequently, 5 articles were excluded for the following reasons: did not include individuals with T2DM (N = 1), published abstract only (N = 1), non-English publication (N = 1), not published between 2019–2024 (N = 1), and retracted article (N = 1), leaving 11 articles eligible for full-text screening, all of which were included in this review ([Figure 1](#)).

### Characteristics of Included Studies

Characteristics of the included studies are presented in [Table 2](#). The majority of these studies were published in 2022 (N = 3, 27.27%), 2021 (N = 3, 27.27%), and 2019 (N = 3, 27.27%), with primary locations being China (N = 2, 18.18%), Italy (N = 2, 18.18%), and Spain (N = 2, 18.18%). The study designs were diverse: four studies (36.36%) were Randomized Controlled Trials, and four (36.36%) were Quasi-Experimental Studies. Other designs included Non-Randomized Controlled Trials, Observational Prospective Studies, and Not Specified, each accounting for 9.10%. The sample sizes varied, ranging from 1 to

**Table 1** Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
<ul style="list-style-type: none"> <li>Human participants aged 18 years and above</li> <li>Original quantitative study published in English between 2019–2024</li> <li>Investigate the impact of educational intervention in individuals with insulin-treated T2DM</li> <li>All types of settings are acceptable</li> </ul>	<ul style="list-style-type: none"> <li>The study did not include the population of interest</li> <li>Conference proceeding, abstract, review article, protocol, letter to editor, point or viewpoints, dissertation, and grey literature</li> </ul>



**Figure 1** PRISMA Flow Chart.

**Adapted from:** Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ* 2021;372:n71. doi: 10.1136/bmj.n71.<sup>13</sup>

100 (N = 3, 27.27%), between > 100 and 300 (N = 6, 54.54%), and more than 300 (N = 2, 18.18%). Professionals involved in educational intervention included Nurses (N = 5, 38.46%), Endocrinologists (N = 1, 7.69%), and Medical Staff (N = 1, 7.69%). Participant age, focus population, and educational interventions included in the study varied and can be found in [Table 2](#).

## The Impact of Educational Intervention in Individuals with Insulin-Treated T2DM

A summary of the findings on the impact of educational intervention on individuals with insulin-treated T2DM is provided in [Table 3](#). According to the data synthesis, five major themes have emerged: 1) Glycemic control (including subthemes such as improving HbA1C, decreasing postprandial plasma glucose (PPG), and decreasing fasting plasma glucose (FPG)), 2) Insulin-related complications (including subthemes such as reducing hypoglycemic events and reducing the size of lipohypertrophy), 3) Knowledge Attitude Practice (KAP) (including subthemes such as engaging in self-management, improving insulin injection technique, improving knowledge, and improving the attitude toward insulin treatment), 4) Optimal dose of insulin, and 5) Improving quality of life.

**Table 2** Characteristics of Included Studies

Characteristics	Number of included studies (N)*	Percentage (%)
<b>Publication Year</b>		
2018	1	9.10
2019	3	27.27
2020	1	9.10
2021	3	27.27
2022	3	27.27
<b>Country</b>		
China	2	18.18
Italy	2	18.18
Spain	2	18.18
The Netherland	1	9.10
Romania	1	9.10
Vietnam	1	9.10
Brazil	1	9.10
Indonesia	1	9.10
<b>Study Design</b>		
Randomized Controlled Trial	4	36.36
Quasi-Experimental	4	36.36
Non-Randomized Controlled Trial	1	9.10
Observational Prospective Study	1	9.10
Not Specify	1	9.10
<b>Sample Size</b>		
1–100	3	27.27
>100–300	6	54.54
>300	2	18.18
<b>Professional Involved in Educational Intervention</b>		
Nurse	5	38.46
Endocrinologist	1	7.69
Medical Stuff (Not Specify)	1	7.69
Not Specify	6	46.15

**Notes:** \*One study may report more than one characteristic; the total number of included studies can be > 11.

**Table 3** The Impact of Educational Intervention on Individuals with Insulin-Treated Type 2 Diabetes Mellitus

Reference	Themes										
	Glycemic control			Insulin-related complications		Knowledge Attitude Practice (KAP)				Optimal dose of insulin	Improving quality of life
	Improving HbA1C	Decreasing postprandial plasma glucose (PPG)	Decreasing fasting plasma glucose (FPG)	Reducing hypoglycemic event	Reducing the size of lipohypertrophy	Engaging in self-management	Improving insulin injection technique	Improving knowledge	Improving the attitude toward insulin treatment		
[14]	x			x							
[15]	x		x							x	
[16]	x										
[17]	x			x		x					x
[18]	x	x	x								
[19]							x	x			
[20]	x		x	x						x	
[21]				x	x		x				
[22]	x		x								
[23]								x			
[24]								x	x		
Number (%)	7 (63.63%)	1 (9.09%)	4 (36.36%)	4 (36.36%)	1 (9.09%)	1 (9.09%)	2 (18.18%)	3 (27.27%)	1 (9.09%)	2(18.18%)	1 (9.09%)

## Glycemic Control

### Improving HbA1C

Our review found that educational interventions significantly improve HbA1C in individuals with insulin-treated T2DM, as indicated by seven included studies.<sup>14–18,20,22</sup> For example, a prospective multicenter, randomized parallel-group study assessed the impact of structured education on glycemic control, evaluated with HbA1C, and on the achievement of individualized HbA1C targets when provided to individuals with T2DM at the initiation of basal insulin therapy.<sup>14</sup> The results found that median HbA1C levels at six months after the start of basal insulin were significantly lower in the structured education group than in the control group (7.2% vs 7.4%,  $p < 0.001$ ).<sup>14</sup> Similarly, a study by Bellido et al evaluated whether the eStar program (weekly telephone sessions until individuals with insulin-treated T2DM reached the glycemic target; after that, calls were scheduled monthly for six months) was effective in helping individuals with insulin-treated T2DM reach their optimal insulin glargine dose within six months.<sup>15</sup> The results showed that after six months, significant reductions in mean HbA1C levels were observed in both groups: 1.49% ( $p < 0.001$ ) for the intervention group and 1.08% ( $p < 0.001$ ) for the control group.<sup>15</sup>

### Decreasing Postprandial Plasma Glucose (PPG)

Our review found that education and mobile health management have a significant impact on improving blood glucose levels in individuals with insulin-treated T2DM, particularly in decreasing postprandial plasma glucose (PPG) levels. A study by Chai et al determined the effectiveness of education and mobile health management, such as education sessions by nurses and medical staff, as well as video conferences on diabetes education.<sup>18</sup> The results demonstrated that the PPG levels of 209 individuals with insulin-treated T2DM had decreased significantly at week 16 compared to the first week of intervention (10.4 mmol/l vs 9.5 mmol/l,  $p < 0.001$ ).<sup>18</sup>

### Decreasing Fasting Plasma Glucose (FPG)

Four studies in our review consistently found that fasting plasma glucose (FPG) significantly decreased following various educational interventions.<sup>15,18,20,22</sup> A randomized, open-label, comparative, crossover trial by Gentile et al aimed to compare glycemic control associated with a concentrated insulin analog preparation (U-200 lispro) in individuals with T2DM to that observed with standard U-100 lispro.<sup>20</sup> The outcomes showed that FPG significantly improved after receiving U-200 treatment through a six-month structured education-based rehabilitation protocol on best insulin injection practices, with monthly phone reminders.<sup>20</sup> Similarly, a quasi-experimental, nonequivalent, two-group comparison design by Huang et al found that after receiving a nurse-led online educational program, at three- and six- months post-intervention, the compliance rates of FPG between the intervention and control groups were statistically significant, with the intervention group exhibiting higher compliance rates.<sup>22</sup>

## Insulin-Related Complications

### Reducing Hypoglycemic Event

In our review, four studies collectively demonstrated the efficacy of educational interventions in reducing insulin-related complications, particularly hypoglycemic episodes.<sup>14,17,20,21</sup> For instance, one study implemented a therapeutic education program led by a diabetes specialist nurse, conducted as a prospective, longitudinal study spanning three phases over six months. This program included individual on-site sessions, telephone consultations, and group visits. After the program's completion, there was a significant decrease in hypoglycemic episodes ( $2.52 \pm 1.66$  versus  $0.53 \pm 1.06$ ;  $p < 0.05$ ).<sup>17</sup> Likewise, Gentile et al conducted a randomized controlled trial aiming to assess an intensive, structured, education-based rehabilitation protocol aimed at maintaining proper insulin injection techniques and their relationship with metabolic control, particularly in reducing the occurrence of hypoglycemia. The findings indicated a reduction in the rate of hypoglycemic episodes among participants in the intervention group ( $p < 0.05$ ), resulting in a significant difference between groups after six months ( $p < 0.02$ ).<sup>20</sup>

### Reducing the Size of Lipohypertrophy

In our review, it was identified that a particular educational intervention yielded a notable impact on the size of lipohypertrophy.<sup>21</sup> Specifically, Gentile et al conducted a two-arm, open-label, multicentered, randomized case-control



study. The study aimed to evaluate the durability of structured education effects by monitoring the injection habits and metabolic outcomes of well-trained participants. The study spanned six months and involved educating participants on insulin injection techniques, coupled with monthly phone reminders at intervals of one, two, four, and five months. Following the six-month educational protocol, a reduction in the size of lipohypertrophy at injection sites was observed ( $p < 0.02$ ).<sup>21</sup>

## Knowledge Attitude Practice (KAP)

### Engaging in Self-Management

Improve self-management is a cornerstone practice for diabetes control in individuals with insulin-treated T2DM; this study was conducted in 2021 by Cabré Font et al in Spain, providing a six-month structured therapeutic education program, including a diabetes specialist nurse, in individuals with insulin-treated T2DM attending primary care facilities. This prospective, six-month longitudinal educational study included three phases: personalized education, group education, and follow-up (on-site and telephone visits). This study's findings showed that the participants had significantly improved adherence to self-management at the end of the six-month intervention ( $p < 0.05$ ).<sup>17</sup>

### Improving Insulin Injection Technique

Insulin injection is a complex and vital practice in individuals with insulin-treated T2DM associated with achieving glycemic control as found in two included studies.<sup>19,21</sup> For example, Gentile et al conducted this study in Italy in 2021. It was a two-arm, open-label, multicenter, randomized, case-control study. The intervention group received a structured education session embedded in injection technique education-based rehabilitation sessions at the beginning and then the three-month of the program, and a monthly telephone reminder at one, two, four, and five-month, respectively. The findings depict different behaviors over time. The intervention group achieved a slightly improved insulin injection technique performance, with a 2- to 3.8-fold decrease in negative behavioral basis ( $p < 0.001$ ). On the other hand, the control group performed gradually worse over the six-month follow-up period ( $p < 0.001$ ).<sup>21</sup>

### Improving Knowledge

This review highlights the positive impact of educational interventions on the knowledge of individuals with insulin-treated T2DM.<sup>19,23,24</sup> For instance, Miranda et al conducted a study in Brazil in 2022 using a randomized controlled trial with a problematizing pedagogical methodology. The intervention group participated in six monthly educational sessions, while the control group received usual care. The study assessed outcomes at three-time points: recruitment, three months, and six months. Participants in the intervention group demonstrated a significant increase in diabetes knowledge over time compared to the control group ( $p < 0.05$ ).<sup>23</sup>

### Improving the Attitude Toward Insulin Treatment

Our review found that educational intervention enhances patient's attitudes regarding insulin therapy. Ratri et al conducted a one-group pretest-posttest design study in Indonesia. This study provides a six-minute educational video encompassing two parts of information, including information about T2DM and insulin therapy for individuals with insulin-treated T2DM. The insulin-related knowledge and attitudes toward insulin treatment were measured before and after watching the video. This study revealed increased patient knowledge and a positive attitude toward insulin treatment after watching the educational video ( $p < 0.05$ ).<sup>24</sup>

## Optimal Dose of Insulin

Our study found that telephone-delivered intervention could help individuals with insulin-treated T2DM obtain optimal insulin doses, as shown by the results indicating that the number of participants who achieved appropriate glycemic control in the intervention group was higher than in the control group.<sup>15</sup> Additionally, significant changes in glycemic control, measured by HbA1C as well as fasting blood glucose, were found after completing the six-month telephone-delivered program in the intervention group.<sup>15</sup> In another study comparing treatment using U-100 lispro with U-200 lispro, it was found that U-200 lispro treatment significantly improved fasting blood glucose, HbA1C, severe or mild hypoglycemic rates, and daily fast-acting insulin analog dose during both the baseline period and the end of the U-100 lispro usage period.<sup>20</sup>



## Improving Quality of Life

One included study reported that educational intervention helps improve the quality of life of individuals with insulin-treated T2DM.<sup>17</sup> According to Font et al individuals with insulin-treated T2DM were provided with a six-month therapeutic education program administered by a diabetic specialist nurse, and they were evaluated before and after the intervention. The results showed that the participant's perception of quality of life post-intervention had significantly improved ( $p < 0.05$ ).<sup>17</sup>

## Discussion

The findings of this systematic review indicate that educational interventions significantly improve HbA1C levels in individuals with insulin-treated T2DM. Seven studies demonstrated substantial reductions in HbA1C following educational programs.<sup>14–18,20,22</sup> These findings suggest that personalized and structured educational approaches, whether through in-person or remote support, are effective in enhancing glycemic control as measured by HbA1C.

The success of these interventions can be attributed to several factors. First, structured education helps individuals with insulin-treated T2DM understand the importance of glycemic control and provides them with the necessary skills to manage their insulin therapy effectively.<sup>25,26</sup> Second, regular follow-up and support, such as through telephone consultations, ensure continuous engagement and adherence to the prescribed treatment regimen.<sup>27,28</sup> Lastly, including individualized targets and personalized education ensures that interventions are tailored to meet each individual's specific needs, thereby maximizing the potential for improved outcomes.<sup>29</sup> Educational interventions have also been shown to decrease postprandial plasma glucose (PPG) levels significantly.<sup>18</sup> This suggests that integrating technology with traditional educational approaches can enhance participant engagement and adherence, leading to better postprandial glycemic control. The reduction in PPG levels can be particularly important for managing T2DM as postprandial hyperglycemia is a known risk factor for cardiovascular complications.<sup>30</sup> By focusing on PPG, educational interventions not only improve overall glycemic control but also potentially reduce the risk of diabetes-related complications.<sup>31</sup> This dual benefit underscores the importance of incorporating PPG management into educational programs for individuals with insulin-treated T2DM.

Four studies included in this review consistently reported significant decreases in fasting plasma glucose (FPG) following educational interventions.<sup>15,18,20,22</sup> The success of these interventions in reducing FPG can be linked to improving the participants' knowledge and adherence to insulin therapy. Education that emphasizes the correct timing and technique of insulin injections, as well as lifestyle modifications such as diet and exercise, plays a crucial role in achieving optimal FPG levels.<sup>32,33</sup> Furthermore, continuous support and follow-up, whether through in-person sessions or online programs, help reinforce these behaviors, ensuring sustained improvements in glycemic control.<sup>32–34</sup>

Hypoglycemic events and lipohypertrophy are two common insulin-related complications.<sup>35</sup> Hypoglycemia poses a significant risk, while lipohypertrophy has been associated with elevated HbA1C levels and greater daily insulin requirements.<sup>36</sup> Four studies examined in our review demonstrated that educational interventions have the potential to decrease occurrences of hypoglycemia<sup>14,17,20,21</sup> while one study identified the efficacy of educational interventions in diminishing lipohypertrophy.<sup>21</sup> These findings are consistent with a study investigating an educational program targeted at reducing the severity of hypoglycemia, which observed a significant decrease in the frequency of severe hypoglycemia among participants.<sup>37</sup> Educational interventions typically encompass knowledge proven to be effective in reducing both hypoglycemic events<sup>38</sup> and lipohypertrophy.<sup>21</sup> The topic should cover the importance of glycemic control, lifestyle modification, self-monitoring of blood glucose, insulin's mechanism of action, device usage training, and injection techniques for insulin management.<sup>14</sup>

Implementation of such a program can be carried out by various healthcare professionals, including nurses, diabetes specialist nurses, or multidisciplinary teams. An effective educational program within this context should be a tailored approach, and adaptable enough to accommodate the individual needs of patients.<sup>39</sup> Furthermore, the integration of follow-up and reinforcement strategies becomes imperative to sustain patient engagement and adherence to the program.<sup>40</sup> Utilizing methods such as personal visits or telephone calls can serve as valuable tools to both motivate and remind patients of their

commitments and responsibilities throughout the program's duration. These strategies not only reinforce the educational content delivered but also foster a supportive environment conducive to the patient's overall well-being and progress.<sup>41,42</sup>

The present study found that educational interventions significantly improved diabetes-related knowledge among individuals with insulin-treated T2DM. Studies by Chu et al, Miranda et al, and Ratri et al demonstrate the positive effects of educational programs on the participants' knowledge,<sup>19,23,43</sup> and enhanced knowledge serves as a foundation for improved self-management practices and leads to better glycemic control. Moreover, Cabré Font et al also found that participants who received educational intervention were more likely to adhere to recommended self-management practices.<sup>17</sup> Chu et al and Gentile et al reported that educational programs significantly enhanced the participant's insulin injection skills, leading to more effective insulin administration.<sup>19,20</sup> As mentioned in a previous study, knowledge gained from educational interventions helps individuals with insulin-treated T2DM understand the importance of various aspects of diabetes management.<sup>44</sup> This includes choosing appropriate foods, adhering to medication regimens, using correct insulin injection techniques, and managing complications associated with diabetes and insulin injections.<sup>44,45</sup>

Receiving insulin treatment may be perceived as a sign of worsening diabetes and can be stigmatizing. This perception can cause a negative attitude towards diabetes and insulin treatment, potentially leading to poor diabetes management.<sup>46</sup> Therefore, reducing negative attitudes or fostering positive attitudes towards diabetes and insulin treatment is crucial for effective diabetes management in individuals with insulin-treated T2DM.<sup>47</sup> Enhancing knowledge of diabetes and insulin treatment through educational interventions was demonstrated to improve attitude in individuals with insulin-treated T2DM.<sup>43</sup> This can be explained by the evidence that educational interventions can significantly improve knowledge and attitudes by raising individuals' understanding of diabetes and insulin treatment, reducing stigmatization, and boosting their confidence in engaging in self-management practices. These contribute to improved adherence to insulin treatment and glycemic control.<sup>9,48,49</sup>

Consistent with our findings, previous studies have shown that educational programs, including insulin administration and appropriate techniques, can encourage individuals with insulin-treated T2DM to achieve the optimal dose of insulin.<sup>32,50</sup> For example, Silva & Bosco (2015) found that group discussions and practical workshops on adjusting basal and bolus insulin doses improved glycemic control after a 12-week program.<sup>50</sup> Similarly, an educational program about a new automatic injector for adults with T2DM enhanced insulin injection techniques.<sup>32</sup> Techniques such as properly remixing cloudy insulin, lifting a skin fold, releasing at a 90-degree angle, keeping the pen needle beneath the skin for more than 10 seconds, and rotating the injection site and pen needle after each administration were beneficial for individuals with T2DM. These practices resulted in improved glycemic control.<sup>32</sup>

Our findings reported that educational intervention significantly improved the quality of life of individuals with insulin-treated T2DM. Educational interventions provide information regarding the condition and its treatment, enabling individuals with insulin-treated T2DM to develop self-management skills and improve self-management capabilities, which in turn improve their quality of life.<sup>51</sup> Our findings align with previous studies. A quasi-experimental study of the effects of socio-educational programs among patients with digestive ostomies reported an increase in their quality of life. In addition to patients' quality of life, educational intervention helps improve their caregivers' quality of life.<sup>52</sup> A randomized controlled trial of the effect of educational intervention among family caregivers of hemodialysis reported improved quality of life after educational programs.<sup>53</sup> A systematic review of the effectiveness of educational interventions among parents and children with food allergies also reported a significant improvement in quality of life.<sup>51</sup>

## Study Limitations

Despite the positive findings, this systematic review has several limitations. Firstly, the heterogeneity of the educational interventions, including variations in content, delivery methods, duration, and frequency, complicates the identification of the most effective components. Additionally, many studies had short follow-up periods, raising questions about the long-term sustainability of observed improvements in glycemic control. The diversity of study populations, often limited to specific geographic locations, may affect the generalizability of the results. Finally, the review's restriction to English-language studies introduces potential publication and language bias, possibly excluding relevant research in other languages.

## Conclusion

Educational interventions are a crucial element in diabetes care, particularly for individuals with insulin-treated T2DM. These interventions have been shown to significantly enhance diabetes-related knowledge, improve attitudes towards diabetes and insulin treatment, and foster better self-management practices, including proper insulin injection techniques. Moreover, they lead to improved glycemic control and quality of life. Evidence also indicates that educational interventions can reduce complications such as hypoglycemia and lipohypertrophy. Therefore, it is recommended that healthcare settings develop and provide tailored educational programs for individuals with insulin-treated T2DM to optimize their outcomes and reduce complications.

## Supplementary Material

The Supplementary Material for this article can be found online.

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## Disclosure

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