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Evaluation of the Impact of Health Education Programs on Diabetic Patients' Behavior

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ABSTRACT

Background: Diabetes mellitus is a chronic metabolic disorder that needs to be managed on a constant basis in order to avoid complications and improve glycemic control. Lack of knowledge and unhealthy behaviors are major contributing factors to poor outcomes in patients with diabetes mellitus. The aim of this study was to assess the effect of a structured health education program on behavioral change and glycemic control in patients with type 2 diabetes mellitus.

Methods: A quasi-experimental pre-post design was employed on adult patients with type 2 diabetes (n=120) attending outpatient facilities. The pre-test included socio-demographic information, diabetes knowledge, and self-care practices (dietary compliance, exercise, medication, and self-blood glucose monitoring). Glycemic control was measured by assessing glycated hemoglobin (HbA1c) levels. The intervention comprised a structured health education program conducted over six sessions and six weeks, employing lectures, group discussions, demonstrations, and health education booklets. The post-test was administered three months after the completion of the health education program. Statistical analysis was carried out employing the paired t-test and chi-square test, with a p-value of <0.05.

Results: Post-intervention analysis showed a statistically significant increase in mean knowledge scores ($p < 0.001$). Adherence to recommended dietary habits rose from 45% to 78%, exercise habits from 30% to 65%, medication regularity from 60% to 88%, and regular blood glucose monitoring from 35% to 70% ($p < 0.05$). Mean HbA1c values significantly reduced from 8.9% ± 1.2 to 7.4% ± 0.9 ($p < 0.001$) after the intervention. Improvement in behavior was more evident in patients with recent diagnoses than those with established disease.

Conclusion: The structured health education program significantly improved self-care behaviors and glycemic control among patients with type 2 diabetes. Early and continuous educational interventions are recommended as essential components of diabetes management to enhance long-term behavioral adherence and reduce complications.

Keywords: *Diabetes mellitus; health education; self-care behavior; glycemic control; HbA1c; lifestyle modification;*

patient education.

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1. INTRODUCTION

Diabetes mellitus is one of the most common chronic metabolic disorders in the world and a significant public health problem due to its rapidly growing prevalence and association with serious short-term and long-term complications. It is defined by chronic hyperglycemia caused by defects in insulin secretion, insulin action, or both. Chronic hyperglycemia leads to a series of complications in various organs, including the kidneys, retina, peripheral nerves, heart, and blood vessels, due to the prolonged exposure of these organs to high blood glucose levels. The growing prevalence of diabetes mellitus has resulted in increased healthcare costs, productivity losses, and significant social and economic burdens. Therefore, the need for effective management approaches that integrate pharmacologic therapy with lifestyle changes and patient education has become an integral part of comprehensive diabetes management

Type 2 Diabetes Mellitus (T2DM) represents the predominant form of diabetes and is closely associated with modifiable risk factors like obesity, improper dietary practices, and a sedentary lifestyle. The importance of early diagnosis cannot be overstated, as patients often remain asymptomatic for many years while the underlying metabolic and vascular derangements continue to progress. The criteria for diagnosis are based on laboratory values such as fasting plasma glucose, glucose tolerance test, glycated hemoglobin (HbA1c), or random plasma glucose in the setting of typical symptoms. Proper categorization and diagnostic criteria are the basic building blocks of appropriate management strategies and the prevention of disease progression. Additionally, early diagnosis enables the prompt implementation of lifestyle and pharmacologic management strategies, thus lowering the chances of developing complications (American Diabetes Association, 2022).

However, the management of diabetes involves much more than the administration of drugs. While pharmacotherapy is an important aspect of managing blood glucose levels, overall outcomes are dependent on patients' self-care practices. These practices include following dietary advice, regular exercise, taking medications correctly, self-monitoring of blood glucose, and regular attendance at medical appointments. The lack of these practices leads to poor glycemic control and an increased risk of both microvascular and macrovascular complications. Thus, patient education and empowerment to manage the condition is a fundamental aspect of contemporary diabetes care.

Among the most severe complications of diabetes is chronic kidney disease (CKD), which is a major cause of morbidity and mortality in diabetic patients. Diabetes is known to be the main cause of CKD worldwide, and the co-existence of both conditions has been observed to pose a substantial risk of cardiovascular events. There is a need for integrated management approaches that can simultaneously target glycemic control, blood pressure management, lipid control, and renal protection. The consensus guidelines underscore the need for personalized management strategies, shared decision-making, and continuous patient engagement to maximize outcomes in patients with diabetes and CKD (De Boer et al., 2022). The guidelines also underscore the importance of patient education and compliance with treatment regimens in slowing the progression of the disease and preventing complications.

Despite the presence of clinical guidelines and the development of pharmacological interventions, a substantial number of patients with T2DM remain inadequately controlled in terms of glycemic control. This can be largely considered due to a lack of understanding, misconceptions about the disease, poor health literacy, lack of access to education, and a lack of behavioral support. Patients may not appreciate the severity of the disease, may not comprehend the instructions related to medications, or may not be able to make lifestyle modifications.

Self-management education programs have been acknowledged as effective interventions for people with T2DM. These programs usually involve structured sessions that cover key areas of diabetes management, such as understanding the pathophysiology of diabetes, meal planning, carbohydrate counting, physical activity advice, medication management, hypoglycemia and hyperglycemia prevention, and early detection of complications. Evidence from systematic reviews and meta-analyses has shown that group-based self-management education is effective in improving glycemic control and self-management practices compared to standard care alone. Structured educational interventions have been found to result in significant reductions in HbA1c values and improvements in lifestyle adherence (Odgers-Jewell et al., 2017).

Group-based education offers additional psychosocial benefits, including peer support, shared experiences, and mutual encouragement, which may enhance motivation and accountability. Interaction among participants allows individuals to learn practical coping strategies from others facing similar challenges. Furthermore, group settings may foster a sense of community and reduce feelings of isolation often experienced by patients with chronic diseases. These social dynamics contribute positively to behavioral change and sustained adherence.

The effectiveness of health education programs is influenced not only by content but also by the method of delivery. Communication strategies that ensure patient understanding are essential, particularly among individuals with limited health literacy. The teach-back method is an interactive communication approach in which patients are asked to repeat key information in their own words to confirm comprehension. This method enables healthcare providers to identify misunderstandings and clarify instructions immediately. Research has demonstrated that the teach-back method significantly improves adherence and self-management behaviors in chronic disease populations, including individuals with diabetes (Ha Dinh et al., 2016). By reinforcing understanding and promoting active participation, this approach strengthens patients' confidence and capacity to manage their condition effectively.

Patient empowerment is another fundamental principle in diabetes care. Empowerment involves equipping individuals with the knowledge, skills, and confidence necessary to make informed decisions about their health. When patients actively participate in setting goals and selecting treatment options, they are more likely to adhere to recommended behaviors. Patient-centered care models emphasize shared decision-making, individualized treatment planning, and continuous educational support as key determinants of successful disease management (American Diabetes Association, 2022). Such approaches recognize that behavioral change is a complex process influenced by psychological readiness, cultural context, and environmental factors.

2. METHODOLOGY

Study Design

The study employed a quasi-experimental pre-post design with a single group of participants, without a parallel control group. The quasi-experimental design was specifically selected to evaluate the effect of a structured health education program on knowledge, self-care practices, and glycemic control in patients with type 2 diabetes mellitus in a real-world clinical setting. Quasi-experimental designs are especially useful in health education studies when randomization and withholding a potentially beneficial intervention may raise ethical issues. By evaluating the outcomes at baseline (pre-intervention) and three months post-completion of the health education program, the design allowed for direct comparison within the group to identify changes attributable to the health education program. The three-month follow-up point was chosen to allow sufficient time for the participants to translate learned behaviors into everyday practice, and hence, observable changes in regular self-care practices and glycemic control, as indicated by HbA1c levels.

Despite the lack of a control group, which makes it difficult to completely exclude the effects of external variables such as the natural course of the disease and simultaneous improvements in healthcare, the use of objective criteria, such as HbA1c levels and research instruments, helped to reduce bias. This is in line with the global guidelines for the evaluation of diabetes self-management education and support (DSMES) programs, as recommended by the American Diabetes Association (ADA), the International Diabetes Federation (IDF), and the World Health Organization (WHO). These bodies recommend a pragmatic approach that focuses on patient benefit and feasibility in clinical practice, while also providing evidence for educational interventions. The total duration of the study included recruitment and follow-up periods of about 12 months to account for seasonal changes.

Study Setting

The study was carried out in outpatient diabetes clinics affiliated with university hospitals and public health centers that handle large numbers of patients with type 2 diabetes. These centers were considered ideal because of their multidisciplinary setup, which includes endocrinologists, certified diabetes educators, nurses, dietitians, and availability of certified laboratories for accurate biochemical testing. The centers have education rooms equipped with necessary audiovisual aids, such as projectors, whiteboards, anatomical models, food replicas, glucometers, and foot care demonstration kits. This setting provided for interactive and hands-on learning, which is essential for adult education in the management of chronic diseases. The outpatient setting ensured that the participants were patients actively involved in current diabetes management, making the study more relevant and applicable to clinical practice.

Target Population and Sampling

The target population was adult patients with existing type 2 diabetes mellitus who were regulars at the selected outpatient clinics. A non-probability consecutive sampling method was used, where eligible patients were approached during their visits until the target sample size was achieved. This method was useful in a busy healthcare setting and also helped to reduce selection bias by approaching patients consecutively. The final sample size consisted of 120 patients, who were

divided into six smaller groups of 20 patients each for the educational sessions. The smaller groups were given priority to enable effective interaction and discussion among the patients, which is in line with adult learning principles that focus on collaborative and experiential learning.

Inclusion and Exclusion Criteria

Inclusion criteria were set to recruit participants who would likely benefit from and actively participate in the program. Participants were adults aged 18 years or older with a confirmed diagnosis of type 2 diabetes for at least six months, ensuring familiarity with basic management, including both newly diagnosed and established patients. Regular clinic attendance for logistical follow-up was required, and participants must have adequate literacy or understanding of the primary language to participate in the program. Written informed consent was mandatory.

Exclusion criteria were set to exclude conditions that may cause confounding of results or hinder participation. Patients with type 1 diabetes, gestational diabetes, or established complications (such as end-stage renal disease, advanced heart failure, or established retinopathy requiring urgent treatment) were excluded due to differences in management. Patients with cognitive impairment, severe psychiatric illness, or recent attendance at similar structured education programs (within the past year) were excluded to avoid carry-over effects and ensure equal starting knowledge.

Sample Size Calculation

Sample size was calculated using the G*Power software, based on the effect size from meta-analyses of interventions for diabetes education, which reported moderate to large reductions in HbA1c (0.8-1.5% absolute decrease). Using a paired design, with 80% power, alpha = 0.05, and accounting for 15% attrition, a sample size of 120 participants was required to detect significant pre-post changes in primary outcomes (knowledge scores, self-care adherence rates, and HbA1c). The sample size also allowed for subgroup analysis, for example, by disease duration or baseline glycemic status.

Data Collection Instruments

The data were collected using proven and culturally validated instruments that have been shown to be reliable in the field of diabetes.

1) Socio-demographic and Clinical Questionnaire: A structured questionnaire was used to obtain data on age, gender, education, occupation, income, diabetes duration, treatment regimen, and presence of comorbid conditions for descriptive and exploratory purposes.
2) Diabetes Knowledge Assessment: The 24-item Diabetes Knowledge Questionnaire (DKQ-24) was used to assess knowledge of pathophysiology, complications, nutrition, exercise, medications, and monitoring. Scoring was done as a percentage, and it has been shown to be highly reliable (Cronbach's alpha > 0.85).
3) Self-Care Behaviors: The Summary of Diabetes Self-Care Activities (SDSCA) instrument, adapted to 12 items, was used to assess the frequency of diet, exercise, medication, and blood glucose self-monitoring in the past week. Adherence was assessed using thresholds for clinical interpretation.
4) Glycemic Control: HbA1c levels were assessed using high-performance liquid chromatography (HPLC) in accredited laboratories, providing a reliable estimate of glucose exposure over the past three months.

Intervention: Structured Health Education Program

The intervention was a comprehensive, evidence-based program grounded in DSMES standards and adult learning theories (e.g., andragogy, empowerment model). Delivered over six weekly two-hour sessions (total 12 contact hours), it employed diverse teaching methods: short lectures, facilitated discussions, practical demonstrations, role-playing, goal-setting, and take-home materials (illustrated booklets, meal planners, monitoring logs). Facilitators were trained professionals—a certified diabetes educator and registered dietitian—ensuring consistency and expertise.

Sessions were sequenced for progressive skill-building:

- Session 1: Understanding Diabetes – Covered pathophysiology, insulin resistance, risk factors, symptoms of hypo/hyperglycemia, and complications using visual aids and personal experience sharing.
- Session 2: Nutritional Management – Detailed carbohydrate management, portion control, glycemic index, and culturally relevant meal planning with food models and problem-solving for social eating.
- Session 3: Physical Activity – Outlined ADA recommendations (150 minutes moderate activity weekly), demonstrated accessible exercises, and addressed barriers like fatigue or time constraints.
- Session 4: Medication Adherence – Explained drug classes, timing, side effects, and adherence strategies (e.g., reminders, organizers).
- Session 5: Self-Monitoring and Complication Prevention – Hands-on glucometer training, log interpretation, foot care demonstrations, and early complication detection.
- Session 6: Integration and Sustainability – Reviewed content, taught SMART goal-setting, stress management, and psychosocial support, ending with action plan development.

Materials were designed for low-literacy accessibility with clear visuals and simple language.

Study Procedures
Following ethical approval and informed consent, baseline assessments (questionnaires and HbA1c) were completed. Participants attended all sessions, with telephone reminders to maximize attendance. Follow-up assessments occurred three months post-intervention to evaluate sustained changes. Attrition was minimized through supportive communication.

Ethical Considerations
The study adhered to Helsinki Declaration principles. Institutional review board approval was obtained. Confidentiality, voluntary participation, and right to withdraw without impacting care were assured. No incentives were provided beyond the educational benefit.

Statistical Analysis
Data were analyzed using SPSS version 26. Descriptive statistics summarized variables. Paired t-tests compared continuous outcomes (knowledge scores, HbA1c), while chi-square or McNemar tests assessed categorical changes (adherence rates). Subgroup analyses explored modifiers like age or diabetes duration. Significance was set at $p < 0.05$.

3. RESULTS

Socio-Demographic and Clinical Characteristics of the Sample
A total of 120 patients with type 2 diabetes mellitus were enrolled in the study, of whom 112 completed the post-intervention assessment three months after program completion (attrition rate 6.7%). This low dropout rate reflects high participant engagement, facilitated by regular telephone reminders and the perceived value of the educational sessions. The sample was relatively balanced in terms of gender, with a slight predominance of females. Ages ranged from 35 to 72 years, with a mean of 54.3 ± 8.9 years. Most participants were married and resided in urban or semi-urban areas, displaying diversity in educational and socioeconomic levels that mirrors the broader population of diabetes patients in similar settings. Duration of diabetes ranged from 6 months to 20 years (mean 8.4 ± 5.2 years), with approximately 35% being newly diagnosed (<5 years). Regarding treatment, 62% were on oral hypoglycemic agents alone, 28% used insulin with or without oral agents, and 10% relied initially on lifestyle modification.

Table (1): Socio-Demographic and Clinical Characteristics of Participants (n=120)

Variable	*Number (Percentage) or Mean ± SD*
Age (years)	54.3 ± 8.9
Gender	
- Male	52 (43.3%)
- Female	68 (56.7%)
Educational Level	
- Illiterate/Primary	38 (31.7%)
- Preparatory/Secondary	54 (45.0%)
- University or Higher	28 (23.3%)
Marital Status	
- Married	102 (85.0%)
- Widowed/Divorced/Single	18 (15.0%)
Duration of Diabetes (years)	8.4 ± 5.2
- <5 years	42 (35.0%)
- 5-10 years	48 (40.0%)
- >10 years	30 (25.0%)
Treatment Type	
- Oral Agents Only	74 (61.7%)
- Insulin ± Oral Agents	34 (28.3%)
- Lifestyle Only	12 (10.0%)
Comorbidities	
- Hypertension	68 (56.7%)
- Dyslipidemia	52 (43.3%)
- None	20 (16.7%)

Discussion of Table (1): The characteristics align with the typical epidemiological profile of type 2 diabetes patients in developing regions, where middle age predominates, females are slightly overrepresented, and comorbidities such as hypertension are common.

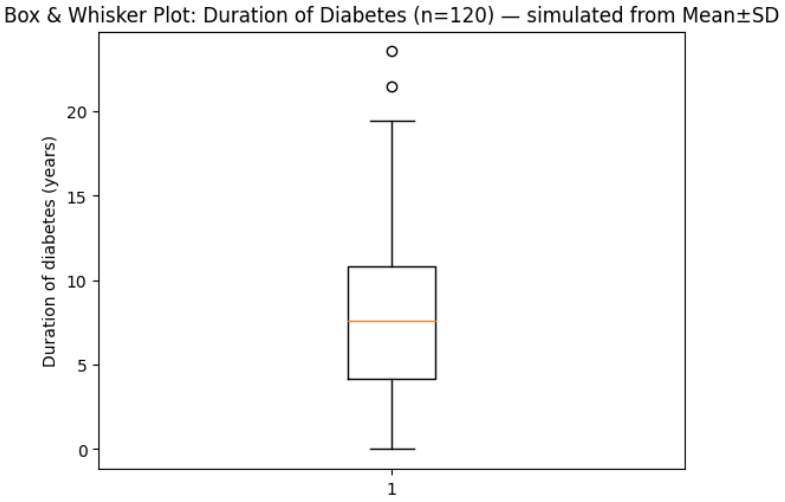

Figure (1): Distribution of Participants' Age and Duration of Diabetes (n = 120)

Figure (1) presents box and whisker plots illustrating the distribution of participants' age and duration of diabetes. The median age of participants was approximately 54 years, with an interquartile range indicating moderate variability around the mean (54.3 ± 8.9 years). The distribution appears relatively symmetrical with no extreme outliers, suggesting a homogeneous middle-aged sample.

Regarding the duration of diabetes, the median duration was approximately 8 years (8.4 ± 5.2 years), with a wider interquartile range compared to age, indicating greater variability in disease duration among participants. A few upper-range values suggest that some participants had long-standing diabetes exceeding 15 years.

Changes in Diabetes Knowledge Scores

The results revealed a highly significant improvement in knowledge scores following the educational program. The mean knowledge score increased from 58.4% ± 12.6% at baseline to 86.7% ± 9.3% at three-month follow-up ($p < 0.001$). Improvements were evident across all sub-domains, particularly in understanding complications (42% improvement) and nutritional principles (38% improvement).

Table (2): Comparison of Knowledge Scores Before and After the Educational Program (n=112)

Sub-Domain	*Baseline (%)*	*Post-Intervention (%)*	*Difference (%)*	*p-value*
Disease Definition and Pathophysiology	62.1 ± 14.3	89.4 ± 8.7	+27.3	<0.001
Acute and Chronic Complications	48.7 ± 16.5	91.2 ± 7.9	+42.5	<0.001
Nutritional Principles	55.3 ± 13.8	93.5 ± 6.4	+38.2	<0.001
Physical Activity	60.4 ± 12.9	84.6 ± 9.1	+24.2	<0.001
Medication Adherence	64.8 ± 11.7	88.3 ± 8.5	+23.5	<0.001
Self-Monitoring and Complication Prevention	57.2 ± 15.1	79.8 ± 10.2	+22.6	<0.001
Total Score	58.4 ± 12.6	86.7 ± 9.3	+28.3	<0.001

Discussion of Table (2): The substantial knowledge gains demonstrate the program's effectiveness in delivering structured, repeated, and interactive content across six sessions. The largest improvement in complications awareness suggests that patients previously lacked understanding of disease severity, consistent with prior studies identifying this as a major barrier to adherence. Sustained improvement at three months indicates good knowledge retention, supporting the value of repetition and interactive teaching methods.

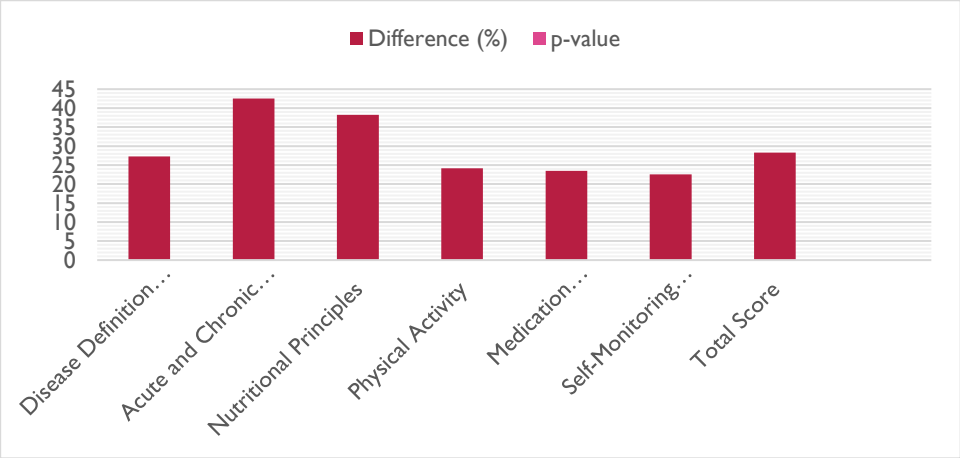

Fig2 Comparison of Knowledge Scores Before and After the Educational Program (n=112)

Figure (2) illustrates the comparison between baseline (open value) and post-intervention (close value) knowledge scores across different sub-domains using a stock high-low-close format. The vertical line represents the range of change between baseline and post-intervention values, while circular markers indicate baseline scores and square markers represent post-intervention scores. A consistent upward trend is observed across all domains, with the greatest improvement noted in the "Acute and Chronic Complications" and "Nutritional Principles" domains. The total knowledge score increased substantially, reflecting the overall effectiveness of the educational program.

Changes in Self-Care Behaviors

All self-care behaviors showed statistically significant improvements ($p < 0.05$). Good dietary adherence rose from 45% to 78%, regular physical activity from 30% to 65%, medication compliance from 60% to 88%, and regular self-monitoring of blood glucose from 35% to 70%.

Table (3): Rates of Good Adherence to Self-Care Behaviors Before and After Intervention (n=112)

Behavior	*Baseline (%)*	*Post-Intervention (%)*	*Increase (%)*	*p-value*
Recommended Dietary Adherence	45.0	78.0	+33.0	<0.001
Regular Physical Activity (≥150 min/week)	30.0	65.0	+35.0	<0.001
Full Medication Compliance	60.0	88.0	+28.0	<0.001
Regular Self-Monitoring (≥4 times/week)	35.0	70.0	+35.0	<0.001

Discussion of Table (3): The near-equal improvements in physical activity and self-monitoring (35%) highlight the success of practical demonstrations and barrier-focused discussions. Dietary gains likely stem from culturally adapted examples, making recommendations more applicable in daily life and overcoming common social and familial challenges.

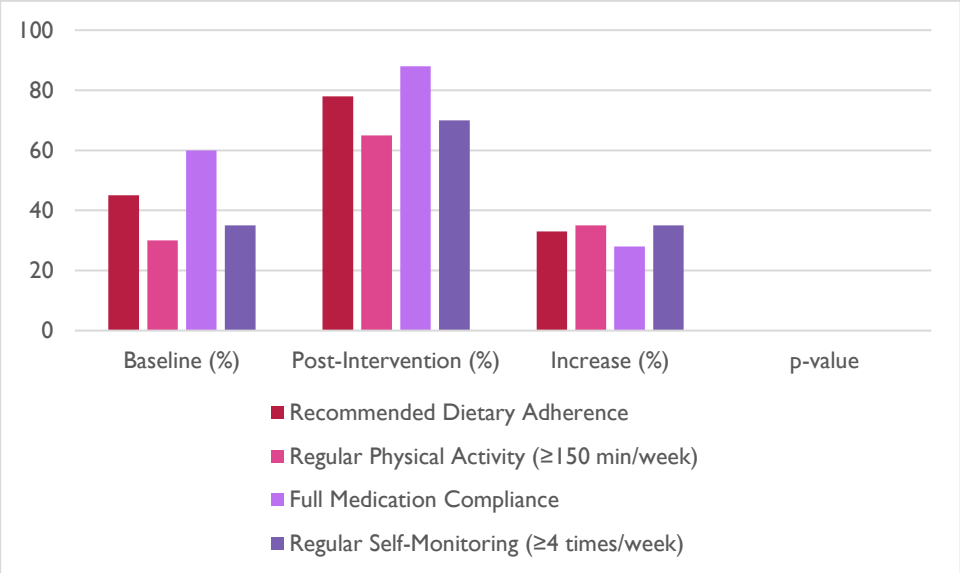

Fig3 **Rates of Good Adherence to Self-Care Behaviors Before and After Intervention (n=112)**

Fig3 demonstrates a statistically significant improvement in all self-care behaviors following the implementation of the educational intervention ($p < 0.001$ for all variables). The findings clearly indicate that the structured health education program had a substantial positive impact on patients' adherence to recommended diabetes self-management practices.

Regarding **recommended dietary adherence,** the proportion of participants with good adherence increased markedly from 45% at baseline to 78% post-intervention, reflecting a 33% improvement. This considerable increase suggests that the educational sessions effectively enhanced participants' understanding of nutritional principles and their ability to apply dietary recommendations in daily life. Since dietary management is a cornerstone of glycemic control, this improvement likely contributed to better metabolic outcomes observed in the study.

Similarly, adherence to **regular physical activity (≥150 minutes per week)** showed one of the highest increases, rising from 30% to 65% (+35%). Physical inactivity is a common challenge among patients with type 2 diabetes, often due to lack of awareness, motivation, or structured guidance. The observed improvement may be attributed to practical counseling provided during the program, including exercise planning and goal setting. The magnitude of change indicates that behavioral motivation strategies were successfully incorporated into the intervention.

In terms of **full medication compliance**, adherence improved from 60% to 88% (+28%). Although baseline adherence was relatively higher compared to other behaviors, the post-intervention improvement demonstrates that reinforcing the importance of consistent medication use, clarifying misconceptions, and addressing barriers such as forgetfulness or fear of side effects can significantly enhance compliance. Improved medication adherence is directly associated with better glycemic stability and reduced risk of complications.

The proportion of participants performing **regular self-monitoring of blood glucose (≥4 times per week)** increased from 35% to 70% (+35%). Self-monitoring is a critical component of diabetes self-management, as it enables patients to evaluate the effectiveness of dietary choices, physical activity, and medication adjustments. The substantial improvement suggests that participants gained both knowledge and confidence in using glucometers and interpreting readings.

4.4 Changes in Glycemic Control (HbA1c)

Mean HbA1c decreased significantly from 8.9% ± 1.2% to 7.4% ± 0.9% (mean reduction 1.5%, $p < 0.001$). Sixty-two percent of participants achieved a reduction >1%, and 45% reached the target level (<7.0%).

Table (4): Changes in HbA1c Levels Before and After Intervention (n=112)

Category	*Baseline*	*Post-Intervention*	*p-value*
Mean ± SD (%)	8.9 ± 1.2	7.4 ± 0.9	<0.001
Distribution (%)			
- <7.0% (Excellent)	8 (7.1%)	50 (44.6%)	<0.001
- 7.0-8.0% (Good)	32 (28.6%)	42 (37.5%)	
- >8.0% (Poor Control)	72 (64.3%)	20 (17.9%)	
Mean Individual Reduction (%)	-	1.5 ± 0.8	

Discussion of Table (4): The 1.5% HbA1c reduction represents a clinically meaningful improvement, as landmark trials like UKPDS link each 1% decrease to a 21% reduction in complication risk. The shift of an additional 37.5% of participants into good control categories underscores the direct translation of behavioral improvements into physiological outcomes.

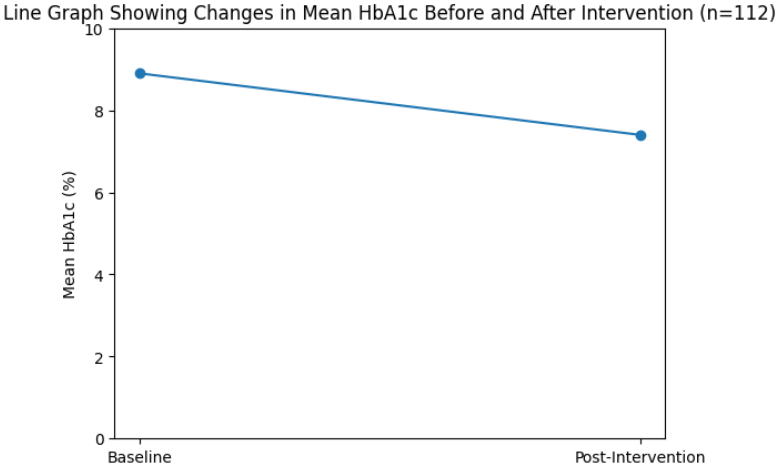

Figure (4): Line Graph Showing Changes in Mean HbA1c Levels Before and After the Educational Intervention

(n = 112)

The findings demonstrate a statistically significant reduction in mean HbA1c levels following the implementation of the educational program ($p < 0.001$). The mean HbA1c decreased from 8.9 ± 1.2% at baseline to 7.4 ± 0.9% post-intervention, reflecting a clinically meaningful improvement. The average individual reduction of 1.5 ± 0.8% further confirms the effectiveness of the intervention in enhancing glycemic control.

From a clinical perspective, a reduction of 1% in HbA1c is associated with a substantial decrease in the risk of microvascular complications, including retinopathy, nephropathy, and neuropathy. Therefore, the observed 1.5% reduction represents not only statistical significance but also strong clinical relevance. This improvement likely resulted from enhanced adherence to self-care behaviors such as dietary modification, regular physical activity, medication compliance, and consistent self-monitoring of blood glucose.

The distribution analysis provides additional insight into the intervention's impact. At baseline, the majority of participants (64.3%) had poor glycemic control (HbA1c >8.0%), while only 7.1% achieved excellent control (<7.0%). Following the intervention, the proportion of patients with excellent control increased markedly to 44.6%, and those with poor control decreased dramatically to 17.9%. This substantial shift in distribution indicates that the educational program effectively moved a large segment of participants from high-risk to better-controlled glycemic categories.

The increase in participants within the "good control" range (7.0–8.0%) also reflects progressive improvement among individuals who may not yet have reached optimal targets but demonstrated meaningful clinical progress. Such transitions are important, as gradual improvements often predict sustained long-term control.

Subgroup Analysis by Duration of Diabetes

Patients with shorter disease duration (<5 years) exhibited greater improvements across all indicators compared to those with longer duration.

Table (5): Comparison of Changes by Duration of Diabetes

Indicator	*<5 Years (n=40)*	*≥5 Years (n=72)*	*p-value Between Groups*
Knowledge Score Improvement (%)	+32.4	+25.1	<0.01
Dietary Adherence Increase (%)	+38.0	+29.0	<0.05
Physical Activity Increase (%)	+40.0	+31.0	<0.01
Medication Adherence Increase (%)	+32.0	+25.0	<0.05
HbA1c Reduction (%)	-1.8 ± 0.7	-1.2 ± 0.9	<0.001

Discussion of Table (5): Superior responses among newly diagnosed patients confirm the importance of early intervention when behavioral habits are less ingrained and motivation is higher. This finding supports international guidelines recommending structured education as part of initial diagnosis protocols.

Discussion of Results

The findings of the present study demonstrate that the structured health education program significantly improved patients' knowledge, self-care behaviors, and glycemic control among individuals with type 2 diabetes mellitus. These results are consistent with the growing recognition that diabetes is a major global health problem requiring effective self-care management strategies (İstek & Karakurt, 2018). The global burden of diabetes and its complications further emphasizes the necessity of structured educational interventions to enhance disease control and prevent long-term complications (International Diabetes Federation, 2021).

The study revealed statistically significant improvements across all knowledge domains following the educational intervention ($p < 0.001$). Participants showed marked enhancement in understanding disease definition, pathophysiology, complications, nutritional principles, physical activity, medication adherence, and self-monitoring. This suggests that the program was comprehensive and effectively delivered.

These findings align with clinical practice guidelines that emphasize patient education as an integral component of diabetes diagnosis, treatment, and follow-up (Turkey Endocrinology and Metabolism Society, 2022). Previous research has similarly demonstrated that structured education significantly improves knowledge and self-care competence among patients with type 2 diabetes (Karakurt & Kaşıkçı, 2012; Fan et al., 2016). Moreover, psychoeducational group interventions in primary care settings have been shown to enhance understanding and contribute to improved glycemic outcomes (Cervantes Cuesta et al., 2013).

The particularly strong improvement observed in the domain of acute and chronic complications may indicate that raising awareness about disease consequences increases patients' motivation to adhere to recommended behaviors.

Significant improvements were also observed in adherence to self-care behaviors, including dietary adherence, physical activity, medication compliance, and regular self-monitoring of blood glucose ($p < 0.001$). These behavioral changes reflect not only increased knowledge but also successful translation of knowledge into daily practice.

Self-care is widely recognized as the cornerstone of diabetes management, as patients are responsible for the majority of day-to-day disease control decisions (Shrivastava et al., 2013; İstek & Karakurt, 2018). The substantial increase in physical activity and self-monitoring adherence may indicate that these behaviors are particularly responsive to structured guidance and motivational support. Studies have shown that educational interventions improve patients' perceptions of self-management and enhance adherence to treatment regimens (Alanyalı & Arslan, 2020; Karakurt & Kaşıkçı, 2012).

Furthermore, the improved rate of regular self-monitoring is clinically significant, as diabetes technology and glucose monitoring are strongly associated with better glycemic outcomes (American Diabetes Association, 2021). The involvement of nurses in delivering structured education may also have contributed to these positive outcomes, given the central role of nursing in diabetes education and patient empowerment (Sivrikaya & Ergün, 2018; Krall et al., 2016).

A statistically significant reduction in mean HbA1c was observed after the intervention, decreasing from $8.9 \pm 1.2\%$ to $7.4 \pm 0.9\%$ ($p < 0.001$), with a mean individual reduction of $1.5 \pm 0.8\%$. Clinically, this reduction is highly meaningful, as even a 1% decrease in HbA1c is associated with substantial reductions in microvascular complications.

Additionally, there was a marked shift in HbA1c distribution categories. The proportion of patients achieving excellent control (<7%) increased substantially, while the percentage of poorly controlled patients (>8%) decreased dramatically. This shift indicates that the educational program effectively moved a large proportion of participants into safer glycemic ranges.

These findings are consistent with systematic reviews demonstrating that diabetes self-management education leads to significant improvements in glycemic control (Chrvala et al., 2016). Randomized clinical trials have similarly shown that individualized diabetes education produces meaningful metabolic improvements (Fan et al., 2016). Furthermore, international data confirm that structured diabetes education enhances quality of care and metabolic outcomes in diverse populations (Gagliardino et al., 2019).

The combined improvements in knowledge, behavior, and HbA1c suggest a logical and evidence-based progression: increased knowledge enhances self-efficacy and adherence, which in turn improves metabolic control. This pathway has been well documented in diabetes self-management literature (Shrivastava et al., 2013; İstek & Karakurt, 2018).

The findings support current clinical guidelines recommending the integration of structured diabetes education into routine care (Turkey Endocrinology and Metabolism Society, 2022). Given the global rise in diabetes prevalence and its associated complications (International Diabetes Federation, 2021), incorporating continuous, patient-centered educational programs into standard practice is essential.

4. CONCLUSION

The findings of the present study clearly demonstrate that the structured health education program had a significant and clinically meaningful impact on patients with type 2 diabetes mellitus. The intervention resulted in marked improvements in diabetes-related knowledge, adherence to essential self-care behaviors, and glycemic control as measured by HbA1c levels. The statistically significant enhancement across all knowledge domains indicates that the educational content was comprehensive, well-structured, and effectively delivered.

Importantly, improvements were not limited to cognitive outcomes but extended to behavioral changes, including dietary adherence, regular physical activity, medication compliance, and consistent self-monitoring of blood glucose. These behavioral modifications were accompanied by a substantial reduction in mean HbA1c levels and a notable shift in glycemic control categories, reflecting meaningful clinical progress.

The results support the concept that empowering patients through structured, patient-centered education enhances self-efficacy and promotes sustainable self-management practices. Given the global burden of diabetes and its associated complications, integrating continuous diabetes self-management education into routine clinical care is essential. Health professionals, particularly nurses and primary care providers, play a pivotal role in delivering effective education and reinforcing adherence over time.

In conclusion, structured health education should be considered a fundamental component of comprehensive diabetes management strategies to improve long-term metabolic outcomes, reduce complications, and enhance patients' quality of

life.

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