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Original Research Article

Impact of clinical pharmacist mediated patient education on HbA1c and insulin adherence among diabetic population

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ABSTRACT

Background: To evaluate the association of structured clinical pharmacist-mediated patient education with glycemic control, medication adherence, and diabetes self-management among insulin-treated adults with diabetes mellitus.

Methods: A single-arm prospective cohort study was conducted from July 2024 to March 2025 among 70 adults with type 1 or type 2 diabetes mellitus receiving insulin therapy for at least three months at the Department of Diabetology, NRI Academy of Sciences General and Super Specialty Hospital, Chinakani, Andhra Pradesh, India. Participants received structured pharmacist-mediated education on diabetes self-management, insulin administration and storage, medication adherence, lifestyle modification, and self-monitoring of blood glucose, supported by a Patient Information Leaflet. HbA1c, fasting blood glucose (FBS), postprandial blood glucose (PPBS), MMAS-8, and DMSES were assessed at baseline and after three months. Continuous variables were summarized as mean $\pm$ SD and compared using paired Student's t-tests; $p < 0.05$ was considered statistically significant.

Results: Mean HbA1c decreased from $8.754 \pm 1.915\%$ to $8.085 \pm 1.481\%$ (reduction 0.669%; $p = 0.00013$). FBS decreased by 18.274 mg/dL ($p = 0.0078$), and PPBS decreased by 25.257 mg/dL ($p = 0.00187$). MMAS-8 increased from 3.957 ± 1.215 to 5.585 ± 1.210 ($p = 0.00000127$), while DMSES increased from 4.216 ± 1.137 to 5.983 ± 1.408 ($p = 0.00000189$).

Conclusions: Pharmacist-mediated education was associated with improved glycemic parameters, medication adherence, and diabetes self-management self-efficacy. Due to the absence of a control group, findings represent pre-post associations rather than definitive causal effects.

Keywords: Clinical pharmacist, Diabetes mellitus, Insulin therapy, Medication adherence, Glycemic control, Patient education

INTRODUCTION

Diabetes mellitus (DM) is a major chronic metabolic disorder and an important public health concern because of its increasing prevalence, complications, and healthcare burden. The disease is characterized by chronic hyperglycemia resulting from defects in insulin secretion, insulin action, or both. According to the International

Diabetes Federation Diabetes Atlas, an estimated 589 million adults aged 20-79 years were living with diabetes in 2024, and this number is projected to reach approximately 853 million by 2050.¹

DM is broadly classified into type 1 diabetes mellitus (T1DM), type 2 diabetes mellitus (T2DM), gestational diabetes mellitus, and other specific forms resulting from

genetic, pancreatic, endocrine, or drug-related causes.^{2,3} T1DM is characterized by autoimmune destruction of pancreatic β -cells, with genetic and environmental factors contributing to disease development.⁴⁻¹² T2DM is primarily driven by insulin resistance together with progressive decline in pancreatic β -cell function and accounts for the majority of diabetes cases worldwide.^{2,13-17}

Persistent hyperglycemia contributes to microvascular complications such as retinopathy, nephropathy, and neuropathy and to macrovascular complications including coronary, cerebrovascular, and peripheral vascular disease.¹⁸ Comprehensive management of cardiovascular and metabolic risk factors is therefore important for reducing diabetes-related morbidity and mortality.^{19,20}

HbA1c is a key indicator of long-term glycemic control because it reflects average blood glucose over approximately the preceding two to three months. The 2026 American Diabetes Association Standards of Care recommend an HbA1c goal of $<7\%$ for many nonpregnant adults when this can be achieved safely, while emphasizing individualized targets according to health status, hypoglycemia risk, treatment burden, and patient preferences.²¹ Regular assessment of HbA1c and glucose measures such as FBS and PPBS remains important for evaluating treatment response.²¹

Insulin therapy is essential for survival in T1DM and may be required in T2DM when individualized glycemic goals are not achieved with other therapies or when marked hyperglycemia or progressive β -cell failure is present.²² Correct insulin administration is an important component of safe and effective therapy; current recommendations emphasize appropriate injection sites, site rotation, storage, needle use, and avoidance of injection-related complications such as lipohypertrophy.²³

Several factors can interfere with insulin and medication adherence, including regimen complexity, injection-related concerns, fear of hypoglycemia, misconceptions, inadequate technique, cost, and difficulty integrating treatment into daily routines.²⁴⁻²⁷ Recent evidence also indicates that pharmacist-led interventions can improve objectively measured medication adherence, although effects vary according to medication class, intervention duration, and delivery method.²⁸

Medication adherence is a critical determinant of treatment success in chronic diseases. The World Health Organization defines adherence as the extent to which a person's behaviour corresponds with agreed recommendations from a healthcare provider.²⁹ In diabetes, adherence encompasses appropriate medication use together with dietary measures, physical activity, and glucose monitoring.

Self-efficacy also influences diabetes self-management. It refers to an individual's confidence in performing

behaviours required to achieve desired outcomes. Diabetes self-management requires active participation in medication administration, dietary planning, physical activity, glucose monitoring, and recognition of hypo- and hyperglycemia. The Diabetes Management Self-Efficacy Scale (DMSES) is used to assess confidence in performing these self-care behaviours.³⁰

Clinical pharmacists can contribute to multidisciplinary diabetes care through patient counselling, medication therapy management, disease education, adherence assessment, identification of drug-related problems, and reinforcement of self-management skills. Diabetes care standards recognize pharmacists as appropriate members of teams providing diabetes self-management education and support, while recent clinical evidence continues to demonstrate potential benefits from pharmacist integration.³¹⁻³⁵

Pharmacist-led interventions have been associated with improvements in HbA1c, medication adherence, diabetes knowledge, and self-management behaviours.^{31,34-38} Education that specifically addresses insulin administration may be particularly relevant because errors in storage, site selection, injection technique, and needle practices can reduce the effectiveness and safety of insulin therapy.^{23,39}

An umbrella review reported beneficial effects of pharmacist care on diabetes-related outcomes in primary care settings.³¹ Randomized and comparative studies have also demonstrated improvements in treatment outcomes, adherence, or self-management following pharmacist-led interventions.^{34,36,38,40,41} More recent evidence supports this direction: a 2024 randomized trial found improved medication adherence after a multifactorial pharmacist-led intervention, while a 2025 meta-analysis found a modest but significant improvement in pharmacist-led medication adherence measured by proportion of days covered.^{28,39}

Despite the growing evidence supporting pharmacist involvement, data specifically describing structured pharmacist-mediated education among insulin-treated patients in South Indian tertiary-care settings remain limited. Local factors such as educational attainment, treatment complexity, access to care, and the practical burden of insulin administration may influence intervention response. Context-specific evidence is therefore useful for determining how pharmacist education can be implemented in routine diabetes services.

The present study was undertaken to evaluate the association of clinical pharmacist-mediated patient education with glycemic control, medication adherence, and diabetes self-management among insulin-treated patients with diabetes mellitus. The study assessed changes in HbA1c, FBS, PPBS, MMAS-8, and DMSES over three months. In addition to quantifying overall pre-post changes, the study population was characterized according to age, sex, diabetes duration, BMI, educational

status, comorbidity burden, and antidiabetic treatment pattern to provide a clinically relevant description of the cohort.

METHODS

Study design

A prospective cohort study was conducted to evaluate the impact of clinical pharmacist-mediated patient education on glycemic control and insulin adherence among patients with diabetes mellitus receiving insulin therapy. The study assessed changes in clinical and behavioral outcomes before and after implementation of a structured pharmacist-led educational intervention. The prospective design enabled direct evaluation of intervention effectiveness through comparison of baseline and follow-up outcomes.

Study site

The study was conducted in the Department of Diabetology at NRI Academy of Sciences General and Super Specialty Hospital, Chinakani, Guntur District, Andhra Pradesh, India. The hospital is a tertiary care teaching institution that provides specialized diabetes care services to a large population from both urban and rural areas of Andhra Pradesh.

Study duration

The study was carried out over a period of nine months, from July 2024 to March 2025. Patient recruitment, baseline assessments, intervention delivery, follow-up evaluations, and data analysis were completed during this period. Follow-up assessments were conducted three months after the educational intervention.

Study population

The study population consisted of patients diagnosed with diabetes mellitus and receiving insulin therapy either alone or in combination with oral hypoglycemic agents (OHAs). Eligible participants were recruited during their routine visits to the Department of Diabetology.

Sample size

A total of 70 diabetic patients receiving insulin therapy were enrolled in the study. Participants were selected based on predefined inclusion and exclusion criteria and were followed throughout the study period. Participants aged 18 years or older with type 1 or type 2 diabetes mellitus who had been receiving insulin therapy for at least three months, either alone or in combination with oral hypoglycemic agents, were eligible if they were willing to participate, could understand and respond to the study questionnaires, and provided written informed consent. Patients were excluded if they were pregnant and diagnosed with gestational diabetes mellitus, critically ill

and requiring intensive care management, had severe cognitive impairment or psychiatric illness affecting communication, were unwilling to provide informed consent, were unable to complete the three-month follow-up assessment, or had incomplete baseline clinical information.

Ethical considerations

The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki for research involving human subjects. Participation was voluntary, and written informed consent was obtained from all participants prior to enrolment. Confidentiality of patient information was maintained throughout the study. Personal identifiers were removed during data analysis to ensure privacy and anonymity.

Study procedure

The study included baseline assessment, assessment of glycemic control and adherence, pharmacist-mediated educational intervention, and three-month follow-up assessment.

Baseline assessment

During the initial visit, eligible patients were identified and recruited. Baseline demographic, clinical, and therapeutic information was collected using a structured data collection form. The variables recorded included age, gender, educational status, duration of diabetes, body mass index (BMI), type of anti-diabetic therapy, presence of comorbid conditions, and baseline glycemic parameters. Clinical data were obtained from patient medical records and laboratory reports.

Assessment of glycemic control and adherence

Glycated hemoglobin (HbA1c)

HbA1c was used as the primary indicator of long-term glycemic control because it reflects average blood glucose over approximately the preceding two to three months.²¹

Fasting blood sugar (FBS)

Fasting blood glucose values were recorded after a minimum fasting period of eight hours and were used to assess glycemic control.²¹

Post-prandial blood sugar (PPBS)

Postprandial blood glucose levels were assessed approximately two hours after meal consumption and provided information regarding post-meal glucose regulation.²¹

Assessment of medication adherence

Medication adherence was evaluated using the eight-item Morisky Medication Adherence Scale (MMAS-8), a self-reported questionnaire designed to assess medication-taking behaviour and barriers to adherence. Higher scores indicate better adherence.⁴²

Assessment of diabetes self-efficacy

Self-management behaviour and confidence were evaluated using the Diabetes Management Self-Efficacy Scale (DMSES). The DMSES measures confidence in performing diabetes self-care activities, including medication administration, blood glucose monitoring, dietary management, and lifestyle modification. Higher scores indicate better self-management capability and self-efficacy.³⁰ Following baseline assessment, patients received a structured educational intervention delivered by clinical pharmacists. The intervention addressed diabetes self-management, insulin administration and storage, medication adherence, lifestyle modification, and self-monitoring of blood glucose and was supported by a Patient Information Leaflet. The leaflet reinforced practical instructions on insulin administration and storage, consequences of missed doses, recommended duration of use for injection devices, management of hypoglycemia, and techniques to minimize injection-related pain.

Diabetes disease education

Patients received information regarding the nature of diabetes mellitus, its causes and risk factors, the importance of glycemic control, and the long-term complications of uncontrolled diabetes.

Insulin administration counselling

Patients were educated regarding correct insulin injection techniques, timing of insulin administration, appropriate needle usage, injection-site rotation practices, and prevention of lipohypertrophy.

Insulin storage education

Patients were instructed on proper refrigeration requirements, storage temperatures, handling of insulin pens and vials, and recognition of expired or damaged insulin products.

Medication adherence counselling

Clinical pharmacists discussed the importance of regular insulin administration, the consequences of missed doses, methods to improve adherence, and the use of reminders and medication schedules.

Lifestyle modification counselling

Patients received education regarding healthy dietary practices, caloric control, glycemic index awareness, portion control, physical activity recommendations, and weight management strategies.

Self-monitoring of blood glucose (SMBG)

Patients were trained in blood glucose monitoring techniques, interpretation of glucose values, identification of hypo and hyperglycemia, and appropriate corrective actions.

Educational materials

Patient Information Leaflets (PILs) were provided in an understandable format to reinforce verbal counselling and allow participants to review key instructions at home.

Follow-up assessment

Patients were followed for three months after the educational intervention. At follow-up, HbA1c, FBS, PPBS, MMAS-8 score, and DMSES score were reassessed. Post-intervention values were compared with baseline measurements to evaluate pre-post changes associated with the intervention.

Outcome measures

The primary outcome measure was the change in HbA1c following pharmacist-mediated patient education. Secondary outcome measures included the change in fasting blood glucose (FBS), the change in post-prandial blood glucose (PPBS), the change in medication adherence measured using MMAS-8, and the change in diabetes self-management efficacy measured using DMSES. Data were entered into Microsoft Excel and analyzed using Statistical Package for the Social Sciences (SPSS) software. Continuous variables were expressed as mean±standard deviation (SD), while categorical variables were presented as frequencies and percentages. Baseline and post-intervention values were compared using paired Student's t-tests, with $p < 0.05$ considered statistically significant. Because this was a single-arm prospective cohort study without a control group, observed changes were interpreted as pre-post associations rather than definitive causal effects.

RESULTS

A total of 70 patients receiving insulin therapy were enrolled and completed the study. The demographic and clinical characteristics of the participants are summarized in Table 1.

Age distribution

The mean age of participants was 52.62 ± 11.56 years. The largest age group was 50-59 years (26/70, 37.14%), followed by 60-69 years (15/70, 21.43%) and 40-49 years (16/70, 22.86%). The remaining participants were 20-29 years (4/70, 5.71%), 30-39 years (4/70, 5.71%), and 70-79 years (5/70, 7.14%).

Gender distribution

Among the 70 participants, 35 (50%) were male and 35 (50%) were female, indicating equal representation of males and females in the study population.

Duration of diabetes

The mean duration of diabetes was 10.52 ± 5.58 years. Thirty-one participants (44.29%) had diabetes for >12 years, 18 (25.71%) for 8-11 years, 12 (17.14%) for 4-7 years, and 9 (12.86%) for <4 years.

Body mass index (BMI)

Thirty-five participants (50%) had a normal BMI, 23 (32.85%) were overweight, 9 (12.85%) were obese, 2

(2.85%) were underweight, and 1 (1.42%) had severe obesity. Thus, 34 participants (48.57%) were above the normal BMI range, indicating that weight-related lifestyle counselling remained relevant in this cohort.

Educational status

Twenty-three participants (32.85%) were illiterate, 35 (50%) had education up to the 10th class, and 12 (17.14%) had completed intermediate or degree-level education. This distribution highlights the need for patient education materials that can be understood across different literacy levels.

Co-morbid conditions

Seventeen participants (24.28%) had no documented co-morbidities, 28 (40%) had one co-morbidity, and 25 (35.71%) had more than one co-morbidity. The high prevalence of co-morbidity burden is relevant because polypharmacy and competing treatment demands may complicate medication-taking behaviour.

The effectiveness of the pharmacist-mediated educational intervention was evaluated by comparing glycemic parameters measured before and after the intervention (Tables 2 and 3).

Table 1: Overall demographic and clinical characteristics of study participants (n=70).

Variables	Value
Sample size	70
Mean age (years)	52.62 ± 11.56
Male	35 (50%)
Female	35 (50%)
Mean duration of diabetes (years)	10.52 ± 5.58
Insulin only	6 (8.57%)
Insulin + Metformin	6 (8.57%)
Insulin + Metformin + OHA	51 (72.85%)
Insulin + OHA	7 (10%)
BMI: Underweight	2 (2.85%)
BMI: Normal	35 (50%)
BMI: Overweight	23 (32.85%)
BMI: Obese	9 (12.85%)
BMI: Severe obesity	1 (1.42%)
Co-morbidities: None	17 (24.28%)
Co-morbidities: One	28 (40%)
Co-morbidities: More than one	25 (35.71%)
Education: Illiterate	23 (32.85%)
Education: Up to 10th class	35 (50%)
Education: Intermediate/Degree	12 (17.14%)

HbA1c assessment: The baseline mean HbA1c level was $8.754 \pm 1.915\%$, and following the intervention it decreased to $8.085 \pm 1.481\%$, representing an absolute reduction of 0.669% ($p=0.00013$). Although the mean HbA1c remained

above the commonly recommended <7% goal for many nonpregnant adults, the direction and magnitude of change indicate improvement during follow-up and are consistent with the study objective of improving glycemic control.²¹

Table 2: Assessment of HbA1c following pharmacist intervention.

Parameters	Baseline	Post-intervention	Difference	P value
HbA1c (%)	8.754±1.915	8.085±1.481	-0.669	0.00013

Fasting blood sugar (FBS)

The mean fasting blood sugar level at baseline was 147.414±55.151 mg/dL and decreased to 129.140±31.419 mg/dL after the educational intervention, representing a mean reduction of 18.274 mg/dL ($p=0.0078$). This significant reduction indicates improved glycemic control during the follow-up period.

Post-prandial blood sugar (PPBS)

The baseline PPBS level was 196.571±70.930 mg/dL and decreased to 171.314±47.680 mg/dL after the intervention, representing a mean reduction of 25.257 mg/dL ($p=0.00187$). This improvement may reflect the combined effects of improved insulin administration, medication adherence, dietary practices, and glucose monitoring (Table 3).

Assessment of medication adherence

Medication adherence was evaluated using the MMAS-8.42 The baseline mean MMAS-8 score was 3.957±1.215 and increased to 5.585±1.210 following the pharmacist intervention ($p = 0.00000127$) (Table 4). This represents a mean increase of 1.628 points in a self-reported measure of medication-taking behaviour (Table 4).

Within the study population, higher medication-adherence scores were observed among participants with better glycemic control. This observation represents an association within the cohort and should not be interpreted as evidence of a causal relationship.

Assessment of diabetes self-management self-efficacy

Diabetes self-management self-efficacy was assessed using the DMSES.30 The baseline DMSES score was 4.216±1.137 and increased to 5.983±1.408 after intervention ($p=0.00000189$) (Table 5). This increase indicates greater reported confidence in performing diabetes self-care activities during the follow-up period.

Overall Impact of clinical pharmacist intervention

The pharmacist-mediated educational intervention was associated with statistically significant improvements across all evaluated outcomes. HbA1c decreased by 0.669%, FBS by 18.274 mg/dL, and PPBS by 25.257 mg/dL. MMAS-8 increased by 1.628 points and DMSES increased by 1.767 points. These findings support the potential value of structured pharmacist education, while the uncontrolled study design prevents attribution of the changes exclusively to the intervention.

Table 3: Glycemic parameters before and after intervention.

Parameters	Baseline (Mean ± SD)	Post-intervention (Mean ± SD)	p value
HbA1c (%)	8.754 ± 1.915	8.085 ± 1.481	0.00013
FBS (mg/dL)	147.414 ± 55.151	129.140 ± 31.419	0.0078
PPBS (mg/dL)	196.571 ± 70.930	171.314 ± 47.680	0.00187

Table 4: Assessment of medication adherence using MMAS-8.

Parameters	Baseline	Post-intervention	p value
MMAS-8 Score	3.957±1.215	5.585±1.210	0.00000127

Table 5. Assessment of Diabetes Self-Efficacy Using DMSES

Parameters	Baseline	Post-intervention	p value
DMSES Score	4.216±1.137	5.983±1.408	0.00000189

DISCUSSION

The present study found significant pre-post improvements in glycemic parameters, medication adherence, and diabetes self-management self-efficacy among 70 insulin-treated patients who received structured pharmacist-mediated education. The HbA1c reduction of 0.669

percentage points occurred alongside reductions in FBS and PPBS and increases in MMAS-8 and DMSES scores. The overall direction of these findings is consistent with evidence supporting pharmacist involvement in diabetes care, including randomized studies and recent real-world evaluations.^{31,34-38} However, because this was a single-arm

study, the results should be interpreted as associations over time rather than proof of causality.

Insulin adherence is influenced by more than the decision to prescribe insulin. Patients must understand dosing schedules, injection technique, site rotation, storage, needle use, hypoglycemia management, and the practical integration of treatment into daily life. The present intervention addressed these domains through structured counselling and a Patient Information Leaflet. This approach is aligned with updated insulin injection recommendations emphasizing structured education and correct technique as components of safe insulin use.²³

The primary outcome was HbA1c. Mean HbA1c decreased from $8.754 \pm 1.915\%$ to $8.085 \pm 1.481\%$, an absolute reduction of 0.669% ($p=0.00013$). The reduction is directionally consistent with improvements reported in pharmacist-led diabetes interventions.^{35,37,38} Importantly, the post-intervention mean remained above 8% , indicating that statistically significant improvement did not equate to attainment of the usual $<7\%$ goal recommended for many nonpregnant adults; glycemic targets should nevertheless be individualized.²¹

Several mechanisms may explain the observed change. The intervention combined education on insulin administration, storage, adherence behaviour, lifestyle practices, and self-monitoring rather than addressing a single behaviour. Recent evidence supports the importance of structured insulin-injection education, including correct site selection and rotation, safe device use, storage, and prevention of lipohypertrophy.^{23,39} Nevertheless, changes in insulin dose or other medications, usual clinical care, regression to the mean, dietary changes, and other unmeasured factors could also have influenced HbA1c.

FBS decreased from 147.414 ± 55.151 mg/dL to 129.140 ± 31.419 mg/dL ($p=0.0078$), while PPBS decreased from 196.571 ± 70.930 mg/dL to 171.314 ± 47.680 mg/dL ($p=0.00187$). These findings suggest improvement in both fasting and post-meal glycemia during the three-month period. Because the intervention was multifaceted, the contribution of individual components cannot be separated.

Medication adherence improved from a mean MMAS-8 score of 3.957 ± 1.215 to 5.585 ± 1.210 ($p=0.00000127$). This is consistent with the study objective and with evidence that pharmacist-led interventions can improve medication adherence.²⁸ The finding should nevertheless be interpreted cautiously because MMAS-8 is self-reported and can be influenced by recall and social-desirability bias.

The cohort also had a substantial treatment and comorbidity burden: 75.72% of participants had at least one co-morbidity, and most participants received insulin in combination with metformin and/or other oral hypoglycemic agents. This clinical complexity makes medication counselling relevant beyond insulin alone. A pharmacist can review the broader regimen, identify

practical barriers, and reinforce consistent medication-taking behaviour. The present study, however, did not use an objective adherence measure such as pharmacy refill data or proportion of days covered.

The magnitude of the adherence improvement should be considered alongside newer evidence. A 2025 systematic review and meta-analysis found that pharmacist-led interventions improved medication adherence measured by proportion of days covered, although the pooled effect for antidiabetic medications was smaller than for some other chronic medicines and heterogeneity remained substantial.²⁸ This supports the plausibility of an adherence benefit while also emphasizing that intervention effects depend on context, duration, delivery method, and the outcome measure used.

Diabetes self-management self-efficacy also improved. The mean DMSES score increased from 4.216 ± 1.137 to 5.983 ± 1.408 ($p=0.00000189$). Self-efficacy is clinically relevant because patients must independently perform medication administration, glucose monitoring, dietary management, physical activity, and recognition of hypo- and hyperglycemia between clinic visits.³⁰

The improvement in DMSES suggests greater confidence in self-management, but it does not demonstrate that confidence caused the improvement in glycemic control or adherence. Self-efficacy was measured at the same time points as the clinical outcomes, so mediation cannot be established. The finding is nevertheless consistent with the broader role of diabetes self-management education and support in promoting informed decision-making and self-care.^{21,35}

The educational profile of the cohort is important for interpreting the intervention. One-third of participants were illiterate and half had education only up to the 10th class. The use of a simple Patient Information Leaflet alongside verbal counselling was therefore appropriate for a population with heterogeneous literacy. Future studies should assess whether pictorial materials, demonstrations, teach-back methods, or local-language digital resources produce additional benefits in patients with lower health literacy.

Insulin technique was a central component of the intervention. Patients were counselled on injection timing, site rotation, needle use, storage, and prevention of injection-related problems. Recent FITTER Forward recommendations similarly emphasize structured training in insulin delivery, storage, site rotation, needle disposal, and lipohypertrophy prevention.²³ An Indian quasi-experimental study published in 2024 also reported improved knowledge and injection practices following tailored health education on insulin administration.³⁹ The present study did not quantitatively score injection technique, so improvement in technique cannot be directly linked to the observed glycemic changes.

Lifestyle counselling and self-monitoring were also included. This multifactorial approach reflects current person-centred diabetes care, in which diabetes self-management education, physical activity, nutrition, psychosocial support, and medication management are considered together rather than in isolation.²¹ The study design does not allow the effect of any single educational component to be estimated.

The cohort was predominantly middle-aged or older, with a mean age of 52.62 ± 11.56 years and 31 participants having diabetes for more than 12 years. Long-standing diabetes may involve established treatment routines, comorbidities, and accumulated technique errors. In this context, structured re-education may be useful even among patients who have previously received diabetes counselling. The findings should not, however, be generalized directly to newly diagnosed patients, younger populations, or different healthcare settings.

The findings have potential clinical implications for tertiary-care diabetes services. Pharmacists may contribute through structured patient education, adherence support, insulin technique counselling, and reinforcement of self-management. Recent evidence from pharmacist-embedded care models also suggests that integrating pharmacists into routine diabetes services can be associated with meaningful improvements in HbA1c and medication management, although those studies used different designs and patient populations from the present study.³⁵

A practical strength of the intervention is that it relied on face-to-face counselling supported by a Patient Information Leaflet rather than requiring sophisticated digital infrastructure. This may be relevant in settings where patients have variable digital access or travel long distances for follow-up. At the same time, contemporary diabetes care increasingly supports technology-enabled education and follow-up, so future studies could compare face-to-face education with combined in-person and digital approaches.^{21,28}

Several limitations should be considered. The study was conducted at a single tertiary-care centre and included only 70 participants, limiting generalizability. Follow-up was limited to three months and therefore does not establish long-term sustainability. Most importantly, there was no parallel control group, so observed changes could reflect the intervention, concurrent medical care, treatment changes, regression to the mean, or other time-related factors. MMAS-8 and DMSES are self-reported measures and may be affected by recall and social-desirability bias.

Injection technique was not independently scored, and objective adherence measures were not collected. Future multicentre randomized controlled studies should include larger samples, appropriate control groups, objective adherence measures, standardized assessment of injection technique, and longer follow-up.

Overall, the study adds context-specific evidence that structured clinical pharmacist-mediated education was associated with improvements in glycemic parameters, medication adherence, and diabetes self-management among insulin-treated patients. The results are best viewed as supportive pre-post evidence that justifies further controlled evaluation rather than definitive proof of intervention efficacy.

CONCLUSION

The present study found that structured clinical pharmacist-mediated patient education was associated with improvements in glycemic control, medication adherence, and diabetes self-management among insulin-treated patients with diabetes mellitus. HbA1c, FBS, and PPBS decreased, while MMAS-8 and DMSES scores increased over the three-month follow-up period.

The mean HbA1c decreased from $8.754 \pm 1.915\%$ to $8.085 \pm 1.481\%$ ($p=0.00013$), MMAS-8 increased from 3.957 ± 1.215 to 5.585 ± 1.210 ($p=0.00000127$), and DMSES increased from 4.216 ± 1.137 to 5.983 ± 1.408 ($p=0.00000189$). These changes indicate improvement during follow-up, but the absence of a parallel control group prevents definitive causal attribution to the pharmacist intervention.

The findings support the inclusion of clinical pharmacists in multidisciplinary diabetes care, particularly for individualized education, medication-adherence support, insulin administration counselling, and reinforcement of self-management skills.

Future multicentre randomized studies with larger samples, objective adherence measures, standardized assessment of injection technique, and longer follow-up are needed to determine the independent effect, durability, and generalizability of pharmacist-mediated education.

The main limitations were the single-centre setting, relatively small sample size, three-month follow-up, absence of a parallel control group, reliance on self-reported adherence and self-efficacy measures, and lack of objective assessment of insulin injection technique or adherence. These limitations should be considered when interpreting the observed pre-post improvements.

Clinical implications

The findings have important implications for healthcare practice. Clinical pharmacists may contribute to diabetes management through structured patient education, adherence support, insulin administration counselling, and reinforcement of self-management skills. Integrating pharmacists into multidisciplinary diabetes care teams may help improve treatment quality and patient engagement, particularly when interventions are individualized to patient needs.

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