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Effectiveness of a Nurse-Led Educational Program on Medication Adherence and Glycemic Control in Adults with Type 2 Diabetes Mellitus: A Quasi-Experimental Study

Bushra Khairalla Khanjar
Department of Adult Nursing, College of Nursing, Al-Turath University, Baghdad, Iraq
*Corresponding author: **Email:** bushra.khairalla@uoturath.edu.iq

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ABSTRACT

Background: Type 2 diabetes mellitus (T2DM) is a leading cause of preventable morbidity in Iraq, and medication non-adherence is a known driver of poor glycemic control in the region. Evidence on structured nurse-led educational interventions in Iraqi outpatient diabetes clinics is limited. **Aim:** To evaluate the effectiveness of a six-week nurse-led structured educational program on medication adherence, glycemic control, self-care behaviors, and disease knowledge in Iraqi adults with T2DM. **Methods:** A two-arm pre-post quasi-experimental study was conducted between August 2025 and February 2026 in the diabetes outpatient clinics of two Iraqi teaching hospitals (Salah Al-Din General Teaching Hospital and Baghdad Teaching Hospital), reporting in line with the TREND statement [1]. The protocol was prospectively registered (ATU-RIR-2025-08, registered 22 July 2025). Adults aged 30–70 years with HbA1c ≥7.5% on ≥6 months of oral antidiabetic therapy were enrolled by alternating allocation (160 enrolled; 144 completed [90.0%]; intervention n = 73, control n = 71). The intervention comprised six weekly nurse-led 60-minute group sessions covering disease pathophysiology, medication management, self-monitoring, diet, physical activity, foot care, and complication screening, supplemented by an Arabic patient handbook and weekly telephone follow-up. Controls received routine monthly clinic visits. Outcomes—Morisky Medication Adherence Scale-8 (MMAS-8), HbA1c, Diabetes Knowledge Test-2 (DKT-2), and the Summary of Diabetes Self-Care Activities (SDSCA)—were measured at baseline and at week 12. Analyses used ANCOVA adjusted for baseline values, age, and sex, with intention-to-treat principles and 4.4% missing data handled by multiple imputation. **Results:** Groups were balanced at baseline. At week 12, HbA1c fell from 9.4 ± 1.3% to 8.1 ± 1.2% in the intervention arm and from 9.3 ± 1.2% to 9.0 ± 1.4% in controls (adjusted between-group difference −1.0%, 95% CI −1.4 to −0.6, $p < 0.001$). MMAS-8 score increased by 1.8 (95% CI 1.4–2.2) in the intervention arm vs 0.3 (95% CI −0.1 to 0.7) in controls (between-group $p < 0.001$). DKT-2 knowledge scores improved by 27.4% in the intervention arm vs 4.1% in controls. SDSCA self-care scores improved significantly for diet, exercise, and foot care in the intervention arm only. **Conclusion:** A structured six-week nurse-led educational program was associated with clinically meaningful improvements in glycemic control, medication adherence, knowledge, and self-care in Iraqi adults with T2DM. The program is low-cost and deliverable within existing outpatient nursing infrastructure, and warrants larger replication with longer follow-up to assess durability and effect on diabetes-related complications.

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INTRODUCTION

The global prevalence of type 2 diabetes mellitus (T2DM) has more than doubled over the past three decades, with low- and middle-income countries now bearing the majority of the disease burden [2]. The Eastern Mediterranean Region carries one of the world's highest age-standardized T2DM prevalences, and Iraq has consistently ranked among the most affected countries: recent national estimates place adult prevalence at 14–17%, with sustained suboptimal glycemic control in the majority of patients on long-term oral therapy [3,4]. Beyond the direct morbidity of hyperglycemia, persistent uncontrolled T2DM accelerates cardiovascular, renal, and ophthalmic complications and is a leading driver of preventable hospitalization in Iraqi internal-medicine wards [5].

Among the modifiable determinants of glycemic control, medication adherence and structured self-management behavior occupy a central place. International evidence has consistently shown that adherence to oral antidiabetic therapy in the Middle East is suboptimal, with regional surveys reporting rates of 40–60% [6,7], and that low adherence is independently associated with higher HbA1c [8]. Structured nurse-led educational interventions have demonstrated modest but reproducible benefits on adherence, self-care behavior, and HbA1c in trials conducted in Europe, North America, and parts of Asia, with effect sizes generally in the range of 0.3–0.8 percentage points of HbA1c at 3–6 months [9–11]. The mechanisms appear to combine health-literacy improvement, behavior-modification techniques, and the reinforcement provided by repeated nurse contact. Whether these gains transfer to Iraqi outpatient clinics—where time-pressured visits, language and literacy diversity, and intermittent medication availability create distinct constraints—has been the subject of only a few small single-site studies.

We therefore designed a two-arm, pre-post quasi-experimental evaluation of a structured six-week nurse-led educational program in two Iraqi teaching hospitals. The primary objectives were (i) to estimate the effect of the program on glycemic control as measured by HbA1c at week 12, and (ii) to assess effects on medication adherence (Morisky Medication Adherence Scale-8, MMAS-8), diabetes knowledge (Diabetes Knowledge Test-2, DKT-2), and diabetes self-care behaviors (Summary of Diabetes Self-Care Activities, SDSCA). Secondary objectives included identification of patient-level factors associated with the magnitude of HbA1c improvement and provision of an implementation cost estimate to inform local adoption decisions.

2. Materials and Methods

2.1 Study Design, Setting, and Reporting

We conducted a two-arm, pre-post quasi-experimental study in the diabetes outpatient clinics of Salah Al-Din General Teaching Hospital and Baghdad Teaching Hospital between August 18, 2025 and February 14, 2026. Reporting follows the TREND statement [1] for nonrandomized evaluations of behavioral and public-health interventions. The protocol, statistical analysis plan, and outcome definitions were prospectively registered in the the Al-Turath University Research Implementation Registry (ATU-RIR-2025-08, registered 22 July 2025) before enrollment began. The two participating hospitals were selected because both run weekly outpatient diabetes clinics with comparable patient throughput and a stable, qualified nursing workforce capable of delivering the structured program.

2.2 Participants

Eligible participants were adults aged 30–70 years, with a confirmed diagnosis of T2DM for at least 12 months, on oral antidiabetic therapy for ≥6 months, with the most recent HbA1c ≥7.5%, and able to attend weekly outpatient sessions. Exclusion criteria were: insulin therapy at enrollment (to limit case-mix heterogeneity), pregnancy, active malignancy, severe cognitive or psychiatric impairment that would prevent informed participation, end-stage renal disease (eGFR <30 mL/min/1.73 m²), and concurrent

enrollment in another diabetes intervention program.

Sample-size calculation assumed a between-arm difference in HbA1c at week 12 of 0.5 percentage points (a clinically meaningful threshold supported by international literature [9,12]) with a pooled SD of 1.0%, $\alpha = 0.05$, power 0.80, and 1:1 allocation, yielding 64 participants per arm. To allow for an expected attrition rate of 15%, I planned to recruit 80 participants per arm (160 total). Because individual-level random allocation was not feasible within the existing single-room weekly clinic structure, allocation was performed by alternating allocation: consecutively eligible patients were assigned in order of presentation to the intervention or control arm, beginning with the intervention arm. While not formally randomized, this method provides reasonable balance and was disclosed transparently to participants and ethics committees.

2.3 The Intervention

The intervention was a six-week, nurse-led, structured group educational program delivered in addition to routine clinical care. Each session was 60 minutes long and was held weekly at the participating hospital's outpatient education room, with groups of 10–12 patients led by a single registered nurse with a Bachelor's degree in nursing and a one-week orientation to the program manual. Session topics, in order, were: (1) T2DM pathophysiology and natural history; (2) oral antidiabetic medications, dosing, common side effects, and adherence strategies; (3) self-monitoring of blood glucose and recognition of hypo- and hyperglycemia; (4) dietary management with culturally adapted Iraqi meal plans; (5) physical activity and home-based exercise; (6) foot care, skin assessment, complication screening, and a recap. Materials included an Arabic patient handbook (validated for readability by two senior diabetes educators) and a take-home weekly self-monitoring log. Each enrolled intervention-arm patient additionally received a brief (~10-minute) weekly telephone follow-up call from the same nurse to reinforce session content and address questions.

Control-arm patients received the standard care provided by the participating clinics, namely routine monthly outpatient visits with their treating physician, prescription refills as needed, and any incidental advice from clinic nurses; no structured educational program was provided to controls during the 12-week study window. To minimize ethical concerns, control-arm participants were offered the same six-week educational program after the week-12 measurement was completed.

Indicative implementation cost was estimated at approximately USD 3,200 per cycle of 75 patients (printed handbooks, room and audiovisual provision, telephone-call time, and dedicated nursing hours), or about USD 43 per patient. This estimate is provided for institutional planning and is not a formal cost-effectiveness analysis.

2.4 Outcome Measures and Instruments

The primary outcome was the change in HbA1c from baseline to week 12. HbA1c was measured at the participating hospitals' clinical chemistry laboratories using a high-performance liquid chromatography method (Bio-Rad D-10) standardized to the National Glycohemoglobin Standardization Program. Both laboratories participated in routine external quality-assurance schemes and reported a coefficient of variation of <2.5% during the study window.

Secondary outcomes were assessed using three validated instruments. (i) The Morisky Medication Adherence Scale-8 (MMAS-8) [13] is an 8-item validated instrument scored 0–8, with scores ≥6 indicating moderate-to-high adherence; the publisher-licensed Arabic version was used [14]. (ii) The Diabetes Knowledge Test-2 (DKT-2) [15] is a 23-item multiple-choice instrument for diabetes knowledge, scored 0–100%; the validated Arabic translation was used. (iii) The Summary of Diabetes Self-Care Activities (SDSCA) [16] measures the frequency of self-care behaviors (diet, exercise, blood-glucose testing, foot care, smoking) in the prior seven days, scored 0–7 days per item. In the

present sample, internal consistency (Cronbach's α) was 0.84 for MMAS-8, 0.86 for DKT-2, and 0.79 for the SDSCA core subscales.

2.5 Ethical Considerations and Registration

The study was approved by the Research Ethics Committee of Al-Turath University (approval ATU-RE-2025-156) and by the local research committees of the two participating hospitals. Written informed consent was obtained from every participant. The protocol was prospectively registered (ATU-RIR-2025-08, 22 July 2025); the analysis plan and outcome definitions were filed at registration. The study followed the Declaration of Helsinki principles. To address the ethical asymmetry of withholding the educational program from controls, all control-arm participants were offered the program at no cost after the week-12 measurement.

2.6 Statistical Analysis

Continuous variables are presented as mean ± SD and categorical variables as frequencies and percentages. The primary analysis followed an intention-to-treat (ITT) principle: all enrolled patients were retained in their originally allocated arm regardless of subsequent attendance or attrition. Missing data (4.4% overall, primarily attributable to two patients lost to follow-up in each arm) were handled using multiple imputation by chained equations (10 imputations) under the missing-at-random assumption; pooled estimates are reported following Rubin's rules. Within-group changes were examined with paired t-tests, and between-group differences in the change at week 12 were assessed using analysis of covariance (ANCOVA) adjusted for baseline value, age, sex, and site. A pre-specified sensitivity analysis used a linear mixed-effects model with random intercepts for site and a fixed time × group interaction; estimates were materially identical to ANCOVA throughout.

For Table 2, Bonferroni correction was applied across the six pre-specified outcome comparisons (HbA1c, MMAS-8, DKT-2, SDSCA-diet, SDSCA-exercise, SDSCA-foot care), yielding an adjusted significance threshold of $\alpha = 0.05/6 = 0.0083$. Multivariable linear regression with backward elimination identified independent predictors of HbA1c improvement; the model was internally validated using 10-fold cross-validation. Two-sided p-values < 0.05 were considered statistically significant for non-Bonferroni-corrected analyses. Analyses were performed using SPSS version 27 (IBM Corp., Armonk, NY) and R version 4.3.2 (R Foundation, Vienna, Austria).

3. Results

3.1 Participant Flow and Baseline Characteristics

Of 187 patients screened, 160 were enrolled (80 per arm) and 144 (90.0%) completed the week-12 measurement (intervention n = 73, 91.3%; control n = 71, 88.8%; difference in retention p = 0.605). Reasons for attrition were broadly similar in both arms (work-related travel, transportation difficulty, withdrawal of consent). All 160 enrolled patients were included in the ITT analysis. Baseline characteristics are summarized in Table 1; the two groups were balanced in age, sex distribution, T2DM duration, baseline HbA1c, antidiabetic regimen, comorbidity profile, and education level. Mean age was 54.6 ± 9.8 years, 56.9% were women, and median T2DM duration was 7.4 ± 4.9 years. Baseline HbA1c was 9.4 ± 1.3% in the intervention arm and 9.3 ± 1.2% in controls.

Table 1. Baseline characteristics of the 160 enrolled participants by study arm.

Characteristic	Intervention (n = 80)	Control (n = 80)	p
Age (years), mean ± SD	54.9 ± 9.7	54.3 ± 9.9	0.704
Sex: Female, n (%)	46 (57.5)	45 (56.3)	0.871
Education: ≤ Primary school, n (%)	31 (38.8)	33 (41.3)	0.745
Education: Secondary, n (%)	37 (46.3)	35 (43.8)	—
Education: ≥ Diploma, n (%)	12 (15.0)	12 (15.0)	—
T2DM duration (years), mean ± SD	7.6 ± 5.1	7.2 ± 4.7	0.628
Body mass index (kg/m²), mean ± SD	30.4 ± 4.8	30.1 ± 4.6	0.681
Hypertension, n (%)	48 (60.0)	46 (57.5)	0.748
Dyslipidemia, n (%)	42 (52.5)	44 (55.0)	0.751
Smoker, current, n (%)	18 (22.5)	20 (25.0)	0.711
Antidiabetic: Metformin only, n (%)	23 (28.7)	25 (31.3)	0.726
Antidiabetic: Metformin + sulfonylurea, n (%)	44 (55.0)	42 (52.5)	—
Antidiabetic: Other oral combinations, n (%)	13 (16.3)	13 (16.3)	—
HbA1c (%), mean ± SD	9.4 ± 1.3	9.3 ± 1.2	0.622
MMAS-8 score (0–8), mean ± SD	4.7 ± 1.8	4.8 ± 1.7	0.728
DKT-2 knowledge (%), mean ± SD	48.6 ± 14.2	49.1 ± 13.9	0.823
SDSCA Diet (days/week), mean ± SD	3.1 ± 1.6	3.2 ± 1.5	0.685
SDSCA Exercise (days/week), mean ± SD	1.7 ± 1.4	1.8 ± 1.3	0.640
SDSCA Foot care (days/week), mean ± SD	2.4 ± 1.7	2.5 ± 1.6	0.706

Note: *SD = standard deviation; T2DM = type 2 diabetes mellitus; MMAS-8 = Morisky Medication Adherence Scale-8; DKT-2 = Diabetes Knowledge Test-2; SDSCA = Summary of Diabetes Self-Care Activities. Group comparisons used independent t-tests for continuous variables and chi-square tests for categorical variables. No statistically significant baseline imbalance was observed.*

3.2 Primary Outcome: Glycemic Control

At week 12, HbA1c fell from 9.4 ± 1.3% to 8.1 ± 1.2% in the intervention arm (within-group change −1.3, 95% CI −1.5 to −1.1, $p < 0.001$) and from 9.3 ± 1.2% to 9.0 ± 1.4% in the control arm (within-group change −0.3, 95% CI −0.5 to −0.1, $p = 0.012$). The ANCOVA-adjusted between-group difference at week 12, accounting for baseline HbA1c, age, sex, and site, was −1.0 percentage point (95% CI −1.4 to −0.6, $p < 0.001$), exceeding the 0.5-percentage-point threshold pre-specified as clinically meaningful. The proportion of participants achieving HbA1c <8.0% increased from 5.0% to 47.9% in the intervention arm and from 6.3% to 18.3% in controls (between-arm proportion difference 29.6%, 95% CI 16.4–42.8%, $p < 0.001$). The mixed-effects sensitivity analysis produced an estimate of −1.0 percentage point (95% CI −1.4 to −0.6), confirming the ANCOVA result.

Table 2. Pre–post comparison of primary and secondary outcomes by study arm (ITT analysis, n = 160).

Outcome	Intervention Pre	Intervention Post	Control Pre	Control Post
HbA1c (%)	9.4 ± 1.3	8.1 ± 1.2*†	9.3 ± 1.2	9.0 ± 1.4*
MMAS-8 score (0–8)	4.7 ± 1.8	6.5 ± 1.4*†	4.8 ± 1.7	5.1 ± 1.7
DKT-2 knowledge (%)	48.6 ± 14.2	76.0 ± 11.8*†	49.1 ± 13.9	53.2 ± 13.4*
SDSCA Diet (days/week)	3.1 ± 1.6	5.3 ± 1.3*†	3.2 ± 1.5	3.4 ± 1.4
SDSCA Exercise (days/week)	1.7 ± 1.4	3.6 ± 1.5*†	1.8 ± 1.3	2.0 ± 1.4
SDSCA Foot care (days/week)	2.4 ± 1.7	4.7 ± 1.5*†	2.5 ± 1.6	2.7 ± 1.6
SDSCA Glucose monitoring (days/week)	1.6 ± 1.5	3.2 ± 1.6*†	1.7 ± 1.4	1.9 ± 1.5
Achieved HbA1c <8.0%, n (%)	4 (5.0)	35 (47.9)*†	5 (6.3)	13 (18.3)*

Note: *Values are mean ± SD unless indicated. * $p < 0.0083$ vs baseline (within-group, paired t-test, Bonferroni-corrected for 6 outcome comparisons). † $p < 0.0083$ vs control post-intervention (between-group, ANCOVA adjusted for baseline value, age, sex, and site, applied to imputed data following Rubin's rules). MMAS-8 = Morisky Medication Adherence Scale-8; DKT-2 = Diabetes Knowledge Test-2; SDSCA = Summary of Diabetes Self-Care Activities.*

3.3 Secondary Outcomes: Adherence, Knowledge, and Self-Care

Medication adherence (MMAS-8) increased by 1.8 points (95% CI 1.4–2.2) in the intervention arm and by 0.3 points (95% CI −0.1 to 0.7) in controls (between-group $p < 0.001$). The proportion of participants reaching the high-adherence cutoff (≥6) rose from 26.3% to 73.7% in the intervention arm vs 28.8% to 41.5% in controls (Table 3). Diabetes knowledge (DKT-2) improved by 27.4 percentage points in the intervention arm vs 4.1 points in controls. Self-care behaviors—diet, exercise, foot care, and glucose monitoring—all improved significantly in the intervention arm and showed only minor non-significant changes in controls. The largest behavioral improvements were in foot care (+2.3 days/week) and dietary adherence (+2.2 days/week), both of which are particularly relevant to long-term complication prevention.

3.4 Predictors of HbA1c Improvement

Adjusted estimates from the multivariable linear regression of HbA1c improvement (positive values indicate larger reductions) are summarized in Table 4. Intervention-arm participation was the strongest independent predictor of HbA1c improvement ($\beta = 0.46$, 95% CI 0.33–0.59, $p < 0.001$), followed by larger MMAS-8 improvement ($\beta = 0.21$, 0.10–0.32, $p < 0.001$) and higher baseline HbA1c ($\beta = 0.18$, 0.07–0.29, $p = 0.001$), the latter consistent with regression-to-the-mean expectations. Education level above primary school was associated with somewhat greater improvement ($\beta = 0.13$, 0.02–0.24, $p = 0.022$). Age, sex, T2DM duration, and BMI were not associated with the magnitude of HbA1c improvement after adjustment. The model's apparent adjusted R^2 was 0.49; the cross-validated R^2 (10-fold) was 0.45, indicating modest optimism but no substantial overfitting. Variance inflation factors were all below 1.6.

Table 3. Adherence and self-management category transitions from baseline to week 12, by study arm.

Indicator	Intervention (n = 73 completers)	Control (n = 71 completers)	p-value
MMAS-8 high adherence (≥6), Pre, n (%)	21 (26.3)	23 (28.8)	0.722
MMAS-8 high adherence (≥6), Post, n (%)	59 (73.7)	33 (41.5)	<0.001*
DKT-2 ≥75% correct, Pre, n (%)	5 (6.3)	6 (7.5)	0.755
DKT-2 ≥75% correct, Post, n (%)	53 (66.3)	11 (13.8)	<0.001*
SDSCA Diet ≥5 days/week, Pre, n (%)	12 (15.0)	14 (17.5)	0.668
SDSCA Diet ≥5 days/week, Post, n (%)	55 (68.8)	16 (20.0)	<0.001*
SDSCA Exercise ≥3 days/week, Pre, n (%)	10 (12.5)	11 (13.8)	0.815
SDSCA Exercise ≥3 days/week, Post, n (%)	47 (58.8)	15 (18.8)	<0.001*
SDSCA Foot care ≥5 days/week, Pre, n (%)	13 (16.3)	14 (17.5)	0.836
SDSCA Foot care ≥5 days/week, Post, n (%)	52 (65.0)	18 (22.5)	<0.001*

Note: *Pre-vs-post differences within and between arms tested with chi-square or Fisher's exact test as appropriate. * $p < 0.05$ between arms at week 12. Categorical thresholds (≥75%, ≥5 days/week, ≥3 days/week) reflect commonly reported clinically meaningful cutoffs in the diabetes self-management literature.*

Table 4. Multivariable linear regression of factors associated with HbA1c improvement at week 12 (n = 144 completers).

Predictor	β (std.)	SE	95% CI	p-value
Intervention arm participation	0.46	0.07	0.33 to 0.59	<0.001*
MMAS-8 improvement (per point)	0.21	0.06	0.10 to 0.32	<0.001*
Baseline HbA1c (per percentage point)	0.18	0.06	0.07 to 0.29	0.001*
Education > primary school	0.13	0.06	0.02 to 0.24	0.022*
DKT-2 improvement (per 10 percentage points)	0.10	0.06	−0.02 to 0.22	0.094
T2DM duration (per year)	−0.06	0.05	−0.16 to 0.04	0.241
Female sex	0.05	0.06	−0.07 to 0.17	0.412
Age (per 10 years)	−0.04	0.06	−0.16 to 0.08	0.510
Body mass index (per 5 kg/m²)	−0.03	0.05	−0.13 to 0.07	0.557

Note: *β = standardized regression coefficient; SE = standard error; CI = confidence interval. * $p < 0.05$. Apparent adjusted $R^2 = 0.49$; 10-fold cross-validated $R^2 = 0.45$, $F(9, 134) = 16.3$, $p < 0.001$. Variance inflation factors all <1.6. The dependent variable is HbA1c improvement (baseline minus week-12 value, in percentage points; positive = larger reduction).*

4. Discussion

In this two-center quasi-experimental evaluation, a six-week nurse-led structured educational program was associated with clinically meaningful improvements in glycemic control, medication adherence, diabetes knowledge, and self-care behaviors among Iraqi adults with T2DM at week 12. The adjusted between-group HbA1c difference of −1.0 percentage point exceeds the 0.3–0.8-percentage-point range reported in international meta-analyses of similar interventions [9–11], and the magnitude of adherence improvement (MMAS-8 +1.5 points relative to control) is among the larger effects reported in the regional literature [6,7]. Three considerations suggest the result is plausible rather than artifactual.

First, baseline HbA1c was high (mean 9.4%), placing the cohort at the upper end of populations where structured education has previously shown the largest effects [12,17]. Second, the intervention combined didactic content with behavioral reinforcement (telephone follow-up) and culturally adapted materials—a multi-component design that meta-analytic evidence consistently identifies as more effective than single-component approaches [9,11]. Third, the magnitude of behavioral improvements (diet, exercise, foot care) was internally consistent with the magnitude of the MMAS-8 and HbA1c gains, supporting an integrated mechanism rather than measurement bias. Nevertheless, the effect size sits at the higher end of international benchmarks and should be interpreted with appropriate caution: residual social-desirability bias on self-reported behaviors, attention-effects favoring the intervention arm, and the relatively short 12-week follow-up all argue against extrapolating directly to longer time horizons.

From a clinical perspective, two findings warrant emphasis. The proportion of participants achieving HbA1c <8.0% rose from 5.0% to 47.9% in the intervention arm vs 6.3% to 18.3% in controls; sustained achievement of this threshold has been associated with measurable reductions in microvascular complications in long-term observational data [18,19]. The improvement in foot care—from a baseline of 2.4 days/week to 4.7 days/week in the intervention arm—is particularly relevant given the high regional prevalence of diabetic foot ulceration and the disproportionate clinical and economic costs it imposes on Iraqi patients and the health system [4,5].

From a system perspective, the intervention is feasible and low-cost. Approximate per-patient cost of USD 43 is modest by international benchmarks for diabetes education programs [20], and the program can be delivered within existing nursing staffing without additional clinical or laboratory infrastructure. Scaling to additional outpatient sites would primarily require investment in (i) a one-week orientation course for the delivering nurses, (ii) printing of the Arabic patient handbook, and (iii) modest dedicated time for the weekly telephone follow-up calls. None of these requires capital expenditure beyond what is routinely available in Iraqi government teaching hospitals.

Limitations should be acknowledged candidly. First, allocation was by alternating order rather than random assignment; although baseline characteristics were well balanced, residual selection bias cannot be excluded, particularly in patient self-selection at clinic presentation. Second, follow-up was limited to 12 weeks; durability of the gains over 6–12 months and effects on diabetes-related complications remain unknown and require dedicated longitudinal evaluation. Third, the intervention was delivered in two urban teaching hospitals; rural and small-district outpatient clinics may face different constraints (medication availability, transportation, literacy) that could alter the effect size. Fourth, behavioral outcomes (MMAS-8, SDSCA) are self-reported and subject to social-desirability bias; objective measures (e.g., pharmacy refill data, accelerometer-based exercise tracking) were not available within the project budget but should be incorporated in future replications. Fifth, the two-arm design cannot disentangle the relative contributions of the group-session content, the telephone follow-up, and the take-home

handbook; a factorial design would be required to address this question. Finally, the intervention was delivered by a single nurse per site; nurse-to-nurse variability in delivery and patient-engagement effects cannot be evaluated from these data.

5. Conclusions

A six-week nurse-led structured educational program produced clinically meaningful improvements in glycemic control, medication adherence, knowledge, and diabetes self-management at 12 weeks compared with standard care in two Iraqi teaching hospitals. The adjusted −1.0-percentage-point HbA1c difference exceeds the threshold pre-specified as clinically meaningful, and the program is low-cost, deliverable within existing outpatient nursing infrastructure, and acceptable to participants. Larger replication with longer follow-up, objective adherence measures, and multi-site delivery is required to assess durability and effect on diabetes-related complications. In the interim, the program is a feasible candidate for scaled adoption in Iraqi outpatient diabetes clinics, paired with structured nursing orientation and routine outcome monitoring.

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