IJBMC International Journal of Body, Mind and Culture

Volume 13, Issue 5, Article e2026-1373
DOI: 10.61838/ijbmc.v13i5.1373

Article type:
Original Research

Effect of a Pharmacist-Led mHealth and Teleconsultation Intervention on HbA1c in Adults with Type 2 Diabetes in Iraq: A Single-Centre Randomized Controlled Trial

Zahraa. Alkhafaje[1*], Fadya. Al-Hamadani[2], Anmar Thiaa. Al-deen[3]

1 Department of Clinical Pharmacy, College of Pharmacy, Al-Farahidi University, Baghdad, Iraq.
2 Department of Clinical Pharmacy, College of Pharmacy, University of Baghdad, Baghdad, Iraq.
3 Diabetes and Endocrinology Center, AL-Kindi Teaching Hospital, Baghdad, Iraq.

Corresponding author email address:
Zahraa.falaah2200@copharm.uobaghdad.edu.iq

Article history:

Received 17 Feb 2026
Revised 22 Mar 2026
Accepted 01 Apr 2026
Published online 01 May 2026

How to cite this article:
Alkhafaje, Z., Al-Hamadani, F., & Al-deen, A. T. (2026). Effect of a Pharmacist-Led mHealth and Teleconsultation Intervention on HbA1c in Adults with Type 2 Diabetes in Iraq: A Single-Centre Randomized Controlled Trial. International Journal of Body, Mind and Culture, 13(5), Article e2026-1373. https://doi.org/10.61838/ijbmc.v13i5.1373

ABSTRACT

Objective: This study evaluated the effectiveness of an Arabic-language pharmacist-led mHealth and teleconsultation intervention on glycemic control in adults with type 2 diabetes in Iraq.

Methods and Materials: This parallel-group, single-centre randomized controlled trial was conducted at the Endocrinology and Diabetes Centre in Baghdad, Iraq. Of 189 randomized adults with type 2 diabetes, 146 completed the 6-month study and were included in the complete-case analysis: intervention group (n = 76) and standard-care control group (n = 70). The intervention included the Edarat Alsukari mobile application with educational modules, medication reminders, and biweekly pharmacist-led telephone or video consultations. The primary outcome was change in HbA1c at 6 months. ANCOVA was used to adjust for baseline HbA1c imbalance.

Findings: The intervention group had a higher baseline median HbA1c than controls (10.0% vs. 9.4%, p = 0.027). At 6 months, median HbA1c decreased to 8.5% in the intervention group but remained high at 9.75% in controls. After adjustment, the intervention produced a significant HbA1c reduction compared with standard care (adjusted mean difference = −1.35%, 95% CI: −1.68 to −1.02, p < 0.001). Within the intervention group, systolic blood pressure decreased from 133.34 ± 9.4 to 125.75 ± 9.4 mmHg (p < 0.001), and diastolic blood pressure decreased from 88.97 ± 11.9 to 81.08 ± 10.6 mmHg (p < 0.001). BMI and serum creatinine remained stable, and no severe hypoglycemic events were reported.

Conclusion: The pharmacist-led mHealth and teleconsultation intervention significantly improved HbA1c without medication intensification.

Keywords: Diabetes Mellitus, Mobile Applications, Telemedicine, Pharmacists, Glycated Hemoglobin, Iraq.

Introduction

Type 2 Diabetes Mellitus (T2DM) represents a major public health challenge in the Middle East. Diabetes prevalence in Iraq and other Middle Eastern countries exceeds 13%, coinciding with rising obesity rates and lifestyle changes (Al-Rubeaan et al., 2015). Despite the availability of pharmacological therapies, achieving glycemic control targets remains challenging for the Iraqi healthcare system.

"Clinical inertia" occurs when providers delay treatment intensification despite unmet targets, posing a major barrier in Iraq. Mansour et al. reported that this delay is prevalent and leads to prolonged hyperglycemia (Mansour, 2009). The problem is worsened by patients seeing physicians only every three months. Mikhael and Hassali observed that these long intervals leave patients without support, increasing the risk of poor self-care and medication non-adherence (Mikhael et al., 2018; Mikhael et al., 2019; Mukhiddin Ugli et al., 2024).

Mobile health (mHealth) may address challenges occurring between clinic visits. Alanzi's review found that mHealth applications improve patient awareness and adherence in the Arab region (Alsswey et al., 2021). However, most studies focus on subjective outcomes. Few randomized controlled trials in Iraq have evaluated the effects of mHealth on objective clinical endpoints, such as HbA1c, blood pressure, and renal function. The Edarat Alsukari app improved medication adherence and quality of life when combined with pharmacist teleconsultations (Alkhafaje et al., 2026). This follow-up study assesses whether these behavioral changes translate into clinical benefits by evaluating HbA1c reduction, cardiometabolic risk factors, and renal safety, as assessed by serum creatinine.

Nevertheless, important evidence gaps remain in the Iraqi context. Although mHealth interventions have been increasingly studied internationally, fewer randomized controlled trials in Iraq have evaluated culturally tailored Arabic-language mHealth interventions using objective clinical endpoints such as glycated hemoglobin (HbA1c). Moreover, many digital health studies focus on knowledge, satisfaction, usability, or self-reported adherence, whereas fewer examine whether app-based education combined with structured pharmacist-led teleconsultations can translate into measurable improvements in glycemic control. This gap is important because digital interventions may be more effective when they are linguistically appropriate, culturally relevant, and integrated with professional follow-up rather than used as stand-alone tools.

The Edarat Alsukari mobile application was designed to provide Arabic-language diabetes education and medication reminders for adults with T2DM. In the present study, the application was combined with biweekly pharmacist-led telephone or video consultations intended to reinforce medication adherence, address self-care barriers, support goal-setting, and encourage practical lifestyle modification. This combined intervention was developed to provide structured support between routine clinic visits in a resource-limited diabetes care setting in Baghdad, Iraq.

Therefore, this study aimed to evaluate the effect of a pharmacist-led Arabic-language mHealth and teleconsultation intervention on glycemic control among adults with T2DM in Baghdad, Iraq. The primary objective was to determine whether the intervention reduced HbA1c over 6 months compared with standard care. Secondary objectives were to explore changes in blood pressure, body mass index, serum creatinine, and adverse events among participants receiving the intervention. We hypothesized that participants receiving the pharmacist-led mHealth and teleconsultation intervention would achieve a greater reduction in HbA1c at 6 months than participants receiving standard care alone.

Methods and Materials

Study Design and Setting

This study was a parallel-group, single-centre randomized controlled trial conducted at the Endocrinology and Diabetes Centre in the Al-Rasafa area of Baghdad, Iraq. The trial compared a pharmacist-led Arabic-language mobile health (mHealth) and teleconsultation intervention plus standard care with standard care alone among adults with type 2 diabetes mellitus (T2DM). The intervention period lasted 6 months, and outcome assessments were conducted at baseline, 3 months, and 6 months.

The study was conducted in accordance with the principles of the Declaration of Helsinki and the CONSORT guidelines for reporting randomized controlled trials. Ethical approval was obtained from the

University of Baghdad, College of Pharmacy Research Ethics Committee (Ref: 2023/104). All participants provided written informed consent before enrollment.

Participants and Recruitment

Participants were recruited during routine visits to the Endocrinology and Diabetes Centre. The principal investigator screened potentially eligible patients and explained the purpose, procedures, risks, and expected benefits of the study. Patients who met the eligibility criteria and agreed to participate were enrolled after providing written informed consent.

Eligible participants were adults aged 18 years or older with a confirmed diagnosis of T2DM for at least 1 year and a baseline glycated hemoglobin (HbA1c) level of 7% or higher. Participants were also required to own or have regular access to a smartphone with internet connectivity and the ability to install and use a mobile application.

Patients were excluded if they had type 1 diabetes mellitus, gestational diabetes, severe cognitive impairment that could limit their ability to use the intervention or provide informed consent, end-stage renal disease, or current participation in another clinical trial. Participants were withdrawn from the intervention if they missed three consecutive scheduled pharmacist teleconsultations. Participants who did not attend the 6-month outcome assessment were considered lost to follow-up for the primary endpoint.

Randomization and Allocation Concealment

After baseline assessment, eligible participants were randomly assigned in a 1:1 ratio to either the intervention group or the control group. Stratified randomization was used according to baseline HbA1c level to help balance disease severity between groups. Three HbA1c strata were defined: 7% to less than 9%, 9% to 11%, and greater than 11%.

The randomization sequence was generated by an independent statistician who was not involved in participant recruitment, intervention delivery, or outcome assessment. Allocation was concealed from the principal investigator until after participants had completed baseline assessment and were formally enrolled. Participants were then assigned to the intervention or control group according to the predetermined randomization sequence.

Blinding

Due to the nature of the intervention, participants and the pharmacist delivering the teleconsultations could not be blinded to group allocation. This lack of participant blinding may have introduced performance bias, as participants in the intervention group may have been more motivated to improve self-management behaviors. To reduce detection bias, laboratory staff responsible for HbA1c and serum creatinine measurements were blinded to group allocation. Blood pressure measurements were performed by trained clinical staff who were not involved in delivering the intervention.

Intervention Group

Participants assigned to the intervention group received standard diabetes care plus access to the Edarat Alsukari Arabic-language mHealth application and structured pharmacist-led teleconsultations.

The Edarat Alsukari application provided Arabic-language educational content related to T2DM self-management, including information on medication adherence, dietary practices, blood glucose monitoring, physical activity, hypoglycemia prevention, and diabetes complications. The application also included medication reminder functions designed to support regular medication use.

In addition to the mobile application, participants received biweekly pharmacist-led teleconsultations by telephone or video call throughout the 6-month intervention period. The consultations were delivered by a clinical pharmacist and focused on reinforcing diabetes self-management behaviors, identifying barriers to medication adherence, reviewing home glucose logs when available, answering medication-related questions, and supporting individualized goal-setting. The consultations incorporated behavior-change strategies such as motivational interviewing, action planning, problem-solving, feedback, and positive reinforcement.

Each consultation followed a structured format that included: reviewing medication use, asking about missed doses or adverse effects, discussing recent blood glucose readings if available, identifying dietary or lifestyle challenges, reinforcing key educational messages, and agreeing on practical self-management goals before the next contact. When participants reported mild

hypoglycemic symptoms, the pharmacist provided dietary advice and self-management counseling. Medication changes were not made by the pharmacist as part of the intervention; any required medication adjustment remained the responsibility of the treating physician.

Intervention adherence was monitored through attendance at scheduled teleconsultations. Missed consultations were followed up when possible. Participants who missed three consecutive scheduled teleconsultations were considered withdrawn from the intervention according to the predefined withdrawal rule.

Control Group

Participants assigned to the control group received the institution's standard diabetes care. Standard care consisted of routine follow-up visits at the diabetes centre, usually every 3 months, and routine verbal advice provided during clinical consultations. Control participants did not receive access to the Edarat Alsukari application and did not receive scheduled pharmacist-led teleconsultations as part of the study.

Both groups continued to receive usual medical care from their treating physicians. The study intervention did not include medication intensification or medication de-escalation. Any medication decisions during the study period were made by treating physicians according to usual clinical practice.

Outcome Measures

Outcome measures were collected at baseline, 3 months, and 6 months where applicable.

The primary outcome was HbA1c at 6 months. HbA1c was measured using high-performance liquid chromatography with the Bio-Rad D-10 system. Measurements were obtained at baseline, 3 months, and 6 months for both study groups. Laboratory personnel were blinded to group allocation.

Secondary and exploratory outcomes included systolic blood pressure, diastolic blood pressure, body mass index, serum creatinine, and adverse events. Blood pressure was measured after a 5-minute rest using a validated digital sphygmomanometer. Systolic and diastolic blood pressure were recorded in mmHg. Body mass index was calculated as weight in kilograms divided by height in meters squared. Serum creatinine was measured using standard laboratory methods at the centre's laboratory.

Because blood pressure, body mass index, and serum creatinine were evaluated longitudinally within the intervention group, these outcomes were treated as exploratory within-group physiological and safety trends rather than definitive between-group efficacy outcomes.

Adverse events were monitored throughout the study period, with particular attention to hypoglycemic episodes, hospitalizations, severe adverse events, and any event requiring third-party assistance or urgent medical care. Severe hypoglycemia was defined as a hypoglycemic episode requiring assistance from another person. Mild hypoglycemic symptoms were recorded when self-reported by participants and managed through counseling during pharmacist teleconsultations.

Sample Size

The required sample size was estimated using G*Power software. Assuming a medium effect size of Cohen's d = 0.5, 80% statistical power, and a two-sided significance level of 0.05, at least 64 participants per group were required. To allow for potential loss to follow-up, a larger number of participants was randomized.

Statistical Analysis

Data were analyzed using IBM SPSS Statistics, version 26. Continuous variables were summarized as mean ± standard deviation for normally distributed data or median and interquartile range for non-normally distributed data. Categorical variables were summarized as frequencies and percentages.

Normality of continuous variables was assessed using the Shapiro–Wilk test and visual inspection where appropriate. Baseline characteristics were compared between groups using the independent-samples t-test for normally distributed continuous variables, the Mann–Whitney U test for non-normally distributed continuous variables, and the chi-square test or Fisher's exact test for categorical variables.

The primary analysis was conducted using a complete-case approach including randomized participants who completed the 6-month assessment and had available HbA1c data. Because participants with missing 6-month HbA1c values were excluded from the primary analysis, this analysis should be interpreted as a

complete-case or modified intention-to-treat analysis rather than a full intention-to-treat analysis.

Unadjusted between-group comparisons of HbA1c at each time point were performed using the Mann–Whitney U test when the data were not normally distributed. Within-group changes in HbA1c over time were assessed using Friedman's test. To account for baseline HbA1c imbalance between groups, analysis of covariance was performed with 6-month HbA1c as the dependent variable, treatment group as the fixed factor, and baseline HbA1c as a covariate. The adjusted mean difference between groups, 95% confidence interval, and p-value were reported. Given the observed baseline imbalance in sex distribution, a sensitivity analysis adjusting for both baseline HbA1c and sex is recommended.

Within-group changes in systolic blood pressure, diastolic blood pressure, body mass index, and serum creatinine in the intervention group were analyzed using repeated-measures analysis of variance, the paired-samples t-test, or non-parametric alternatives, depending on the distribution and number of measurement time points. These analyses were interpreted as exploratory because randomized between-group comparisons were not available for all secondary outcomes.

Attrition was assessed by reporting the number and percentage of participants lost to follow-up or withdrawn from each study group. Where possible, baseline characteristics of participants who completed the study were compared with those of participants lost to follow-up to evaluate potential attrition bias.

All statistical tests were two-sided, and a p-value of less than 0.05 was considered statistically significant.

Findings and Results

Participant Flow and Attrition

Figure 1 summarizes participant flow. A total of 230 patients were screened, and 41 were excluded for not meeting the inclusion criteria. The remaining 189 participants were randomized. During the 6-month study, 43 participants (22.7%) were lost to follow-up or dropped out. The final complete-case analysis included 146 participants (Intervention group, n=76; Control group, n=70). Attrition analysis showed that these dropouts contributed to baseline imbalances in sex distribution and initial HbA1c levels.

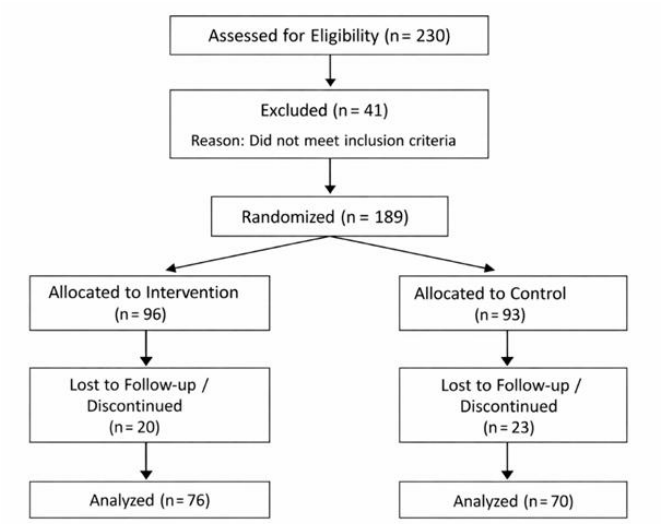

Figure 1

Participant Flow and Recruitment

Baseline Characteristics

Baseline demographic and clinical characteristics of the analyzed cohort are summarized in Table 1. The mean age was 53.37 ± 7.2 years in the Intervention group and 55.06 ± 7.8 years in the Control group (p=0.177). Diabetes duration, family history, and education levels were comparable across both arms. Regarding clinical parameters, approximately 40% of the cohort had a comorbid diagnosis of hypertension, and 34% had dyslipidemia. Baseline diabetes pharmacological therapy was uniform, with the majority of patients prescribed either a combination of Glibenclamide and Metformin (~41–43%) or insulin therapies such as Actrapid and Mixtard (~49–51%).

Despite stratified randomization, the aforementioned participant attrition resulted in significant baseline imbalances in the final sample.

Glycemic control: The Intervention group had a significantly higher baseline median HbA1c (10.0%) than the Control group (9.4%; p = 0.027), indicating a greater initial disease burden in the treatment arm.

Gender distribution: A significant difference was observed (p = 0.001), with a higher proportion of males in the Intervention group (48.7%) compared to the Control group (22.9%).

Table 1

Demographic and Clinical Characteristics of Participants.

Variables	Variables	Control	Intervention	p-value
Variables	Variables	Mean±S.D or No. (%)	Mean±S.D or No. (%)	p-value
Mean age (years)	Mean age (years)	55.06±7.8	53.37±7.2	0.177
Age (years)				
Age (years)	30-45	6 (8.6%0	13 (17.1%)	0.258
Age (years)	46-60	49 (70%)	51 (67.1%)	0.258
Age (years)	61-75	15 (21.4%)	12 (15.8%)	0.258
		70	76	
Sex	Male	16 (22.9%)	37 (48.7%)	0.001**
Sex	Female	54 (77.1%)	39 (51.3%)	0.001**
Duration of disease (year)	1-5	32 (45.7%)	32(42.1%)	
Duration of disease (year)	6-10	32 (45.7%)	35 (46.1%)	
Duration of disease (year)	11-15	6 (8.6%)	9 (11.8%)	
Family history of diabetes	Yes	53 (75.7%)	58 (76.3%)	
Family history of diabetes	No	17(24.3%)	18 (23.7%)	
Education level	No education	1 (1.4%)	1 1.3%)	
Education level	Primary	18 (25.7%)	20 (26.3%)	
Education level	Secondary	23 (32.9%)	33 (43.4%)	
Education level	College	28 (40%)	22 (28.9%)	
Diabetes medication	Glibenclamide+ Metformin	30(42.9%)	31(40.8%)	
Diabetes medication	Actrapid+Mixtard	34 (48.6%)	39 (51.3%)	
Diabetes medication	Insultard+mixtard	2 (2.9%)	0	
Diabetes medication	Actrapid+insultard	4 (5.7%)	4 (5.3%)	
Diabetes medication	Sitagliptin+metformin	0	1 (1.3%)	
Diabetes medication	Glimipride+metformin	0	1 (1.3%)	
Medication duration (years)	1-5	64 (91.4%)	68 (89.5%)	
Medication duration (years)	6-10	6 (8.6%)	8 (10.5%)	

Primary Outcome:

Glycemic Control (HbA1c) Importantly, participants' prescribed diabetes medications were not altered or intensified by treating physicians during the 6-month study period, allowing for the isolation of the intervention's behavioral effects.

Table 2 presents the unadjusted longitudinal changes in HbA1c. In the Intervention group, median HbA1c decreased from 10.0% [IQR: 9.0–11.58] at baseline to 8.8% [IQR: 8.03–10.0] at 3 months, and further to 8.5% [IQR: 8.0–9.5] at 6 months. Conversely, the Control group's median HbA1c was 9.4% [IQR: 8.3–10.7] at baseline, 9.8% [IQR: 8.5–11.0] at 3 months, and 9.75% [IQR: 8.6–10.65] at 6 months.

To account for baseline imbalances due to attrition and mitigate regression to the mean, an Analysis of Covariance (ANCOVA) was performed, adjusting for baseline HbA1c. The adjusted analysis demonstrated a

highly significant treatment effect, with the Intervention group achieving a significantly greater reduction in HbA1c at 6 months compared to standard care (Adjusted Mean Difference: -1.35%; 95% CI: -1.68% to -1.02%; p < 0.001).

Table 2

Changes in HbA1c Levels Between Control and Intervention Groups

Time Point	Control Group (n=70)	Intervention Group (n=76)	Between-Group P-value^
	Median (IQR)	Median (IQR)	
Baseline (T0)	9.4 (8.3 – 10.7)	10.0 (9.0 – 11.58)	0.027*
After 3 Months	9.8 (8.5 – 11.0)	8.8 (8.03 – 10.0)	0.013*
After 6 Months	9.75 (8.6 – 10.65)	8.5 (8.0 – 9.5)	< 0.001**
Within-Group P-value^^	0.367	< 0.001**	

^Between-group comparisons calculated using the Mann–Whitney U test.^^Within-group comparisons calculated using the Friedman test. Significant at p < 0.05. ** Significant at p < 0.01. IQR: Interquartile Range.*

Secondary Outcomes: Exploratory Physiological Trends

were evaluated longitudinally within the Intervention arm to monitor exploratory physiological and safety trends. Similar to diabetes management, participants' antihypertensive medication regimens were not changed during the follow-up period.

Despite stable pharmacological therapy, the Intervention group exhibited significant within-group reductions in blood pressure. Mean systolic blood pressure decreased from 133.34 ± 9.4 mmHg at baseline to 125.75 ± 9.4 mmHg at 6 months (p < 0.001). Diastolic blood pressure similarly declined from 88.97 ± 11.9 mmHg to 81.08 ± 10.6 mmHg (p < 0.001) (Table 3).

Regarding safety metrics, body mass index (BMI) and serum creatinine showed no significant changes, indicating weight neutrality and stable short-term renal hemodynamics (Table 4). Mean BMI was 29.45 ± 4.7 kg/m^2 at baseline and 28.79 ± 4.6 kg/m^2 at 6 months (p=0.387). Mean serum creatinine was 80.86 ± 14.5 µmol/L at baseline and 78.28 ± 15.6 µmol/L at 6 months (p = 0.294).

Table 3

Changes in Blood Pressure in the Intervention Group

Parameter	Baseline (Mean ± SD)	3 Months (Mean ± SD)	6 Months (Mean ± SD)	P-value^
Systolic BP (mmHg)	133.34 ± 9.4	128.8 ± 9.0	125.75 ± 9.4	< 0.001*
Diastolic BP (mmHg)	88.97 ± 11.9	83.96 ± 11.0	81.08 ± 10.6	< 0.001*

^P-values calculated using Repeated Measures ANOVA.

Table 4

Changes in Safety Outcomes (BMI and Renal Function) in Intervention Group

Parameter	Baseline (Mean ± SD)	6 Months (Mean ± SD)	P-value^
BMI (kg/m^2)	29.45 ± 4.7	28.79 ± 4.6	0.387
Serum Creatinine (µmol/L)	80.86 ± 14.5	78.28 ± 15.6	0.294

^P-values calculated using Paired T-test.

Safety and Adverse Events

The intervention was generally well-tolerated. During the 6-month trial, no severe adverse events, hospitalizations, or episodes of severe hypoglycemia requiring third-party assistance were reported in either group. Within the Intervention arm, some participants self-reported episodes of mild hypoglycemia; however, these were self-managed and successfully addressed through targeted dietary advice during the routine pharmacist teleconsultations without necessitating medication de-escalation.

Discussion and Conclusion

Principal Clinical Findings

This single-centre randomized controlled trial evaluated the efficacy of a culturally tailored, pharmacist-led mHealth intervention compared to standard care in adults with T2DM. The primary finding is that the intervention significantly improved long-term glycemic control. After adjusting for baseline imbalances via ANCOVA, the intervention yielded a significant adjusted mean HbA1c difference of -1.35% at 6 months relative to standard care. Conversely, patients in the standard care arm experienced a slight deterioration in glycemic control, highlighting the persistent challenges of clinical inertia and extended gaps between routine clinic visits in this setting.

Mechanisms of Glycemic Improvement

A notable strength of this trial is that the significant HbA1c reduction in the intervention arm was achieved without pharmacological intensification. Because anti-diabetic and antihypertensive medication regimens remained stable throughout the 6-month study, the clinical improvements can be directly attributed to behavioral modifications rather than therapeutic escalation. As demonstrated in our prior evaluation of this specific cohort Alkhafaje et al. (2026), the combination of the Edarat Alsukari app and remote pharmacist teleconsultations significantly enhanced self-reported medication adherence, dietary practices, and self-care behaviors. The biweekly touchpoints likely reinforced medication adherence and intrinsic motivation, demonstrating that optimizing existing therapeutic regimens with digital and professional support can effectively lower HbA1c in this population.

4.3 Exploratory Secondary Outcomes and Physiological Trends

In addition to glycemic control, the study tracked secondary physiological parameters within the intervention arm. We observed statistically significant within-group reductions in both systolic and diastolic blood pressure over the 6-month period. Given that antihypertensive medications were not altered, this hypotensive trend may reflect improved adherence to existing cardiovascular medications or the adoption of dietary modifications (such as sodium restriction) encouraged during the pharmacist consultations. However, because these secondary endpoints were not evaluated against the randomized control group, causal attribution to the mHealth intervention cannot be definitively established, and these findings should be interpreted strictly as hypothesis-generating (Group, 2015).

Furthermore, while the trial was not powered or designed as a comprehensive safety or pharmacovigilance study, basic physiological monitoring indicated that the intervention was weight-neutral (stable BMI) and did not acutely alter short-term renal hemodynamics (stable serum creatinine). The absence of severe hypoglycemic events requiring third-party assistance further supports the intervention's short-term tolerability.

Strengths and Limitations

The strengths of this study include its pragmatic randomized design, the use of objective laboratory endpoints (HPLC for HbA1c), and the successful integration of a culturally tailored digital tool within a resource-limited healthcare system.

However, several important limitations must be thoroughly acknowledged. First, the trial experienced a substantial attrition rate (22.7%), primarily due to loss to follow-up at the 6-month assessment. This required a complete-case (Modified Intention-to-Treat) analysis, which inherently introduces missing data and attrition bias. Consequently, this differential dropout contributed to significant baseline imbalances in sex distribution and initial HbA1c levels between the final analyzed groups. While we analytically mitigated this threat to validity by employing an ANCOVA model to adjust for baseline HbA1c, the potential influence of unmeasured confounders remains .

Second, as previously noted, secondary outcomes (blood pressure, BMI, creatinine) were tracked solely within the intervention arm. The lack of randomized between-group comparisons for these metrics weakens causal inferences regarding cardiometabolic benefits. Third, requiring smartphone ownership introduces selection bias, limiting the generalizability of these findings to digitally literate patients and potentially excluding economically disadvantaged populations. Fourth, while we minimized the risk of digital

contamination by confirming zero baseline app usage among control participants, the lack of continuous monitoring of external app adoption in the control arm remains a theoretical limitation. Finally, as a small, single-centre explanatory trial, broader policy extrapolations should be avoided until these findings are replicated in larger, multicenter effectiveness trials (Stratton et al., 2000).

The integration of the Arabic-language Edarat Alsukari app with biweekly pharmacist teleconsultations successfully improved glycemic control over 6 months in patients with T2DM, driven by behavioral and adherence improvements rather than medication intensification. While exploratory within-group data suggest potential secondary benefits for blood pressure, the study's high attrition rate and single-centre design necessitate cautious interpretation. Future well-powered, multicenter trials with comprehensive control group tracking are required to confirm cardiometabolic benefits and inform broader implementation strategies.

Acknowledgments

The authors express their gratitude and appreciation to all participants.

Declaration of Interest

The authors of this article declared no conflict of interest.

Ethical Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants. Ethical considerations in this study were that participation was entirely optional.

Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

Funding

This research was carried out independently with personal funding and without the financial support of any governmental or private institution or organization.

Authors' Contributions

All authors equally contribute to this study.

References

Al-Rubeaan, K., Al-Manaa, H. A., Khoja, T. A., Ahmad, N. A., Al-Sharqawi, A. H., Siddiqui, K., Alnaqeb, D., Aburisheh, K. H., Youssef, A. M., & Al-Batel, A. (2015). Epidemiology of abnormal glucose metabolism in a country facing its epidemic: SAUDI-DM study: 一个国家面临的糖代谢异常的流行病学研究: SAUDI-DM 研究. *Journal of diabetes*, *7*(5), 622-632. https://doi.org/10.1111/1753-0407.12224

Alkhafaje, Z., Al-Hamadani, F., & Aldeen, A. T. (2026). Evaluation of Mobile Technology and Video Consultations Effectiveness on Patients with Type 2 Diabetes Mellitus in Baghdad-Iraq: A Systematic Review. *Bangladesh Journal of Pharmacology*, *21*(1), 610-621.

Alsswey, A., Al-Samarraie, H., & Bervell, B. (2021). mHealth technology utilization in the Arab world: A systematic review of systems, usage, and challenges. *Health and Technology*, *11*(4), 895-907. https://doi.org/10.1007/s12553-021-00549-3

Group, S. R. (2015). A randomized trial of intensive versus standard blood-pressure control. *New England Journal of Medicine*, *373*(22), 2103-2116. https://doi.org/10.1056/NEJMoa1511939

Mansour, A. A. (2009). Chronic complications of diabetes in Iraq: experience from southern Iraq. *Clinical medicine. Endocrinology and diabetes*, *2*, CMED. S3657. https://doi.org/10.4137/CMED.S3657

Mikhael, E. M., Hassali, M. A., Hussain, S. A., & Shawky, N. (2018). Self-management knowledge and practice of type 2 diabetes mellitus patients in Baghdad, Iraq: a qualitative study. *Diabetes, Metabolic Syndrome and Obesity*, 1-17. https://doi.org/10.2147/DMSO.S183776

Mikhael, E. M., Hussain, S. A., Shawky, N., & Hassali, M. A. (2019). Validity and reliability of anti-diabetic medication adherence scale among patients with diabetes in Baghdad, Iraq: a pilot study. *BMJ Open Diabetes Research & Care*, *7*(1). https://doi.org/10.1136/bmjdrc-2019-000658

Mukhiddin Ugli, A., Hussein, U. A.-R., Diwan, T. M., Mohammed, W. K., Ali, A. F., Amr, E. F., Muften, N. F., Hasan, A. H., Ganieva, N., & Inoyatova, S. (2024). A Comprehensive Study on the Benefits of Education and Home-Based Follow-Up on Diabetes Awareness and Behavior Modifications in Baghdad Teaching Hospital, Iraq. *International Journal of Body, Mind & Culture (2345-5802)*, *11*(4). 10.22122/ijbmc.v11i3.626

Stratton, I. M., Adler, A. I., Neil, H. A. W., Matthews, D. R., Manley, S. E., Cull, C. A., Hadden, D., Turner, R. C., & Holman, R. R. (2000). Association of glycaemia with macrovascular and microvascular complications of type 2 diabetes (UKPDS 35): prospective observational study. *bmj*, *321*(7258), 405-412. https://doi.org/10.1136/bmj.321.7258.405