Original Article
http://mjiri.iums.ac.ir
Medical Journal of the Islamic Republic of Iran (MJIRI)

Med J Islam Repub Iran. 2026 (1 Apr);40.31. https://doi.org/10.47176/mjiri.40.31

Attitudes toward Mobile App Use in Individuals with Type 1 Diabetes Mellitus: A Quasi-Experimental Mixed-Methods Investigation of a Digital Support Tool for Diabetes Self-Management Behavior

Fariba Alaei-Shahmiri[1†], Roya Ghafoury[1†], Shahnaz Rimaz[2], Shakiba Rahimi[3], Mitra Faghihi[4], Zohreh Maghsoomi[3,1], Mohammad E. Khamseh[1*]

Received: 28 Jul 2025 Accepted: 27 Mar 2026 Published: 1 Apr 2026

Abstract

Background: Mobile applications can enhance diabetes self-management by visualizing glucose trends and promoting engagement. However, evidence on their behavioral and clinical effectiveness in environments with constrained resources remains limited. This study evaluated the impact of the Iranian Asan-Chek mobile app on glycemic outcomes and user experiences among adults with type 1 diabetes mellitus (T1DM).

Methods: In a 12-week quasi-experimental mixed-methods study, 148 adults with T1DM were recruited. Seventy-four participants used the Bluetooth-enabled Asan-Chek app (intervention group) and 74 performed structured self-monitoring of blood glucose (control group). Primary outcomes included changes in HbA1c and qualitative insights into user engagement and experience. Semi-structured interviews with 15 purposively selected participants (13 app users, 2 controls, varied in age and diabetes duration) explored attitudes, perceived benefits, and barriers. Transcripts were analyzed thematically.

Results: HbA1c decreased by 0.62% in the app group and by 0.41% in the control group (both $P < 0.001$), without any notable divergence between the intervention and control participants ($P = 0.202$). Changes in BMI, insulin requirements, and glycemic variability during the course of the study exhibited no statistical disparity between the two groups. Qualitative analysis uncovered three motifs: (i) heightened self efficacy and perceived control arising from instant feedback; (ii) stronger motivation prompted by color coded trend charts and reminders and (iii) usability and economic barriers: interface complexity, data driven anxiety, test strip cost, and finger prick fatigue.

Conclusion: Over twelve weeks, qualitative results highlighted that the Asan-Chek app provided motivational and behavioral advantages for individuals with T1DM but did not outperform structured SMBG in attaining HbA1c targets. Addressing challenges through optimized app interface, comprehensive user training, affordable supplies via reimbursement, and AI-driven feedback may help convert these behavioral gains into lasting glycemic improvement.

Keywords: Blood glucose monitoring, Diabetes self-management, Digital health applications, Type 1 diabetes mellitus, User engagement

Cite this article as: Alaei-Shahmiri F, Ghafoury R, Rimaz S, Rahimi S, Faghihi M, Maghsoomi Z, Khamseh ME. Attitudes toward Mobile App Use in Individuals with Type 1 Diabetes Mellitus: A Quasi-Experimental Mixed-Methods Investigation of a Digital Support Tool for Diabetes Self-Management Behavior. *Med J Islam Repub Iran.* 2026 (1 Apr);40:31. https://doi.org/10.47176/mjiri.40.31

Introduction

Individuals with type 1 diabetes mellitus (T1DM) face significant challenges in achieving optimal blood glucose (BG) control despite advances in management strategies (1). According to the 2023 American Diabetes Association guidelines, only about 25% of individuals with T1DM reach the recommended HbA1c target of less than 7% (2).

Corresponding author: *Dr Mohammad E. Khamseh, khamseh.m@iums.ac.ir*

† F. Alaei-Shahmiri and R. Ghafoury contributed equally to this work.

1. Endocrine Research Center, Institute of Endocrinology and Metabolism, Iran University of Medical Sciences, Tehran, Iran
2. Radiation Biology Research Center, Department of Epidemiology, School of Public Health, Iran University of Medical Sciences, Tehran, Iran
3. Research Center for Prevention of Cardiovascular Disease, Institute of Endocrinology and Metabolism, Iran University of Medical Sciences, Tehran, Iran
4. Department of Health Education and Health Promotion, School of Public Health, Iran University of Medical Sciences, Tehran, Iran

↑What is "already known" in this topic:
Sustained glycemic control in adults with type 1 diabetes mellitus (T1DM) remains challenging. Smartphone apps that visualize glucose trends can support self-management, but evidence from environments with constrained resources remains limited.

→What this article adds:
The study suggests that mobile apps may enhance self-efficacy in diabetes self-management and behavioral engagement, even without superior glycemic outcomes. It highlights the potential of simplified design, affordable test supplies, and personalized digital feedback to sustain long-term self-management among adults with T1DM in resource-limited settings.

Hypoglycemia remains a common and serious complication, causing neurological impairments, reduced quality of life, and disruption of daily activities (3, 4). Prevention, early detection, and timely intervention are therefore critical components of diabetes care.

Strategies to lower hypoglycemia risk include self-monitoring of blood-glucose (SMBG), diabetes education, personalized insulin adjustments, lifestyle changes, and regular healthcare follow-up (5–7). However, integrating these tasks into daily life is often burdensome. Technological advances such as blood glucose monitoring systems (BGMS), continuous glucose-monitoring (CGM), and insulin pumps have become integral to diabetes care (8).

Yet, only a minority of patients routinely download and analyze their data to improve glycemic control (9). To address this gap, mobile applications have been developed to synchronize glucometer data with smartphones for real-time tracking and self-management (10–12). An aggregate analysis of 21 distinct trials revealed that mobile apps can significantly reduce HbA1c in T1DM (13). Nonetheless, further research is needed to evaluate clinical effectiveness alongside user satisfaction, benefits, and challenges (14).

Asan-Chek is an Iranian-developed mobile app enabling recording and synchronization of blood glucose and insulin dosages, with data sharing to healthcare providers (HCPs). To our knowledge, no prior studies have assessed such applications within the Iranian population. This study evaluates the Asan-Chek app's impact on glycemic outcomes and user perceptions among individuals with T1DM.

Methods

Study Design and Participants

This 12-week quasi-experimental, prospective, comparative study was conducted at the Endocrine Research Center, Institute of Endocrinology and Metabolism, Iran University of Medical Sciences, Tehran, Iran, between September 2023 and July 2024. It aimed to evaluate the impact of the Asan-Chek digital platform on glycemic control and explore user attitudes among adults with T1DM. Participants were assigned equally to the app or the control group without randomization, consistent with a quasi-experimental design. Eligible participants had a confirmed T1DM diagnosis for over six months, HbA1c below 11%, and were managed using a multiple daily injection (MDI) regimen. They were assigned equally to two groups: 74 app users managing SMBG data through Asan-Chek (intervention) and 74 non-app users (control). Exclusion criteria included pregnancy, psychiatric disorders, infections, prior use of diabetes management apps or CGM, high alcohol intake (>20 g/day), corticosteroid therapy, uncontrolled thyroid dysfunction, or inability/unwillingness to participate.

Individuals were designated to the app-based intervention or the non-app control group through a non-random, comparative assignment approach. Allocation was based on the participants' expressed willingness and ability to use the Asan-Chek app and the availability of Bluetooth-enabled glucometers. Groups were matched on key baseline characteristics, including age, diabetes duration, and HbA1c level, to minimize selection bias and enhance comparability. This pragmatic allocation reflects a quasi-experimental design aimed at evaluating real-world feasibility rather than testing efficacy under controlled conditions.

Prior to inclusion, we secured formal written consent from every subject. All individuals received a comprehensive explanation regarding the research goals, methods, possible hazards and advantages, the optional nature of their involvement, and their freedom to exit the trial whenever they wished without affecting their medical treatment. Participant privacy was rigorously protected; all records were de-identified and managed in compliance with ICH-GCP standards, guaranteeing that no personal data could be traced in the final results or reports.

Data Collection and Analysis

Data regarding patient demographics and clinical variables were recorded at the start of the study and at monthly intervals throughout the 12-week duration (Visits 1–4). Clinical assessments at baseline and study end (Visits 1 and 4) included HbA1c, BMI, waist circumference, blood pressure (SBP, DBP), and insulin dosages. Monthly glucometer data recorded total tests, average daily frequency, mean blood glucose, hypoglycemic episodes (BG <70 mg/dL), hyperglycemic episodes (BG >180 mg/dL), and time-in-range (70–180 mg/dL), calculated as (tests within range ÷ total tests) × 100.

At week 12, participant satisfaction and attitudes were explored through semi-structured interviews with 15 purposively selected individuals (13 app users, 2 controls). Participants were chosen using a maximum-variation approach to capture diversity in gender, age, education, occupation, diabetes duration, and glycemic control. Sampling continued until thematic saturation was reached, meaning that no new concepts emerged in successive interviews. Given the qualitative nature of this component, the unequal group sizes did not undermine analytic validity. A trained qualitative researcher conducted all interviews using a standardized, pilot-tested topic guide. Methodological rigor and trustworthiness were strengthened through independent coding, investigator triangulation, and consensus validation of emergent themes. All sessions were audio-recorded, transcribed word-for-word, and subsequently examined via conventional content analysis techniques. (15).

Transcripts were reviewed repeatedly for theme identification and categorization. A pilot test involving three participants was conducted, leading to refinements in the interview guide. Credibility, dependability, and confirmability were ensured through prolonged engagement, systematic coding, field observations, and detailed documentation (16). Transferability was supported by the inclusion of direct quotations and rich contextual descriptions. Participants were informed of study objectives, confidentiality, voluntary participation, and withdrawal rights before interviews.

[DOI: 10.47176/mjiri.40.31]

Intervention: The Asan-Chek Platform

All participants were instructed to perform SMBG seven times daily per diabetes care standards (17). The Asan-Chek platform is a locally developed, Bluetooth-enabled diabetes data management system comprising three integrated components: a blood glucose (BG) meter, a smartphone application, and a secure web portal. The app automatically synchronizes with compatible meters to log capillary glucose readings and allows manual entry of glucose, insulin doses, and meal information when needed. Data are stored in a cloud-based system accessible to both patients and healthcare providers. The application generates structured reports and three-day glycemic trend charts, displays BG statistics (mean, standard deviation, percentage in range 70–180 mg/dL), and visualizes daily, weekly, and long-term trends as demonstrated in Figure 1.

The web portal provides automated summary updates and facilitates remote review by clinicians. The Asan-Chek platform's automated feedback algorithm and clinician dashboard are shown in Figures 2 and 3. Participants received a brief, standardized orientation on installation, synchronization, and use before beginning the intervention.

Sample Size and Statistical Analysis

Referring to findings from an earlier meta-analysis (13), we determined a sample size of 67 subjects per group to identify a 0.49% variation in HbA1c (power = 80%, α = 0.05). To compensate for a projected 10% attrition, we recruited a total of 148 participants. Descriptive statistics for continuous variables appear as means ± standard deviations (SD) or medians (interquartile range: Q1–Q3), whereas categorical data are listed as frequencies and percentages. We utilized Chi-square (χ^2) tests for categorical comparisons. To evaluate within-group shifts in clinical and glucometer metrics, we applied Paired-Samples t-tests, Wilcoxon tests, or Sign tests where applicable. Differences between groups were assessed using ANCOVA or Quade's nonparametric ANCOVA, with adjustments made for baseline values. All data processing was executed via IBM SPSS Statistics (Version 26.0, Armonk, NY). Significance was established at a two-sided *P*-value of < 0.05. We also calculated effect sizes and 95% confidence intervals to determine the magnitude and precision of the primary and secondary results.

Results

Quantifying Success: Data from the Asan-Chek Study Participant Characteristics

Of 194 volunteers screened at outpatient clinics, 148 were enrolled and equally assigned to the intervention (app users, n=74) and control (non-app users, n=74)

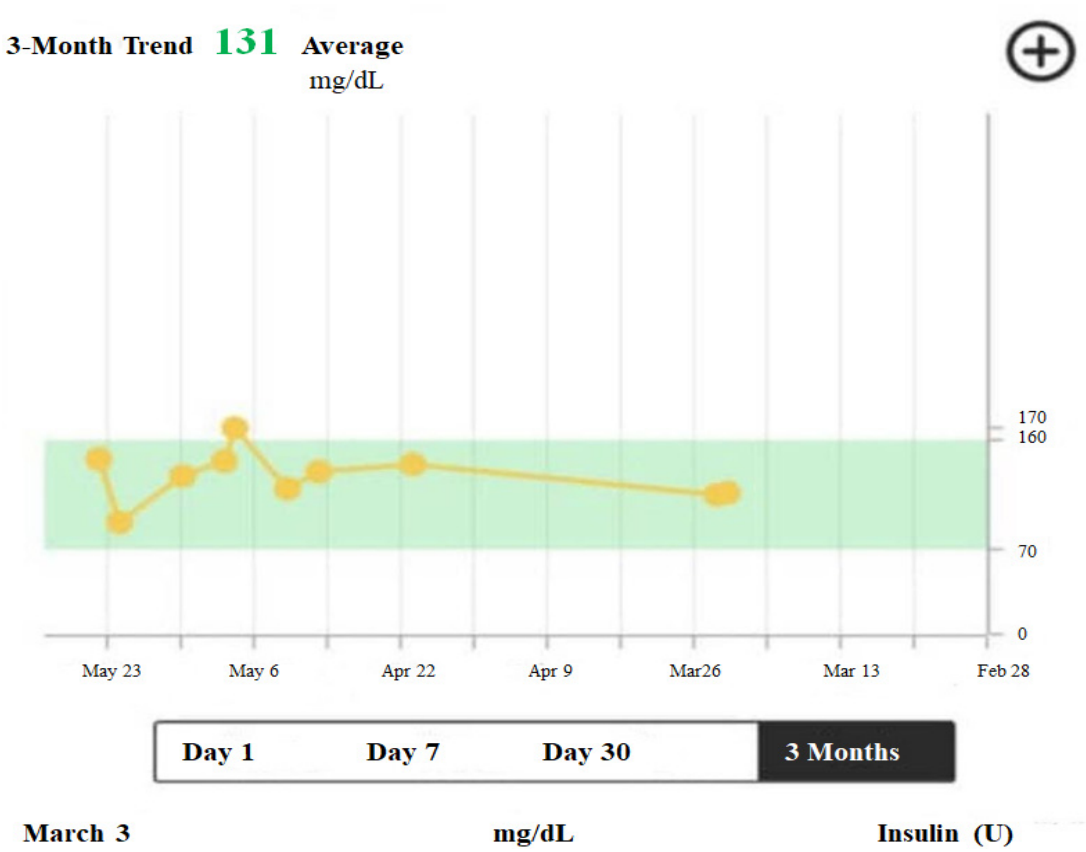

Figure 1. The app provides graphical displays of glucose trends, color-coded feedback, and daily summaries to help users interpret their glucose patterns and adjust daily routines accordingly.

[DOI: 10.47176/mjiri.40.31]

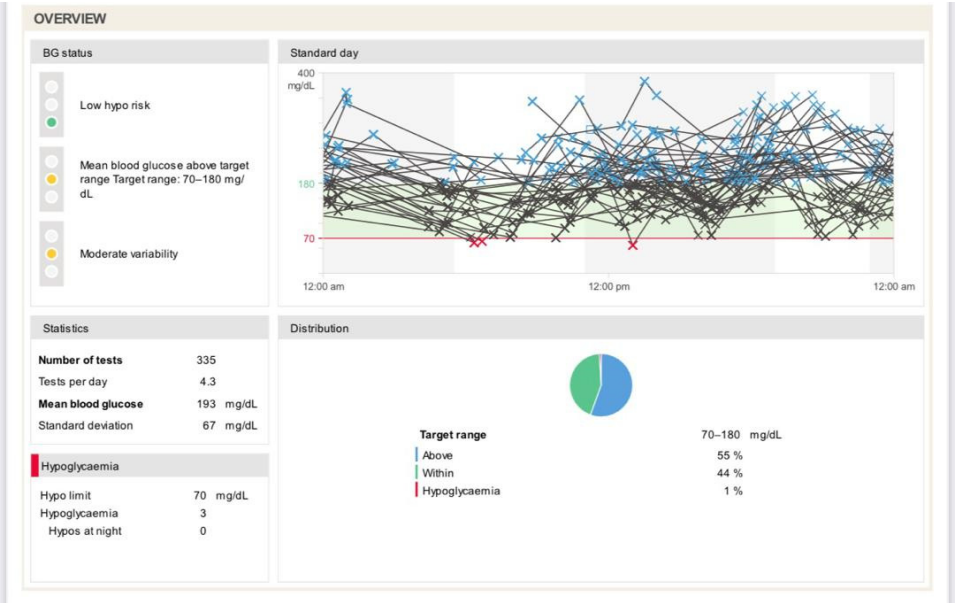

Figure 2. Automated Asan-Chek feedback algorithm for clinicians and health-care providers. The system analyzes uploaded glucose data and generates structured summaries to support clinical decision-making.

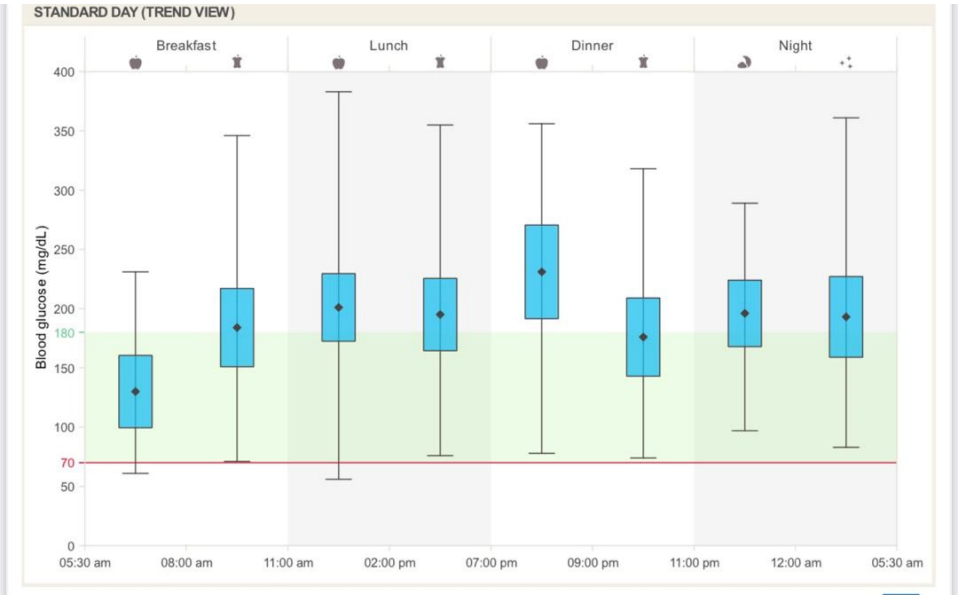

Figure 3. Example of clinician dashboard output produced by the Asan-Chek platform. Aggregated patient data and trend alerts are automatically updated for remote monitoring.

groups. Participant enrollment, group allocation, follow-up, and analysis are summarized in Figure 4. The retention rate was 88.5% (131/148), with 65 and 66 participants completing the study in the intervention and control groups, respectively. Nine participants (12.2%) in the app group and eight (10.8%) in the control group dropped out during the follow-up period, mainly due to relocation to other cities, distance from the study site, or difficulties obtaining time off work. Baseline HbA1c did not differ between completers and dropouts (8.25 ± 1.0 vs. 8.25 ± 0.91, $P = 0.9$). The mean age was 33.7 ± 8.6 years; 51.1% were female. Median diabetes duration was 13.0 years (IQR: 8.5–20.0), and median total daily insulin dose was 60.0 units (IQR: 46.5–74.5). Average baseline HbA1c was 8.29 ± 1.0%, and approximately 66% held an academic degree. Baseline demographic and clinical variables, including waist circumference, blood pressure, and insulin dosages, demonstrated no statistically significant variation across the groups ($P > 0.05$). The baseline demographic and clinical characteristics of the study participants are detailed in Table 1.

[DOI: 10.47176/mjiri.40.31]

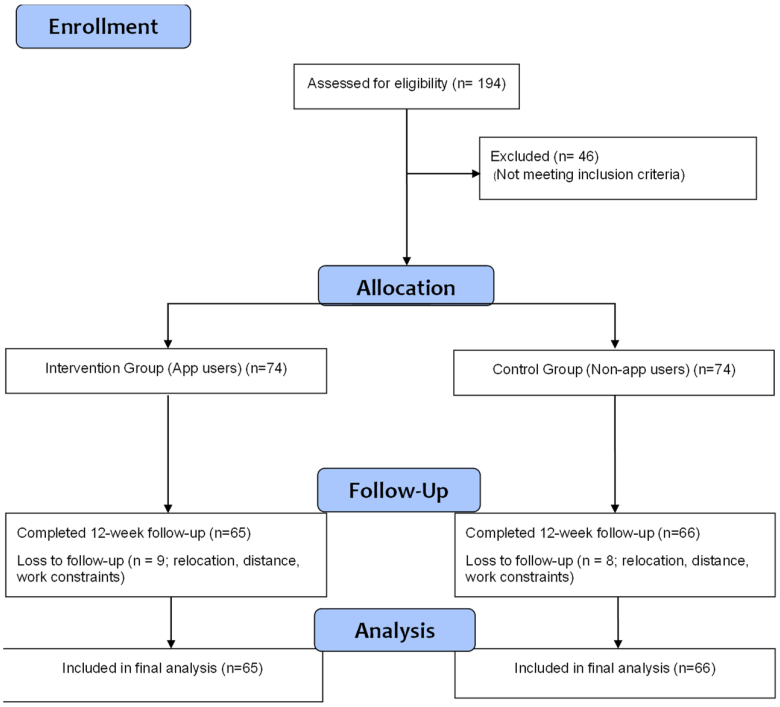

Figure 4. Flowchart of Participant Enrollment, Allocation, Follow-up, and Analysis

Table 1. Baseline characteristics of participants in the study groups

Variable	App users (n=65)	Control group (n=66)	*P*- value
Gender (Female), n (%)	31 (47.7%)	36 (54.5%)	0.433
Age (years)	34 (27-39)	35 (28-41)	0.439
BMI (k/m^2),	24.9 (23.0-28.2)	25.0 (22.3-28.7)	0.739
WC (cm)	88.0 (81.0-95.0)	90.0 (83.0-98.0)	0.403
SBP (mmHg)	120.0 (114.0-129.0)	120.0 (110.0-128.0)	0.525
DBP (mmHg)	80.0 (74.0-85.0)	80.0 (72.0-84.0)	0.225
HbA1C (%)	8.33±1.0	8.24± 1.0	0.626
Diabetes Duration (years)	13.0 (9.0-18.0)	15.0 (8.0-22.0)	0.476
Smoking, n (%)	18 (27.7%)	12 (18.2%)	0.195
Education, n (%)			
High school	1 (1.5%)	2 (3.0%)	0.833
Diploma	20 (30.8%)	22 (33.3%)	
Academic degree	44 (67.7%)	42 (63.6%)	
Basal insulin dose (u)	30.0 (22.0-40.0)	26.0 (20.0-40.0)	0.265
Total daily dose of insulin (u)	60.0 (47.5-70.0)	60.5 (45.0-80.0)	0.969

Data are presented as mean±SD or median (Q1-Q3) unless indicated otherwise

Clinical Outcomes

Both groups experienced significant HbA1c reductions over 12 weeks: app users from 8.33 ± 1.0% to 7.71 ± 1.0% ($P < 0.001$), controls from 8.24 ± 1.0% to 7.83 ± 1.1% ($P < 0.001$). However, the variation across the groups did not achieve statistical significance ($P = 0.202$).

The between-group mean difference in HbA1c reduction was 0.21% (95% CI: –0.11 to 0.52), corresponding to a small effect size. BMI increased slightly but significantly in both groups (app: 24.9 to 25.0 kg/m², $P = 0.011$; control: 25.0 to 25.3 kg/m², $P = 0.001$) without group differences ($P = 0.509$). Similar small effect sizes were observed for BMI and insulin requirements, consistent with the lack of statistically significant between-group differences. Other clinical parameters, such as waist circumference, systolic and diastolic blood pressure, basal and total insulin doses, revealed no notable statistical divergence between the groups ($P > 0.05$). A summary of the changes in clinical measurements for both groups throughout the study is provided in Table 2.

Glucometer-Derived Data

The analysis yielded no statistically significant variations between groups across visits for glucometer-derived measures, including total number of tests, average daily test frequency, mean blood glucose levels, or glycemic variability (standard deviation, coefficient of variation). Mean blood glucose remained stable (intervention: 167.0 to 174.2 mg/dL, $P = 0.817$; control: 173.0 to 171.9 mg/dL, $P = 0.640$). Time-in-range (70–180 mg/dL) showed a slight, non-significant decline in both groups (app users: 52.8% ± 18.6% to 50.7% ± 16.9%, $P = 0.417$). Hypogly-

[DOI: 10.47176/mjiri.40.31]

Table 2. The changes in the clinical measurements during the study period in the study groups

Variable	App users (n=65)				Control group (n=66)				Between-group *P*-value†
	Visit 1	Visit 4	Diff. *	*P*-value	Visit 1	Visit 4	Diff.*	*P*-value	
BMI (kg/m^2)	24.9 (23.0-28.2)	25.0 (23.3-28.1)	0.26 (0.07, 0.46)	0.011	25.0 (22.3-28.7)	25.3 (23.1-28.7)	0.35 (0.16-0.56)	0.001	0.509
WC (cm)	88.0 (81.0-95.0)	89.0 (84.0-96.0)	0.75 (-0.25, 2.00)	0.142	90.0 (83.0-98.0)	90.5 (83.0-100.0)	0.25 (-0.75, 1.25)	0.598	0.615
SBP (mmHg)	120.0 (114.0-129.0)	121.0 (114.0-128.0)	-1.00 (-3.50, 1.50)	0.495	120.0 (110.0-128.0)	121.5 (112.0-131.0)	1.00 (-1.50, 3.50)	0.376	0.518
DBP (mmHg)	80.0 (74.0-85.0)	79.0 (75.0-85.0)	-1.50 (-3.00, 0.50)	0.153	80.0 (72.0-84.0)	80.0 (74.0-84.0)	1.00 (-1.00, 3.00)	0.300	0.245
HbA1C (%)	8.33±1.0	7.71±1.0	0.62 (0.43, 0.82)	<0.001	8.24± 1.0	7.83±1.1	0.42 (0.19-0.64)	<0.001	0.202
Basal insulin dose (U)	30.0 (22.0-40.0)	30.0 (22.0-40.0)	0.00 (0.00, 0.50)	0.628	26.0 (20.0-40.0)	30.0 (20.0-40.0)	0.00 (0.00-1.00)	0.067	0.460
Total daily dose of insulin (U)	60.0 (47.5-70.0)	60.0 (47.5-78.0)	2.50 (0.50, 4.50)	0.05	60.5 (45.0-80.0)	60.0 (45.0-80.0)	0.00 (-2.50, 2.00)	0.892	0.157

Data are presented as mean±SD or median (Q1-Q3) unless indicated otherwise; *, mean/median of the difference between measurement at visit 1 and visit 4 (95% CI), Between-group comparisons were performed using ANCOVA or Quade nonparametric ANCOVA as appropriate; †, adjusted for baseline measurements as a covariate

cemic episodes (BG <70 mg/dL) were infrequent and unchanged within or between groups (median 1; *P*-values > 0.2). Hyperglycemic episodes (BG >180 mg/dL) were more frequent but showed no significant differences within or between groups (app users median 7.0 to 6.0, $P = 0.567$; controls 7.0 to 6.0, $P = 0.252$; between-group $P = 0.546$).

Users Voices: Exploring Qualitative Insights

During the data analysis process, 27 concepts with identical characteristics were categorized to six sub-domains and then, based on mutual features, they were converted into three main categories. The demographic profile of the interviewees is presented in Table 3, while the extracted categories and sub-domains are outlined in Table 4.

Perceived Behavioral Control

Participants reported increased control and mastery over diabetes management through the Asan-Chek app, reflecting two key aspects of Perceived Behavioral Control: self-efficacy and controllability. Many gained confidences in adjusting insulin doses and monitoring blood glucose. For example, one participant shared, "*The app allowed me to track my blood glucose trends, which helped me adjust my insulin doses during peak consumption times. I couldn't do this with traditional glucometers*" (Participant 2).

This improved confidence extended to lifestyle changes such as physical activity and diet and was linked to HbA1c reductions: "*Fluctuations of my blood sugar were decreased, and the app helped me stay more committed to decreasing these fluctuations*" (Participant 7).

Features like reminders and alerts helped users proactively manage their condition. One participant noted, "*The app's alerts made me realize when hypoglycemia was recurring during workouts. I learned to reduce my insulin doses before exercising to avoid these episodes*" (Participant 5).

Regular feedback from the app fostered motivation and a more disciplined approach to self-management.

Perceived Benefits

Participants valued the app's accessibility and intuitive design: "*The app is always accessible on my phone, making it easy to check my blood sugar anytime*" (Participant 8).

Color-coded charts and long-term tracking helped users understand trends and stay on track: "*The diagrams and colors helped me understand daily, weekly, and monthly trends... It even lets you generate a PDF to save or share detailed reports*" (Participant 12).

Table 3. Demographic information of the participants at qualitative phase of the study

No.	Age	Gender	Level of education	Occupation	Diabetes duration (yrs.)	Baseline HbA1c (%)	EOS HbA1c (%)	Group
1	34	Female	Bachelor	Dentist-assistant	20	9.7	9	Control
2	39	Male	Bachelor	IT engineer	26	8.1	7.7	Intervention
3	38	Female	Bachelor	Housewife	6	9.7	7.7	Control
4	32	Female	Bachelor	Housewife	12	8.7	7.9	Intervention
5	39	Female	Bachelor	Housewife	13	7.8	6.7	Intervention
6	43	Male	Bachelor	Sale's manager	27	8.9	7.8	Intervention
7	47	Female	High school diploma	Housewife	26	7	6.6	Intervention
8	30	Female	Bachelor	student	7	9	9	Intervention
9	36	Female	High school diploma	Housewife	30	9.6	8.1	Intervention
10	32	Male	High school diploma	worker	11	9.4	6.7	Intervention
11	25	Female	Bachelor	Housewife	5	7.4	6.8	Intervention
12	29	Male	Master	Faculty	20	7.1	7.0	Intervention
13	32	Female	High school diploma	Tailor	25	6.6	6	Intervention
14	43	Male	Bachelor	Electrical engineer	33	6.6	6.5	Intervention
15	36	Female	High school diploma	Sport trainer	13	7.8	6.6	Intervention

[DOI: 10.47176/mjiri.40.31]

Table 4. Categories and sub-domains of benefits and limitations of diabetes self-management application

Main category	Sub-domain	Code	
Perceived behavioral control (PBC)	Self-efficacy	Diabetes Self-Management	Adjusting insulin doses, diet regimen, and physical activity
		Improved glycemic control	Decreasing HbA1c
	Ability to control	Change in attitude	
		Continuous motivation	
		Self-commitment	
Perceived barriers	Application	Time spent to engage with the App.	
		Short duration of the study	
		Daily-life barriers	
		Perceived stress and anxiety	
	Glucometer	Worry about running out of strip	
		Cost of the strips	
		Pain and fear of needle	
		Skin damage	
		Increasing stress and anxiety	
		Not easy to engage with	
		Adherence to glucose testing protocol	
		Daily-life barriers	
Perceived benefits	Glucometer	Sense of empowerment to control blood glucose	
	Application	Simple accessibility	
		Proper use of colors in the App.	
		Digital blood glucose recording	
		Being accurate and sensitive to measure blood glucose	
		Facilitation of long-term management of diabetes	Facilitating management of the diabetes in parallel to the physician guidance
			Visibility of blood glucose pattern
			Colored charts
			Showing daily, weekly and monthly data of blood glucose

Replacing manual logs with digital records was seen as more convenient and effective: "*I didn't have to write everything down manually. Instead, I could view my three-month glucose history on my phone, which made everything easier*" (Participant 13). Another participant echoed this convenience: "*Since I no longer needed to record my blood glucose levels on paper, it was very convenient*" (Participant 14).

Reminders increased motivation and attentiveness, helping reduce fluctuations: "*This program made me more accurate and sensitive about monitoring my blood sugar*" (Participant 7).

The app supported long-term management by allowing users to track and adjust treatment plans based on historical data: "*Looking back at past months helped me understand how to improve my blood sugar control*" (Participant 10).

Participants appreciated immediate feedback from glucometers during symptoms: "*When I felt symptoms like a dry mouth, I could immediately check my blood sugar and act accordingly*" (Participant 12).

Some felt more secure knowing they could quickly respond to unexpected readings: "*It was fascinating and gave me a great feeling because I had better control over my blood sugar levels*" (Participant 3).

This sense of control increased confidence in managing their condition and reduced anxiety.

Perceived Barriers

Despite its benefits, participants reported several challenges with the app and glucometers. Some found the app initially time-consuming and difficult to use: "*In the beginning, my blood sugar fluctuated a lot, and seeing these fluctuations on the chart made me anxious. It took time to adapt to the app*," said one participant (Participant 5). Others found data visualizations stressful: "*Looking at the charts showing spikes in my blood sugar levels stressed me out and made me hesitant to monitor regularly*" (Participant 10).

Several participants experienced a learning curve: "*When I was learning how to use the app, it was hard and took a long time to understand. But once I got the hang of it, it became easy*," explained Participant 13.

Financial and physical burdens were also significant. Participants frequently cited the high cost and limited availability of test strips: "*Test strips are often unavailable, and their cost is prohibitive*" (Participant 14). Pain from repeated finger pricks was another common issue: "*Testing seven times a day is hard, both because of the pain and the damage to my fingers*, " reported Participant 1.

Daily-life barriers, such as testing difficulties at work, further hindered adherence: "*As a teacher, it was challenging to test my blood glucose during class, so I couldn't always follow the schedule*, " shared Participant 11.

Discussion

This study examined the impact of the Asan-Chek digital platform on diabetes self-management among adults with T1DM, integrating quantitative outcomes with qualitative user experiences. Overall, both the intervention and control groups demonstrated short-term improvements in glycemic control, suggesting that consistent self-monitoring and structured follow-up may play a central

[DOI: 10.47176/mjiri.40.31]

role in glycemic optimization regardless of the monitoring modality. The app group reported greater behavioral engagement, including more frequent glucose testing and higher perceived self-efficacy; however, these perceptions did not correspond to significantly better glycemic outcomes. Qualitative findings suggested that visual feedback, reminders, and data tracking were perceived as motivating and supportive of self-management, while usability challenges, data-related stress, and test-strip costs limited sustained benefit. This divergence between behavioral engagement and clinical efficacy underscores that improved motivation or adherence behaviors may not immediately yield measurable metabolic change.

Similar patterns of early engagement followed by declining adherence have been observed in other app-based studies. For example, the bant app trial in adolescents showed an initial rise in testing frequency but no lasting HbA1c benefit compared to standard care. Likewise, the Ana wa Soukari study found that culturally tailored prompts initially motivated users, but these effects waned after a few months (18, 19). The present findings align with these observations, suggesting that while digital tools can temporarily boost motivation and adherence, maintaining long-term engagement remains challenging. Participants in this study described barriers such as finger-prick discomfort, emotional fatigue from glucose variability, and the perceived burden of frequent data entry. These issues underline a persistent gap between short-term adherence and sustained behavior change. Our qualitative data help explain this pattern, as users described practical and emotional barriers that align with the quantitative trend of early benefit without lasting clinical improvement. Future app designs should prioritize convenience, ease of interpretation, and seamless integration into daily routines to convert early gains into lasting improvements. Without these, digital SMBG platforms risk early adoption followed by abandonment (18, 19).

Sustained engagement emerged as crucial, consistent with results from Handa's cloud-based SMBG system and the mySugr® trial, where faithful users experienced modest HbA1c reductions, while disengaged users saw minimal benefit (20, 21). Our qualitative findings are consistent with this pattern, participants who continued app use reported feeling more in control, even though clinical measures showed limited differences. However, maintaining engagement requires both practical resources (time, testing supplies) and emotional resilience to manage continuous glucose visibility. The cognitive load of manual data entry and trend interpretation deters long-term adherence. This highlights the need for behavior change strategies that not only initiate action but also embed these behaviors into everyday life, supported by ongoing reinforcement, personalized reminders, or coaching (20, 21). Together, these findings illustrate how perceived empowerment can coexist with unchanged clinical outcomes, emphasizing the behavioral, rather than metabolic, impact of short-term digital engagement.

Automation offers a promising solution to user fatigue and engagement decline. Royston's study demonstrated how CGM combined with passive sensor data can predict glucose fluctuations with minimal user input, while Akiyama et al.'s evaluation of the Medtronic MiniMed 770G hybrid closed-loop system showed significant HbA1c reduction and increased time in range, albeit with challenges such as alert fatigue and calibration demands (22, 23).

These perceptions highlight the importance of aligning technological capabilities with users' cognitive and emotional readiness, rather than assuming automation alone leads to better outcomes. Effective automation must balance real-time data benefits with a user's capacity to process information without overwhelm. Although the Asan-Chek platform had some automated features, it still required substantial manual effort, limiting sustained use. Thus, automation that simplifies routine tasks without adding stress may be key to longer-term adherence and clinical gains (22, 23).

Meta-analyses by Teo and Dicembrini further support CGM's advantages over SMBG in improving glycemic control and reducing hypo- and hyperglycemia, though benefits depend on consistent use (24, 25). Our study aligns with this, partial automation improved real-time feedback but did not overcome manual testing burdens or emotional strain, resulting in no significant clinical differences between groups despite within-group improvements. This underscores that technology, user experience, and individualized support must be optimized together to achieve sustainable glycemic control. Developing user-friendly, partially or fully automated systems that sustain engagement while minimizing stress is critical for future success in diabetes self-management (24, 25). Interpretation of these findings should be tempered by the study's quasi-experimental design and lack of randomization, which limit causal inference. Participant self-selection into the app group may have introduced selection bias, as individuals motivated to use digital tools could differ systematically from controls in engagement or health literacy. These methodological constraints should be considered when interpreting behavioral and clinical outcomes. Future studies incorporating randomization, longer follow-up, and adaptive feedback systems could help determine whether the behavioral benefits observed here translate into durable clinical improvement.

Strengths and Limitations

This study's strength lies in its mixed-methods design, combining quantitative glycemic outcomes with qualitative insights on user experiences. The use of validated measures for physiological and patient-reported data enhances the robustness of the findings, and tele-health follow-ups ensured clinical oversight. However, the 12-week duration may have been too short to observe long-term behavioral changes, and a longer follow-up could clarify whether initial engagement is sustainable or reversible. The study design was quasi-experimental and lacked randomization, which may have introduced selection bias; participants who chose to use the app might have differed in motivation or health literacy from those in the control group. The app lacked real-time provider feedback, which may have limited its influence on daily decision-making and glycemic control. These methodological limitations

[DOI: 10.47176/mjiri.40.31]

constrain causal interpretation of the observed improvements. Conducted in a single cultural and healthcare setting, the results may not generalize to other populations with different healthcare systems or technology attitudes.

The small qualitative sample, especially the imbalance between app users and non-users, might limit perspective diversity and thematic depth. Variations in digital literacy could have affected usability perceptions and engagement consistency. Importantly, the study did not assess diabetes-related distress or quality of life using validated tools, limiting understanding of the platform's psychological impact. Additionally, long-term behavioral and clinical outcomes were not evaluated, limiting understanding of the app's sustained effectiveness. Future research should consider integrating AI-driven real-time feedback, extending observation periods, and including objective engagement metrics to better capture digital tool effects on long-term T1DM management.

Future Direction

Future research should aim to balance delivering timely, actionable information with minimizing user overwhelm. Adaptive feedback that personalizes recommendations based on user behavior could support sustained engagement. Integrating predictive analytics to detect and suggest corrections for impending hypo- or hyperglycemic events may reduce manual input burdens. Comparing different levels of automation can help determine when additional efforts like calibrations and alerts yield meaningful clinical benefits in HbA1c or time in range. Clinical integration is crucial, patients may stay more engaged if AI-enhanced platforms can proactively analyze data, offer personalized advice, and adjust treatment plans in near real-time.

Future studies should include standardized assessments of diabetes distress and quality of life to understand how digital tools impact mental well-being and long-term management. Incorporating psychological and educational support, such as cognitive-behavioral strategies or structured diabetes education could further enhance engagement. Larger, longer-duration trials with diverse cultural and socioeconomic populations are needed to identify scalable and effective innovations. Multi-center international studies would improve generalizability across healthcare settings. Collaboration among endocrinologists, behavioral psychologists, and technology developers may yield comprehensive solutions addressing the broad challenges of T1DM management.

Integrating behavioral change theories like the Health Belief Model into app design may improve motivation and sustain long-term behavior change (26). By combining clinical data with user-centered design, digital health tools can evolve from short-term adherence aids to platforms that foster lasting lifestyle improvements.

Conclusion

This study demonstrated that a digital SMBG platform provides valuable behavioral and motivational benefits for managing T1DM. Early enthusiasm among app users highlights the potential of near real-time data and automated alerts to enhance patients' sense of control. However, as engagement waned, the platform's effect on long-term glycemic outcomes diminished. These findings align with similar app-based and automated systems, which reveal both the promise of technology in supporting self-management and the ongoing challenge of sustaining user involvement. While automation and continuous monitoring show greater potential for clinical improvements, they may also cause distress if not thoughtfully implemented. Future innovations should minimize user burden, personalize feedback, and incorporate AI-driven support to realize the full benefits of digital tools. By designing interventions that address both psychological and practical aspects of diabetes management, future research can help convert early successes into lasting improvements in glycemic control and quality of life.

Acknowledgment

The authors would like to thank all participants who contributed to this study. We also acknowledge the support of the research staff involved in participant recruitment, data collection, and study coordination.

Conflict of Interests

The authors declare that they have no competing interests.

Authors' Contributions

Every listed author played a significant role in the study's concept, methodology, data collection, or analytical interpretation. All contributors were involved in writing or critically reviewing the article for intellectual substance, have sanctioned the final version, and accept full responsibility for the work's accuracy and integrity.

Ethical Considerations

The research protocol received formal authorization from the Ethics Committee at Iran University of Medical Sciences (Code: IR.IUMS.REC.1401.704). All experimental procedures were conducted in strict compliance with relevant institutional and global ethical guidelines. We adhered to the principles established in the World Medical Association's Declaration of Helsinki (2013 update). Furthermore, this manuscript follows the reporting standards of the International Committee of Medical Journal Editors (ICMJE) and employs sex and gender classifications consistent with World Health Organization recommendations.

Funding Support

The research received an unrestricted institutional grant from Roche Pars Corporation, Tehran, Iran, on behalf of Roche Diabetes Care Middle East. The sponsors exercised no influence over the experimental design, data acquisition, statistical analysis, or the writing of this manuscript.

Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable

[DOI: 10.47176/mjiri.40.31]

request. Due to privacy and ethical restrictions, the data are not publicly available.

AI Use Statement

The authors used ChatGPT (OpenAI) to assist with grammar, clarity, and language editing during manuscript preparation. The authors reviewed and edited all AI-generated suggestions and take full responsibility for the final content of the manuscript.

References

1. Savard V, Gingras V, Leroux C, Bertrand A, Desjardins K, Mircescu H, et al. Treatment of hypoglycemia in adult patients with type 1 diabetes: an observational study. Can J Diabetes. 2016;40(4):318-23.
2. American Diabetes Association. Novel stem cell-derived islet cell therapy continues to show promise achieving insulin independence in individuals with type 1 diabetes, https://diabetes.org/newsroom/novel-stem-cell-derived-islet-cell-therapy-continues-show-promise-achieving-insulin-independence-individuals-type-1-diabetes; 2023 (accessed 2 July 2025).
3. Ly TT, Maahs DM, Rewers A, Dunger D, Oduwole A, Jones TW. ISPAD clinical practice consensus guidelines 2014. Assessment and management of hypoglycemia in children and adolescents with diabetes. Pediatr Diabetes. 2014;15 Suppl 20:180-92.
4. Johnson SR, Cooper MN, Davis EA, Jones TW. Hypoglycaemia, fear of hypoglycaemia and quality of life in children with type 1 diabetes and their parents. Diabet Med. 2013;30(9):1126-31.
5. Seaquist ER, Anderson J, Childs B, Cryer P, Dagogo-Jack S, Fish L, et al. Hypoglycemia and diabetes: a report of a workgroup of the American Diabetes Association and the Endocrine Society. Diabetes Care. 2013;36(5):1384-95.
6. Kalra S, Mukherjee JJ, Venkataraman S, Bantwal G, Shaikh S, Saboo B, et al. Hypoglycemia: the neglected complication. Indian J Endocrinol Metab. 2013;17(5):819-34.
7. Soufizadeh N, Farhadifar F, Tamri S, Behafarid S, Sharifi K, Aslani S, Naqshbandi M. Diagnostic value of rapid biophysical profile in comparison to biophysical profile in pregnant women with insulin-dependent diabetes. J Fam Reprod Health. 2019;13(4):209.
8. Lundgrin EL, Kelly CA, Bellini N, Lewis C, Rafi E, Hatipoglu B. Diabetes technology trends: a review of the latest innovations. J Clin Endocrinol Metab. 2025 Apr;110(Supplement_2):S165-74.
9. Wong JC, Neinstein AB, Spindler M, Adi S. A minority of patients with type 1 diabetes routinely downloads and retrospectively reviews device data. Diabetes Technol Ther. 2015;17(8):555-62.
10. Cafazzo JA, Casselman M, Hamming N, Katzman DK, Palmert MR. Design of an mHealth app for the self-management of adolescent type 1 diabetes: a pilot study. J Med Internet Res. 2012;14(3):e70.
11. Diabeto Medtech India Pvt Ltd. Diabeto Medtech India Pvt Ltd 2016, http://diabe.to; (accessed 2 July 2025).
12. Glooko. Remote patient monitoring for diabetes 2016, https://www.glooko.com; (accessed 2 July 2025).
13. Hou C, Xu Q, Diao S, Hewitt J, Li J, Carter B. Mobile phone applications and self-management of diabetes: a systematic review with meta-analysis, meta-regression of 21 randomized trials and GRADE. Diabetes Obes Metab. 2018;20(8):2009-13.
14. Eberle C, Löhnert M, Stichling S. Effectiveness of disease-specific mHealth apps in patients with diabetes mellitus: scoping review. JMIR Mhealth Uhealth. 2021;9(2):e23477.
15. Evans D, Norman P. Predicting adolescent pedestrians' road-crossing intentions: an application and extension of the Theory of Planned Behaviour. Health Educ Res. 2003;18(3):267-77.
16. Schwandt TA, Lincoln YS, Guba EG. Judging interpretations: but is it rigorous? Trustworthiness and authenticity in naturalistic evaluation. New Dir Eval. 2007;2007(114):11-25.
17. Diabetes Technology: Standards of Medical Care in Diabetes-2022. Diabetes Care. 2022;45(Suppl 1):S97-s112.
18. Goyal S, Nunn CA, Rotondi M, Couperthwaite AB, Reiser S, Simone A, et al. A mobile app for the self-management of type 1 diabetes among adolescents: a randomized controlled trial. JMIR Mhealth Uhealth. 2017;5(6):e7336.
19. Derkaoui N, Benyakhlef S, Rami I, El Mehraoui O, Messaoudi N, Charif H, et al. Effectiveness of a new smartphone application on type 1 diabetes control and self-management in times of Covid-19: randomized controlled trial. Rev Diabet Stud. 2023;19(2):71.
20. Handa T, Onoue T, Kobayashi T, Maeda R, Mizutani K, Yamagami A, et al. Effects of digitization of self-monitoring of blood glucose records using a mobile app and the cloud system on outpatient management of diabetes: single-armed prospective study. JMIR Diabetes. 2024;9(1):e48019.
21. Cuixart G, Corcoy R, González C. Can a mobile application improve glucose-related and patient-reported outcome measures (PROMS) in people with type 1 diabetes mellitus? A randomized controlled trial using mySugr® app. 2024.
22. Royston S. Personalized understanding of blood glucose dynamics via mobile sensor data. arXiv preprint arXiv:230201400 2023.
23. Akiyama T, Yamakawa T, Orime K, Ichikawa M, Harada M, Netsu T, et al. Effects of hybrid closed-loop system on glycemic control and psychological aspects in persons with type 1 diabetes treated with sensor-augmented pump: a prospective single-center observational study. J Diabetes Investig. 2024;15(2):219-26.
24. Teo E, Hassan N, Tam W, Koh S. Effectiveness of continuous glucose monitoring in maintaining glycaemic control among people with type 1 diabetes mellitus: a systematic review of randomised controlled trials and meta-analysis. Diabetologia. 2022;65(4):604-19.
25. Dicembrini I, Cosentino C, Monami M, Mannucci E, Pala L. Effects of real-time continuous glucose monitoring in type 1 diabetes: a meta-analysis of randomized controlled trials. Acta Diabetol. 2021;58:401-10.
26. Orji R, Vassileva J, Mandryk R. Towards an effective health interventions design: an extension of the Health Belief Model. Online J Public Health Inform. 2012;4(3).

[DOI: 10.47176/mjiri.40.31]