

Effectiveness of a Mobile Application in Promoting Medication Adherence Among Patients With Type 2 Diabetes in a Thai Primary Care Setting: A Randomized Controlled Trial

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Abstract

Background: Medication adherence is an important factor influencing glycemic control in patients with type 2 diabetes mellitus (T2DM). While mobile health applications have been developed to support self-management, research on medication reminder apps for patients with diabetes in Thailand remains limited.

Objective: To evaluate the effectiveness of a medication reminder mobile application on medication adherence compared with usual care in patients with T2DM.

Methods: A randomized controlled trial was conducted at the Family Medicine Outpatient Clinic, Ramathibodi Hospital. Adults aged ≥ 18 years with T2DM, hemoglobin A_{1c} (HbA_{1c}) $\geq 7\%$ or fasting blood glucose (FBG) ≥ 130 mg/dL, and suboptimal adherence (Medication Adherence Scale in Thais [MAST] < 34) were enrolled. Participants were randomly assigned (1:1) to usual care or usual care plus a medication reminder application for 3 months. The primary outcome was the change in MAST score. Secondary outcomes included changes in FBG and HbA_{1c}.

Results: Thirty-one participants were randomized (control, $n = 16$; intervention, $n = 15$). At baseline, medication adherence was significantly lower in the intervention group than in the control group (mean [SD] MAST score, 27.07 [4.82] vs 30.06 [2.46]; $P = .042$). After 3 months, the intervention group demonstrated a greater unadjusted improvement in MAST score (mean [SD] change, 6.87 [4.58] vs 2.69 [4.14]; between-group difference, 4.18 points; $P = .012$). However, after adjustment for baseline adherence using analysis of covariance, the between-group difference was no longer statistically significant (adjusted mean difference, 2.04 points; 95% CI, -0.73 to 4.80; $P = .143$). No statistically significant between-group differences were observed in FBG or HbA_{1c}.

Conclusions: The medication reminder application was associated with improved medication adherence among patients with T2DM; however, the between-group difference was not statistically significant after adjustment for baseline adherence. No significant improvements in glycemic outcomes were observed during the 3-month follow-up. These preliminary findings require confirmation in a larger, adequately powered randomized controlled trial.

Keywords: Mobile application, Medication adherence, Type 2 diabetes

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Introduction

Type 2 diabetes mellitus (T2DM) remains a major global health concern, including in Thailand, where its prevalence continues to increase.¹ It substantially increases the risk of multiple vascular complications and frequently coexists with other chronic conditions, making it a high-impact disease for evaluating interventions that improve medication adherence. In Thailand, only 26.3% of patients achieve target hemoglobin A_{1c} (HbA_{1c}) levels,² and diabetes-related mortality is 25.1 per 100 000 population.³ Consequently, suboptimal glycemic control remains common. Medication adherence is an essential component of effective diabetes management.⁴ Evidence indicates that patients who adhere to prescribed regimens achieve greater reductions in HbA_{1c} (0.90%-1.14%) compared with nonadherent patients (0.49%-0.69%).⁵ Despite its importance, reported rates of medication nonadherence among Thai patients with T2DM range from 16.7% to 64.8%. Factors associated with adherence include regimen complexity, pill burden, and patient knowledge.⁶⁻⁸ The patient-related factor, as part of the World Health Organization adherence model, plays an important role in medication adherence.⁹

Various interventions have been developed to improve medication adherence. However, a systematic review reported heterogeneous findings due to variations in study design and adherence measurement, and no single strategy has been conclusively identified as the most effective approach. Interventions tailored to individual patient characteristics may therefore provide greater benefit.¹⁰

With advances in digital health technology, mobile health (mHealth) applications have emerged as potential tools to support chronic disease management.¹¹ Medication reminder applications provide notification, scheduling, and tracking functions designed to address patient-related barriers to adherence. Previous studies conducted in other countries have demonstrated improved medication adherence among patients with diabetes treated in tertiary care settings.¹² In Thailand, a medication reminder application significantly improved adherence among patients with stroke;¹³ however, evidence among patients with T2DM remains limited. Furthermore, differences in language, healthcare systems, and patient characteristics may limit the generalizability of findings from other countries, highlighting the need to evaluate the effectiveness of a Thai-language medication reminder application in the Thai primary care setting.

Therefore, this study aimed to evaluate the effectiveness of a Thai-language medication reminder application in improving medication adherence among patients with T2DM in a primary care setting. Secondary objectives were to assess changes in fasting blood glucose (FBG) and HbA_{1c} levels. Family medicine clinics provide continuous, comprehensive, and longitudinal care for patients with T2DM, making them an appropriate setting to evaluate interventions that support long-term medication adherence under routine clinical practice. Conducting the study in this setting enhances the applicability of the findings to primary care practice.

Methods

Study Design and Setting

A randomized controlled parallel-group trial was conducted at the Family Medicine Outpatient Clinic, Ramathibodi Hospital, Bangkok, Thailand, from July 2024 to March 2025. The study was approved by the Institutional Review Board of Ramathibodi Hospital. Written informed consent was obtained from all participants.

Participants

The sample size was calculated using Stata, version 18 (StataCorp LLC). Based on a mean (SD) Medication Adherence Scale in Thais (MAST) score of 26.46 (6.62)¹⁴ in the control group and a minimal clinically important difference of 4.54 points, with a 2-sided α of 0.05 and 80% power, 35 participants per group were required. Allowing for a 20% loss to follow-up, the target sample size was 42 participants per group. The final sample size was determined by the number of eligible participants during the study period.

Adults aged ≥ 18 years with T2DM receiving oral antidiabetic medications for at least 6 months were eligible for inclusion if they had $\text{HbA}_{1c} \geq 7\%$ or FBG ≥ 130 mg/dL within the previous 6 months and a MAST score < 34 . Participants were required to use a smartphone and be able to communicate in Thai. Exclusion criteria included cognitive impairment, pregnancy, current use of insulin or glucagon-like peptide-1 receptor agonists, and use of medications that substantially affect blood glucose levels.

Randomization and Blinding

Participants were randomly assigned in a 1:1 ratio using block randomization with sequentially numbered, sealed, opaque envelopes prepared by an independent researcher. Participants received separate instructions according to their allocated group, and the application was individually installed on each participant's smartphone to minimize contamination between groups. Laboratory personnel and outcome assessors were blinded to group allocation. Data analysis was conducted using coded group assignments.

Intervention

Both groups received usual diabetes care. This consisted of routine outpatient follow-up and medication management by their treating physicians according to standard clinical practice. Participants in the intervention group additionally used a Thai-language medication reminder application for 3 months. Participants were asked to download and register for the "Remind Me" application on their smartphones. The application is a free medication management tool available on both Android and iOS platforms. The researchers provided standardized guidance on how to use the application at enrollment. Participants were also encouraged to seek assistance from researchers if technical issues occurred during the study period. The application provided medication scheduling, reminder notifications, and adherence tracking reports. Participants in the intervention group were encouraged to use the application daily and to record their medication intake as scheduled. All data generated by the application were stored locally on the participants' mobile devices. Participants in both groups continued routine follow-up visits as scheduled by their physicians.

Outcome Measures

The primary outcome was the change in MAST score from baseline to 3 months. The MAST is a validated 8-item questionnaire with scores ranging from 0 to 40, where higher scores indicate better medication adherence. A score of 34 or higher indicates good medication adherence, whereas scores below 34 indicate suboptimal adherence. Secondary outcomes included changes in FBG and HbA_{1c} over the same period. Outcome assessments were performed 3 months after enrollment, allowing sufficient time for changes in medication-taking behavior to occur and for HbA_{1c} to reflect changes in

glycemic control, while remaining feasible within routine outpatient follow-up schedules. Baseline demographic and clinical characteristics were recorded at enrollment. MAST scores, FBG, and HbA_{1c} were assessed at baseline and at the 3-month follow-up visit.

Statistical Analysis

Statistical analyses were performed using RStudio, version 2024.12 (Posit). Categorical variables were presented as frequencies and percentages, and continuous variables as mean (SD) or median (IQR), as appropriate.

Between-group comparisons were conducted using the independent *t* test or Mann-Whitney *U* test for continuous variables and the chi-square test or Fisher exact test for categorical variables. Within-group comparisons were performed using the paired *t* test or Wilcoxon signed rank test.

The primary outcome, defined as the between-group difference in the change in MAST score, was analyzed using the independent *t* test and further adjusted using multivariable linear regression for baseline adherence. Secondary outcomes were analyzed using similar methods.

All analyses followed the intention-to-treat principle. A 2-tailed *P* value < .05 was considered statistically significant. Consequently, the achieved sample size was below the planned target, limiting statistical power. Findings were interpreted cautiously, with greater emphasis on effect estimates and 95% CIs than on statistical significance alone.

Results

A total of 119 patients attending the family medicine outpatient clinic were screened for eligibility. Among them, 88 patients were excluded due to not meeting the inclusion criteria (*n* = 81), declining to participate (*n* = 5), or being unable to use the application (*n* = 2). Consequently, 31 participants were enrolled and randomized into 2 groups: 16 participants in the control group and 15 participants in the application group. All participants completed the 3-month follow-up and were included in the final analysis (Figure 1).

The mean (SD) age of participants was 52.26 (10.48) years, and 64.5% were female (*n* = 20), while 35.5% were male (*n* = 11). Hypertension and dyslipidemia were the most common comorbidities, present in 20 (64.5%) and 25 (80.6%) participants, respectively. The median (IQR) duration since diabetes diagnosis was 60 (24-90) months. Baseline demographic and clinical characteristics were generally comparable between groups, although the mean (SD) baseline MAST score was significantly lower in the application group than in the control group (27.07 [4.82] vs 30.06 [2.46]; *P* = .042) (Table 1).

At the end of the study, medication adherence improved in both groups, with a greater increase observed in the application group. In the application group, the mean (SD) MAST score increased from 27.07 (4.82) at baseline to 34.33 (4.35) at 3 months, representing a mean (SD) change of 6.87 (4.58) points (*P* < .001). In the control group, the mean (SD) score increased from 30.06 (2.46) to 32.75 (2.67) (Table 2). After adjustment for baseline adherence using analysis of covariance (ANCOVA), the between-group difference was no longer statistically significant (adjusted mean difference, 2.04 points; 95% CI, -0.73 to 4.80; *P* = .143).

When comparing the mean difference in MAST scores from baseline to the end of the study between the groups, the application group showed a statistically significant increase of 4.18 points (*P* = .012) (Figure 2).

Changes in glycemic parameters were also evaluated. In the control group, FBG increased by 6.06 mg/dL, and HbA_{1c} increased by 0.08%. In contrast, the application group showed a decrease in FBG of 14.40 mg/dL and a reduction in HbA_{1c} of 0.53%. However, the mean differences in FBG and HbA_{1c} between groups were not statistically significant (Table 3).

Figure 1. Enrollment Diagram

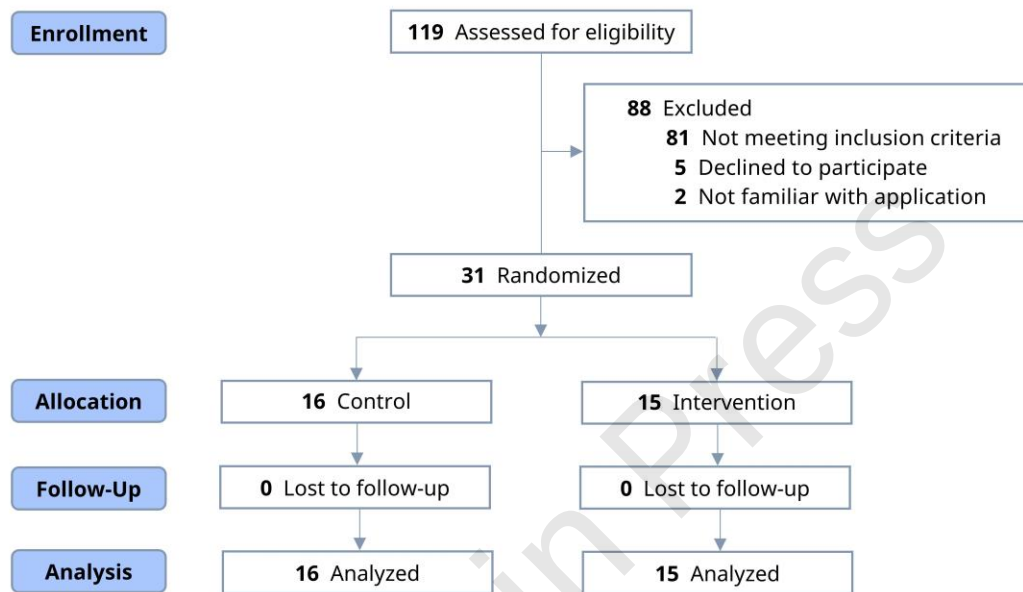


Table 1. Baseline Characteristics of Participants

Characteristic	No. (%)			P Value
	Total (n = 31)	Control (n = 16)	Application (n = 15)	
Age, mean (SD), y	52.26 (10.48)	54.38 (10.88)	50.00 (9.67)	.248 ^c
MAST score, mean (SD)	28.61 (4.02)	30.06 (2.46)	27.07 (4.82)	.042 ^c
FBG, mg/dL	170.10 (55.16)	163.56 (56.21)	177.00 (55.09)	.507 ^c
HbA _{1c} , mean (SD), %	8.29 (1.54)	8.21 (1.62)	8.37 (1.52)	.786 ^c
BMI, kg/m ²	28.80 (4.90)	29.90 (5.48)	27.62 (4.06)	.200 ^c
Sex				
Male	11 (35.5)	4 (25.0)	7 (46.7)	.376 ^b
Female	20 (64.5)	12 (75.0)	8 (53.3)	
Duration of diabetes, median (IQR), mo	60 (24-90)	60 (18-111)	48 (29-72)	.474 ^d
No. of pills, median (IQR)	5 (4-7)	5 (4-6.25)	5 (4-7)	.919 ^d
Frequency of meals per day, mean (SD)	2.58 (0.80)	2.75 (0.86)	2.40 (0.74)	.234 ^c
Comorbidity				
Hypertension	20 (64.5)	8 (50.0)	12 (80.0)	.171 ^a
Dyslipidemia	25 (80.6)	12 (75.0)	13 (86.7)	.653 ^a

Table 1. Baseline Characteristics of Participants (Continued)

Characteristic	No. (%)			P Value
	Total (n = 31)	Control (n = 16)	Application (n = 15)	
Medical benefit scheme				
Ramathibodi's security scheme	5 (16.1)	3 (18.8)	2 (13.3)	.722 ^a
Social security scheme	2 (6.5)	2 (12.5)	0 (0.0)	
Civil servant medical benefit scheme	17 (51.5)	8 (50.0)	9 (60.0)	
Self-payment	6 (19.4)	3 (18.8)	3 (20.0)	
Other	1 (3.2)	0	1 (6.7)	
Education				
Primary school	5 (16.1)	2 (12.5)	3 (20.0)	.878 ^a
High school	11 (35.5)	6 (37.5)	5 (33.3)	
Bachelor's degree	10 (32.3)	5 (31.2)	5 (33.3)	
Master's degree and higher	5 (16.1)	3 (18.8)	2 (13.3)	

Abbreviations: BMI, body mass index; HbA_{1c}, hemoglobin A_{1c}; FBG, fasting blood glucose; MAST, Medication Adherence Scale in Thais.

^a Fisher exact test.

^b Chi-square test.

^c Student's independent-samples *t* test.

^d Mann-Whitney *U* test.

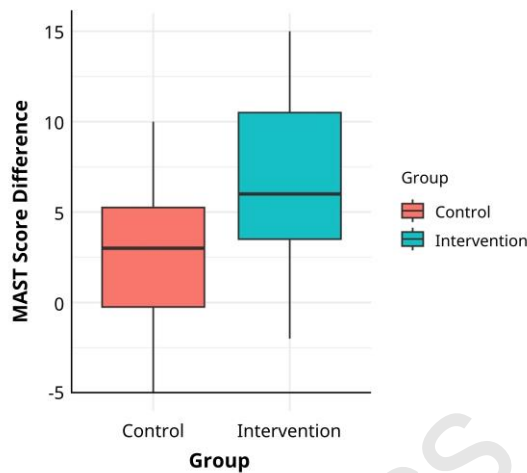
Table 2. Comparison of Medication Adherence Scores at Baseline and the Follow-Up Visits at 3 Months Between the Application and Control Groups

Outcome	Mean (SD)		P Value*
	Control	Application	
MAST score at baseline	30.06 (2.46)	27.07 (4.82)	.042
MAST score at 3-month follow-up	32.75 (2.67)	34.33 (4.35)	.374
Change in MAST score (baseline to 3 months)	2.69 (4.14)	6.87 (4.58)	.012

Abbreviation: MAST, Medication Adherence Scale in Thais.

* Student's independent-samples *t* test.

Figure 2. Box Plot Comparing the Mean Difference in Medication Adherence Scores From Baseline to Follow-Up



Abbreviation: MAST, Medication Adherence Scale in Thais.

Table 3. Mean Differences in Fasting Blood Glucose and Hemoglobin A_{1c} Between the Application and Control Groups

Outcome	Mean Difference (SD)		P Value*
	Control	Application	
FBG, mg/dL	6.06 (33.90)	-14.40 (67.50)	.303
HbA _{1c} , %	0.08 (1.10)	-0.53 (1.52)	.212

Abbreviations: HbA_{1c}, hemoglobin A_{1c}; FBG, fasting blood glucose.

* Student's independent-samples *t* test.

Discussion

This randomized controlled trial evaluated the effectiveness of a medication reminder application in improving medication adherence among patients with T2DM in a primary care setting. Although the application group had lower baseline adherence scores, a significantly greater improvement in medication adherence was observed in this group after the 3-month intervention. However, no significant differences in FBG or HbA_{1c} levels were observed between the groups.

These findings are consistent with those of Rai et al,¹⁵ who reported improved medication adherence among non-insulin-using patients with T2DM using a smartphone application without significant changes in FBG or HbA_{1c} levels over 3 months. Similarly, Huang et al¹² found a significant reduction in barriers to medication adherence using the Adherence Starts with Knowledge 12 (ASK-12) questionnaire, although this did not translate into improved glycemic outcomes. Differences between studies may be related to variations in study populations, intervention components, and the inclusion of insulin-treated patients in Huang's study. Comparable findings have also been reported in studies evaluating reminder-based interventions, including SMS reminder systems¹⁶, which consistently improved medication-taking behavior. Furthermore, a systematic review

and meta-analysis by Peng et al¹⁷ concluded that mobile health applications are generally effective in improving medication adherence across chronic diseases. Similar findings have also been reported in a systematic review¹⁸, suggesting that digital health interventions are likely to influence behavioral outcomes, such as medication adherence.

The improvement in medication adherence observed in this study may be attributed to the application's customizable medication reminders, scheduling functions, and adherence tracking, which may help reduce unintentional nonadherence.¹⁷ Reminder notifications may promote habit formation by helping patients establish consistent medication-taking routines while reducing forgetfulness, one of the most common causes of unintentional nonadherence. In addition, the adherence-tracking function may increase patients' awareness of their medication-taking behaviors and encourage greater self-management.¹⁹ Previous studies have also suggested that digital health platforms can improve patient engagement and facilitate collaborative diabetes management when integrated with healthcare provider support. Although the application evaluated in this study did not include clinician feedback or medication adjustment, its reminder and tracking functions may represent practical first steps toward improving adherence in routine primary care. However, several challenges were identified, including application stability issues, notification system limitations on Android devices, and variations in participants' digital literacy, which may have influenced the effectiveness of the intervention.²⁰

Although the intervention group demonstrated a significantly greater improvement in medication adherence in the unadjusted analysis, its baseline medication adherence was significantly lower than that of the control group. After adjustment for the baseline MAST score using ANCOVA, the between-group difference was attenuated and was no longer statistically significant. Baseline imbalance and regression to the mean may have influenced the observed improvement, while the lower baseline adherence and limited statistical power may also have obscured the true magnitude of the intervention effect. Therefore, the adjusted findings should be interpreted cautiously.

Furthermore, no statistically significant differences in HbA_{1c} or FBG were observed between the groups. Nevertheless, the intervention group demonstrated a numerical reduction in HbA_{1c} of 0.53%, whereas the control group showed a slight increase, suggesting a potentially favorable trend that may not have been detected because of limited statistical power.

Several factors may explain these findings. First, the 3-month follow-up period may have been too short for improvements in medication-taking behavior to translate into measurable changes in glycemic control, as sustained behavioral changes are often required before clinical benefits become evident.²¹ Second, the present study was powered to detect differences in medication adherence rather than glycemic outcomes, and the relatively small sample size may have limited the ability to detect modest but clinically meaningful reductions in HbA_{1c} or FBG.

In addition, medication adherence represents only one aspect of diabetes self-management. Glycemic control is influenced by multiple factors, including dietary habits, physical activity, disease duration, medication adjustments during routine clinical care, weight changes, and the natural progression of diabetes.²² Consequently, improved medication adherence alone may not be sufficient to produce measurable short-term improvements in glycemic biomarkers.

Finally, the medication reminder application was designed primarily to reduce unintentional nonadherence through reminder notifications and medication scheduling.

Unlike more comprehensive digital health interventions, it did not provide diabetes education, behavioral coaching, personalized feedback, or direct communication with healthcare providers. These additional components may be necessary to achieve greater improvements in glycemic outcomes. Future studies with larger sample sizes, longer follow-up periods, and more comprehensive digital interventions are warranted to further evaluate the relationship between improved medication adherence and glycemic control.

In addition, the group mean values reported in this study may not fully reflect individual variability in treatment response. Although the intervention group demonstrated greater overall improvement, some participants may have experienced substantial improvements, whereas others showed little or no change. Such heterogeneity may have been influenced by differences in baseline characteristics, health behaviors, medication adjustments during routine care, and engagement with the application. Therefore, the group-level findings should be interpreted with appropriate caution.

Furthermore, because this study was conducted at a single university-affiliated outpatient clinic in Bangkok, the findings may not be generalized to other healthcare settings, where levels of digital literacy, access to smartphones, and available healthcare resources may vary.

Clinical Implications

This study suggests that a medication reminder application may be a useful adjunct to standard diabetes care for improving medication adherence. Its features, including medication reminders and adherence tracking, may support both patients and healthcare providers in monitoring treatment adherence. In addition, such applications may enhance patient engagement and self-management by promoting routine medication-taking behavior and increasing awareness of adherence patterns. Future development of the application may benefit from improvements in notification reliability and user interface design to enhance usability and user engagement. Additional features that track application usage frequency and medication logging patterns may help evaluate user engagement and medication-taking behaviors over time. Integration with electronic health records or communication channels with healthcare providers may further enhance its utility in supporting medication adherence within routine primary care settings. The small sample size was the main limitation, reducing statistical power and the precision of the effect estimates. Larger sample sizes and longer follow-up periods are needed to evaluate the long-term clinical impact of this intervention.

Conclusions

The medication reminder application was associated with greater improvement in medication adherence among patients with T2DM. However, after adjustment for baseline adherence, the between-group difference was not statistically significant. No significant improvements in glycemic outcomes were observed during the 3-month follow-up. Given the small sample size, these findings should be considered preliminary and interpreted with caution. Larger, adequately powered randomized controlled trials with longer follow-up periods are needed to confirm the effectiveness of the intervention.

Additional Information

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Ethics Approval: The study protocol was approved by the Committee on Human Rights Related to Research Involving Human Subjects, Faculty of Medicine Ramathibodi Hospital, Mahidol University (MURA 2024/329 on 9 May 2024).

Clinical Trial Consideration: This trial was submitted for registration with the Thai Clinical Trials Registry (TCTR20240826003 on 14 May 2024).

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