Two-way SMS Reminders for Medication Adherence and Quality of Life in Adults with Type 2 Diabetes: A Randomized Controlled Trial

Chantira Chiaranai, Saranya Chularee, Warithorn Prawatwong, Sujirat Srithongluang*

Abstract: Non-adherence to a medication regime often has a negative impact on patient outcomes. With a relatively low cost, many countries are using short messaging services to reduce non-adherence rates. In Thailand, research using a short messaging service reminder for people to take their medications is understudied. This multi-center randomized controlled trial, 2-arm, parallel-group research aimed to determine the effects of 2-way SMS reminders on the medication adherence and quality of life of adults with type 2 diabetes mellitus. Data were collected from 63 participants with diabetes in a treatment group (33) and a control group (30). The sample consisted of adults aged 18 and older who were diagnosed with diabetes living in a northeast province of Thailand. All participants received standard care, but those in the treatment group also received a tailored 2-way short message service as a mobile health (mHealth) treatment for four months. Medication adherence was measured by the level of hemoglobin A1c. Quality of life was measured using the Thai version of a Quality-of-Life Questionnaire developed by the World Health Organization and the Diabetes-39 Questionnaire. Data were analyzed using descriptive statistics. One-way repeated measures ANOVA was used to compare hemoglobin A1c levels and quality of life mean scores across three-time points (0, 2, and 4 months).

The results revealed that at the completion of the study, the participants in the treatment group had significantly lower hemoglobin A1c than those in the control group and significantly better health-related quality of life, demonstrating that the 2-way SMS reminder service improved their health outcomes. Thus, it is recommended that nurses should employ mHealth, such as 2-way SMS reminder solutions tailored to patients' daily routines. A future investigation comparing the cost-effectiveness and patient outcomes of different mHealth technologies is suggested.

Pacific Rim Int J Nurs Res 2023; 27(3) 457-471

Keywords: Diabetes, Medication adherence, mHealth, Quality of life, Randomized control trial, Short message service

Received 5 April 2023; Revised 17 May 2023; Accepted 18 May 2023

***Chantira Chiaranai**, RN, PhD, SFHEA-UKPSF, Associate Professor, Institute of Nursing, Suranaree University of Technology, Thailand. E-mail: chantira@sut.ac.th*

***Correspondence to: Saranya Chularee**,* RN, PhD, SFHEA-UKPSF, Assistant Professor, Institute of Nursing, Suranaree University of Technology, Thailand. E-mail: saranya.c@sut.ac.th*

***Warithorn Prawatwong**, RN, MNS, Instructor, Institute of Nursing, Suranaree University of Technology, Thailand. E-mail: waritorn@sut.ac.th*

***Sujirat Srithongluang**, RN, MNS, AFHEA-UKPSF, Instructor, Institute of Nursing, Suranaree University of Technology, Thailand. E-mail: sujirat@sut.ac.th*

Introduction

Type 2 diabetes mellitus (T2DM) comprises more than 95% of all diabetes is a health problem worldwide, with rising prevalence and mortality rates.[1] Reports have shown that between 2000-2019, the prevalence of T2DM has been rising more rapidly in low- and middle-income countries, including Thailand, than in high-income countries, with the mortality rate due to diabetes increasing by 13%.[1] In 2021, it was

reported that there were approximately one million Thais with diabetes and 62,631 deaths per 100 thousand population caused by diabetes.[2] Moreover, in 2021, around 9.1 million Thai people suffered from hypertension, the highest prevalence among non-communicable diseases, followed by people with diabetes.[2] T2DM, if not managed well, can progress to complications, such as chronic kidney disease, stroke, coronary artery disease, and neuropathy in the feet, increasing the chance of foot ulcers, infections, and the eventual need for limb amputation.[3] These complications also increase the disease burden for individuals and the health system.

Medication compliance is critical for diabetes management, and healthcare providers must develop effective strategies to improve it. High levels of non-compliance lead to dangerous situations for patients and a higher burden for their caregivers. The consequences of non-compliant behavior in those with T2DM have adverse outcomes for the patients.[4,5] It leads to treatment failure, disease progression, the emergence of insulin resistance when the treatment is interrupted early, and unavoidable hospitalizations. An example of non-compliant behaviors is when people fail to take the correct dose of their medications at the prescribed times. That is, medication is not compliant with their medication schedule, for instance, when a patient takes their medication late, forgets to take their medication as prescribed, or decides to skip. Some people with diabetes only take their medications just before an appointment with their professional caregivers, which is also known as "white-coat adherence (WCA)." Notably, it has been widely reported that WCA has a negative effect on the pre-visit glucose control of diabetes with moderate to poor glycemic control.[6]

Moreover, the COVID-19 pandemic has caused failures in providing medical services to people with T2DM.[7] The effects of the pandemic and social distancing on people's well-being have been widely reported.[8] It was suggested that patients without an emergency condition, like people with T2DM, should postpone travel and stay home to protect them from exposure to COVID-19.[9] Healthcare sectors have tried many strategies to increase medication compliance, thereby improving patient outcomes, such as telemedicine or mobile health (mHealth), remote diagnosis, treatment, and consultation of patients using remote communication, modern technology, mobile phone, and computer multimedia, which allow patient access to the full benefits of medical technology and education when social interaction or direct contact with healthcare providers is limited.[8,10,11] In Western countries, an extremely effective intervention has been adopting an appointment reminder system, i.e., reminding patients a few days before their appointments by telephone call or short message service (SMS).[12-14] A recent systematic review of the literature concludes that telehealth, or mHealth, increased medication compliance and reduced non-attendant rates.[15,16] The literature also contained recommendations that innovative strategies for alleviating medication adherence in patients and reliable adherence measures are needed.[7] However, many of those interventional studies assumed a "one-size-fits-all" approach. All clients received reminder messages in the same pattern when implementing reminder systems. Nonetheless, the research recommends that the most effective reminder system should be based on the individuals' preferences.[14]

Current evidence suggests that telehealth positively improves self-management in people living with T2DM, resulting in improved glycemic control.[18,19] In Thailand, research on implementing patient preferences in reminder systems and its relationships to non-compliance is sorely lacking and inconclusive. One study of Thais with tuberculosis using cellphone calls to remind them to take their medication by Kunawararak and others[20] found that this method was highly successful. However, one limitation of this study was that it required the caregivers to make each reminder call individually. In addition, a randomized controlled trial study (RCT)[21] on youth-friendly services and mobile phone applications to promote adherence to pre-exposure prophylaxis

(PrEP) among adolescent men who have sex with men and transgender women at-risk for HIV in Thailand found that youth-friendly PrEP services enabled good adherence among only half of the adolescent PrEP users. A pre-post experimental study conducted in Thailand,[22] who studied the effects of SMS reminders on treatment adherence and health-related quality of life (HRQoL) in older people, reported that older people demonstrated a significantly better HRQoL at the completion of the study.[22] Nevertheless, this study was limited due to its study design and a need for biological markers that supported the improvement of HRQoL in older people. Therefore, the aim of this RCT was to overcome the limitations of previous studies by utilizing 2-way SMS reminders, customized to patients' preferences, to improve medication adherence and HRQoL in individuals with T2DM in comparison between participants in treatment and control groups. Glycate hemoglobin (HbA1c) was used as a biological marker to measure medication adherence. Participants in the experimental group who receive 2-way SMS reminders were expected to exhibit better glycemic control compared to those in the control group who received usual care. The use of mHealth technology, particularly 2-way SMS, is expected to improve medication adherence and result in better glycemic control, thereby preventing negative consequences of non-compliance like hospitalization and disease progression.

Method

Study Design: This study was a single (evaluator) blinded randomized control trial (RCT) with parallel control and intervention groups. This report followed the checklist for randomized trial based on the CONSORT guidelines.

Participants and Setting: This multi-center RCT study was conducted at three hospitals in a province in the northeast of Thailand. The target population consisted of Thai adults aged 18 and older who were diagnosed with diabetes. The inclusion criteria were: 1) being able to comprehend Thai, 2) being prescribed oral medications to lower blood sugar, 3) having a cellular phone and using SMS services, and 4) being willing to take part in the study. They were excluded if they: 1) were not able to fully take part in the study, 2) had hearing and/or vision loss, or 3) had a psychiatric problem.

Sample and Sampling: It is recommended that effect-size estimates must be derived from previous research and theory to dispel suspicions that they might have been taken from data used in the study or, even worse, constructed to justify a particular sample size.[23] Therefore, we calculated the effect size (d) using the effect size equation proposed by Glass.[24] Secondly, we inquired about the statistical numbers from a previous study of the effectiveness of mobile and internet interventions in patients with obesity and type 2 diabetes.[25] Therefore, our study's effect size was 0.71, considering a large effect size (> 0.6). Thus, we set the statistical significance level at 0.05, a large effect size (0.71), and the power at 80%. Lastly, we used a 2-tail table,[26] yielding a sample size of 64 (32 in each group). Typically, in one clinical trial study, there might be a number of dropouts that affect the power of the study if the rate is too high. Therefore, to address that potential problem, we recruited 70 participants (35 for each group) to participate in our study.

To achieve randomization into the two groups, first, the research assistant (RA) retrieved potential participants' medical records to evaluate their eligibility against the inclusion criteria. Second, the participants were matched in pairs by age, gender, and length of illness. Third, they were randomly assigned (1:1) to the intervention or control group using sequentially numbered, sealed, opaque envelopes. Next, the RA approached the participants and performed the data collection. Lastly, the data collected from the participants in both groups were stored in a password-locked computer that only the RA could access. Therefore, this study is a single (evaluator) blinded RCT study. **Figure 1** shows the CONSORT flow chart of participation through the trial with the rationales of the participants that dropped out.

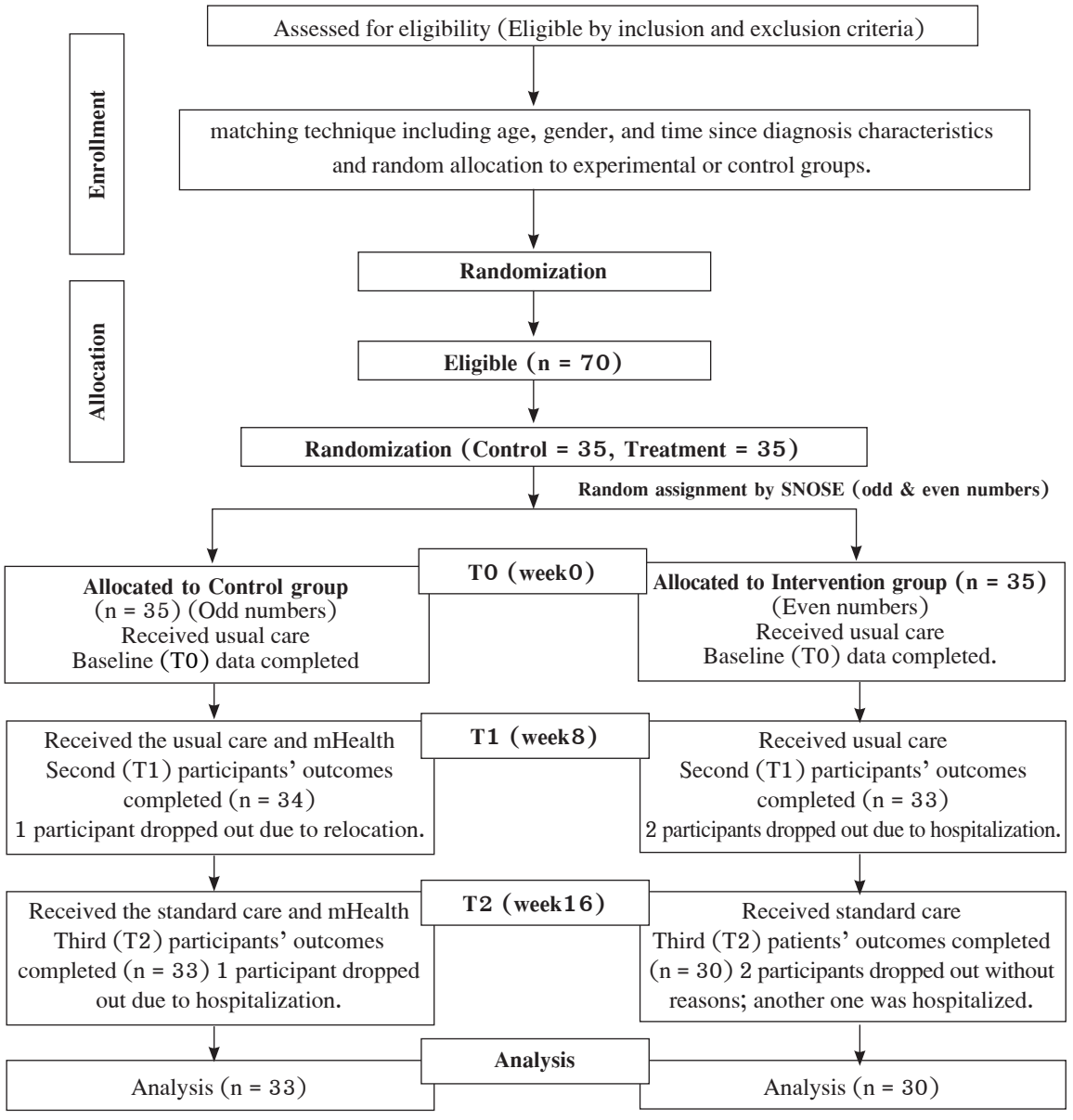

Figure 1. CONSORT Flow chart of participation through the trial

Ethical Considerations: The study proposal was fully approved by the Institutional Review Board (IRB) of the Suranaree University of Technology (protocol number: EC12-60), Thailand. Informed consent was obtained from the participants before the start of data collection and after thoroughly discussing the details regarding the objective of the study, program implementation, benefits and potential risks, time consumption, confidentially, and the right to withdraw at any time before the completion of data collection without any repercussion. To ensure confidentiality and prevent disclosure of medical information to unrelated individuals, researchers utilized only one mobile phone to receive messages from participants

who wished to keep their medical diagnosis private. This study was reviewed and approved by the Thai Clinical Trial Registry (TCTR) Committee (TCTR ID: TCTR 20210425001).

Data Collection: Potential participants were recruited by the physician in charge according to the inclusion criteria. On their first visit (T0), upon their agreement to participate in the study, participants in both groups were asked to complete the research instruments, and their HbA1c levels were retrieved from their medical records. Their medication information, appointments, and SMS text message preferences were entered into the medication-taking reminder program (MTRP). The participants in the intervention group received 2-way SMSs in addition to their standard care. Each participant was taught to operate his/her mobile phone to receive and respond to the reminder messages to ensure they were competent. They were informed that they would receive tangible reminder messages the following day. In the subsequent time points of the study, namely T1 (second time) and T2 (third time), participants from both groups were provided with a questionnaire package through regular mail, typically 2-3 days prior to their scheduled appointment. They were asked to complete the self-report questionnaires and return them to the RA at their appointment. This allowed the participants sufficient time to complete the questionnaires without time pressure. On the appointment days of T1 and T2, the RA approached them and obtained their HbA1c data. In addition, the RA waited to enter their prescribed medicines and appointment data into the MTRP after the participants received their prescribed treatment.

Research Instruments: Patient outcomes were measured at the next two follow-up visits, which were at weeks 8 (T1) and 16 (T2) of the study. Three research instruments to obtain the data comprised 1) a demographic data form, 2) the MTRP, and 3) outcome questionnaires. Once the participants received the text reminder, they would respond by pressing the number 803 (the study number), followed by the number 0 or 1 (0 = forgot, 1 = already took medication). The patient outcomes included 1) the level of glycated hemoglobin (HbA1c), and 2) the HRQoL questionnaires.

1. *The Demographic Data Form:* This form consisted of participants' sex, age, marital status, education, occupation, length of illness, monthly income, and comorbidity.

2. *Medication adherence*: In this study, medication adherence was defined as the degree to which participants with T2DM followed medication prescriptions, which is the proximal outcome. However, we measured the distal outcome, which is the HbA1c level. HbA1c is an important indicator of long-term glucose levels and has been recommended for use in the diagnosis of diabetes by the American Diabetes Association (ADA).[27] The goal for the HbA1c in most people with T2DM is 7% or less. Therefore, having an HbA1c greater than 7% is considered a poorly controlled diabetes and a low level of treatment adherence.[28] The participants' HbA1C levels were obtained from their medication records, which the physician mandated to have their blood drawn during every appointment.

3. *Quality of life:* It is strongly recommended that the combined use of disease-specific and generic instruments are helpful strategies for diabetes HRQoL assessment.[29] Therefore, in the present study, HRQoL was measured both generic and disease-specific HRQoL measurements.

3.1 Generic HRQoL instrument: The WHOQOL-BREF-THAI questionnaire developed by the WHO was used as the generic HRQoL.[30] Originally, there were 26 items; however, items 1 and 26 asked about the participant's overall health and were excluded. Thus, the final version consisted of 24 items, focusing on the patient's perception of four domains of life; physical (7 items), psychological (6 items), social relationships (3 items), and environmental domains (8 items). Respondents were asked to rate their perception of the degree to which an individual is healthy, comfortable, and able to participate in or enjoy life events in the past two weeks. The Likert scale of 1-5 ranged from

1 = not at all to 5 = most. The overall HRQoL ranges from 24 to 120. One example question is, *"How satisfied are you with your daily life over the past 2 weeks?"* Higher scores indicate a higher HRQoL. The Cronbach alpha reliability of the WHOQOL-BREF-THAI has been reported to be 0.84 in prior studies.[31] The Cronbach alpha reliability of the WHOQOL-BREF-THAI of the current study was 0.88.

3.2 Disease-specific HRQoL: The Diabetes-39 (D-39) questionnaire is a reliable and valid scale for measuring HRQoL in people with T2DM cross-cultural differences.[32,33] The D-39 Thai version was used to measure disease-specific HRQoL in this study. It consists of 39 items with five dimensions of patients' lives: diabetes control (13 items); anxiety and worry (4 items); social burden (6 items); sexual function (3 items); energy and mobility (10 items); and other health problems and diabetes complications (3 items). Each item is rated on a 7-point Likert scale, ranging from "not affected at all" to "extremely affected." The D-39 questionnaire also includes an overall evaluation (2 items), which is the patients' self-perceived overall rating of HRQoL and self-perceived rating of the severity of diabetes. Overall HRQoL and overall severity of T2DM were included as individual items and assessed on a 7-point Likert scale ranging from "highest quality" to "lowest quality" and "not severe at all" to "extremely severe," respectively. The instrument's developers granted permission to use the D-39 questionnaire (English and Thai versions). High scores on the HRQoL represent a poor HRQoL. An example question from the D-39 questionnaire is, *"How much has your diabetes medication schedule affected the quality of your life?"* The overall reliability of the D-39 ranged from 0.82 to 0.93.[34] The Cronbach alpha reliability of this study was 0.84.

Study Intervention: We used a medication-taking reminder program (MTRP) to deliver text messages to the participants in the intervention group. The MTRP was developed and copyrighted by the first author (CC) and was previously used with older people.[22] We further developed the MTRP to have an additional feature that allows the participants to respond to the researcher team once they have taken their prescribed medications. Moreover, the messages sent to the study participants were based on their preferences related to how they recognized their medications, whether by name, appearance, shape, or size.

Standard Care: All participants received standard diabetes care from their diabetes clinical service. This included blood collection, face-to-face meetings with their physician, educational advice and counseling, and prescribed medications.

Data Analysis: Data were analyzed using descriptive statistics. The sample's characteristics were tested for differences using Chi-square and Fisher's exact tests. Independent t-tests, dependent t-tests, and one-way repeated measures ANOVAs were used to compare the HbA1c levels and HRQoL mean scores between groups and across the three-time points (T0, T1, T2).

Results

Participants' characteristics

Initially, we enrolled 70 participants with T2DM. The proportion of the participants between males and females was 1:1. Of the 70 T2DM patients enrolled, 63 completed the study (Control = 30, Treatment = 33). For the characteristics of participants in both groups, as shown in **Table 1**, most of the participants in both groups were aged 40- 60 years old, had education higher than the secondary level, were actively employed, had been diagnosed with T2DM for less than six years and had an earned income higher than 10,000 Baht/month (approx. 330 USD). More than 50% of them had at least one comorbidity in addition to T2DM. Using Chi-square tests and Fisher's exact tests, we found no differences between the two groups in terms of sex, age, marital status, education, occupation, length of illness, income, and comorbidity.

Table 1. Comparison of participants' characteristics between control and treatment groups

Sample Characteristics	Control (35)	Treatment (35)	p-value
	N (%)	N (%)	
[1]Sex			0.057
Male	17 (48.57)	18 (51.43)	
Female	18 (51.43)	17 (48.57)	
[2]Age (Years)	Mean 51.49 (12.16)	Mean 53.86 (12.83)	0.556
Less than 40	7 (20.00)	5 (14.29)	
40-60	20 (57.14)	20 (57.14)	
Greater than 60	8 (22.86)	10 (28.57)	
[2]Marital status			0.311
Single	4 (11.43)	3 (8.57)	
Married	25 (71.43)	27 (77.17)	
Separated/Divorced	6 (17.14)	5 (14.29)	
[2]Education			6.404
None	0 (0.00)	1 (2.86)	
Primary	13 (37.14)	7 (20.00)	
Secondary	6 (17.14)	6 (17.14)	
Higher than secondary	16 (45.71)	21 (60.00)	
[2]Occupation			9.722
Government officers/ Employees	14 (40.00)	25 (71.43)	
Workers	5 (14.29)	2 (5.71)	
Merchants	4 (11.43)	3 (8.57)	
Farmers/Agriculturists	6 (17.14)	1 (2.86)	
Retired	5 (14.29)	2 (5.71)	
Others	1 (2.86)	2 (5.71)	
[2]Length of illness (years)			2.952
Less than 6	21 (60.00)	20 (57.14)	
6-10	9 (25.71)	13 (37.14)	
11-15	2 (5.71)	0 (0.00)	
Greater than 15	3 (8.57)	2 (5.71)	
[2]Monthly income Baht (USD)			5.277
Less than 5,000 ($150)	8 (22.86)	6 (17.14)	
5,000-10,000 ($150-330)	8 (22.86)	2 (5.71)	
Greater than 10,000 ($330)	19 (54.29)	27 (77.17)	
[1]Comobidity			0.233
No	16 (45.71)	14 (40.00)	
Yes	19 (54.29)	21 (60.00)	

[1]Chi-square test, [2]Fisher's exact test

Level of HbA1c (medication adherence)

At T0, the participants' mean HbA1c in both groups were not significantly different (C = 7.829 ± 1.629, T = 7.886 ± 1.387, $p > 0.05$, respectively). **Table 2** shows the mean HbA1c of the participants in the control and treatment groups. Using repeated measures ANOVA to compare participants' mean HbA1c at T0, T1, and T2, we found that the HbA1c levels of the participants (both within and between groups) were statistically significantly different ($p < .001$) (see **Table 3**). **Figure 2** illustrates the decline of the mean HbA1c in both groups across the three-time points and shows a tremendous decline in the mean HbA1c of the participants in the intervention group.

Table 2. The comparison of mean score of HbA1c, WHOQOL, and D-39 of participants in the intervention group and control group at baseline (independent t-test)

Variables	T0 (Baseline)		t
	Control Mean (SD)	Treatment Mean (SD)	
HbA1C	7.829 (1.629)	7.886 (1.387)	-0.158^{ns}
Generic HRQoL (WHOQOL-THAIBRIEF)			
Physical	26.29 (4.274)	24.12 (3.586)	2.552^{ns}
Psychological	23.77 (3.507)	22.40 (3.098)	1.734^{ns}
Social relationships	10.63 (1.926)	10.26 (1.755)	0.843^{ns}
Environment	30.31 (4.411)	29.34 (4.318)	0.931^{ns}
Overall	91.00 (11.958)	85.86 (10.267)	1.930^{ns}
Disease specific HRQoL (D-39)			
Sexual functioning	17.69 (20.895)	27.14 (22.530)	-1.821^{ns}
Diabetes control	33.98 (16.268)	34.97 (17.086)	-0.247^{ns}
Energy and mobility	28.50 (16.608)	32.53 (15.761)	-1.041^{ns}
Anxiety and worry	31.48 (17.905)	35.66 (20.592)	-0.907^{ns}
Social burden	22.73 (16.033)	25.43 (16.963)	-0.683^{ns}

ns = non-significant, df = 68

Table 3. The comparison of mean HbA1c, generic HRQoL (WHOQOL-THAIBRIEF), and disease specific HRQoL (D-39) of the treatment group and control group across 3 time points (repeated measures ANOVA)

	Intervention group (n = 35)			Control group (n = 35)			Repeated measures ANOVA					
	T0 (n = 35) Mean(SD)	T1 (n = 34) Mean(SD)	T2 (n = 33) Mean(SD)	T0 (n = 35) Mean(SD)	T1 (n = 33) Mean(SD)	T2 (n = 30) Mean(SD)	Source of variation	SS	df	MS	F	p
HbA1C	7.886	7.252	6.562	7.829	7.688	7.853	Intercept	10608.29	1	10608.10	2712.10	0.000
	(1.39)	(1.02)	(.80)	(1.63)	(1.62)	(1.25)	Group	17.95	1	17.95	4.59	0.04
							Error	238.60	61	3.91		
Generic QOL (WHOQOL-THAIBRIEF)												
- Physical	24.12	25.82	26.76	26.29	24.61	24.97	Intercept	123674.84	1	123674.84	6428.30	0.000
	(3.59)	(2.38)	(2.22)	(4.27)	(3.72)	(3.50)	Group	0.11	1	0.11	0.01	0.94
							Error	1173.59	61	19.24		
- Psychological	22.40	23.15	23.67	23.77	22.76	22.93	Intercept	101381.82	1	101381.82	3642.93	0.000
	(3.09)	(3.52)	(3.64)	(3.51)	(3.28)	(4.05)	Group	0.24	1	0.24	0.01	0.93
							Error	1697.62	61	27.830		
- Social relationships	10.26	10.56	10.45	10.63	10.33	10.20	Intercept	20441.47	1	20441.47	2345.12	0.000
	(1.76)	(1.85)	(1.99)	(1.93)	(2.12)	(2.19)	Group	0.10	1	0.10	0.01	0.92
							Error	531.71	61	8.72		

Table 3. The comparison of mean HbA1c, generic HRQoL (WHOQOL-THAIBRIEF), and disease specific HRQoL (D-39) of the treatment group and control group across 3 time points (repeated measures ANOVA) (Cont.)

	Intervention group (n = 35)			Control group (n = 35)			Repeated measures ANOVA					
	T0 (n = 35) Mean(SD)	T1 (n = 34) Mean(SD)	T2 (n = 33) Mean(SD)	T0 (n = 35) Mean(SD)	T1 (n = 33) Mean(SD)	T2 (n = 30) Mean(SD)	Source of variation	SS	df	MS	F	p
- Environment	29.34	29.82	30.79	30.31	29.18	28.17	Intercept	166501.07	1	166501.07	3498.91	0.000
	(4.32)	(4.82)	(4.85)	(4.41)	(4.98)	(4.84)	Group	35.99	1	35.99	0.76	0.39
							Error	2902.78	61	47.59		
- Overall	85.86	89.64	91.45	91.00	87.60	86.27	Intercept	1488034.48	1	1488034.48	5375.10	0.000
	(10.27)	(9.88)	(9.51)	(11.96)	(11.06)	(12.37)	Group	33.38	1	33.38	0.12	0.730
							Error	16887.14	61	276.84		
Disease specific QOL (D-39)												
- Sexual functioning	27.14	19.77	19.36	17.69	27.14	24.30	Intercept	97908.43	1	97908.43	142.07	0.000
	(22.53)	(21.91)	(19.56)	(20.90)	(22.53)	(18.02)	Group	55.60	1	55.60	.081	0.77
							Error	42727.09	61	989.15		
- Diabetes control	34.97	32.03	30.52	33.98	34.97	33.49	Intercept	209147.72	1	209147.72	538.23	0.000
	(17.09)	(17.45)	(18.07)	(16.27)	(17.09)	(16.90)	Group	192.83	1	192.83	.50	0.48
							Error	24092.46	61	388.588		
- Energy and mobility	32.53	27.47	20.58	28.50	32.53	33.76	Intercept	161458.191	1	161458.191	401.70	.000
	(15.76)	(20.12)	(15.35)	(16.61)	(15.77)	(16.07)	Group	1143.67	1	1143.67	2.845	.097
							Error	24920.01	61	401.94		
- Anxiety and worry	35.66	32.79	30.12	31.48	35.66	36.13	Intercept	212144.52	1	212144.52	432.06	.000
	(20.59)	(19.62)	(20.41)	(17.91)	(20.95)	(17.93)	Group	293.27	1	293.27	.60	.44
							Error	30442.74	61	491.01		
- Social burden	25.43	20.43	19.48	22.73	25.43	25.34	Intercept	100244.91	1	100244.91	265.59	.000
	(16.96)	(17.41)	(13.62)	(16.03)	(16.96)	(17.56)	Group	373.40	1	373.40	.99	.32
							Error	23401.42	61	377.44		

T0 = Baseline, T1 = week 8, T2 = week 16

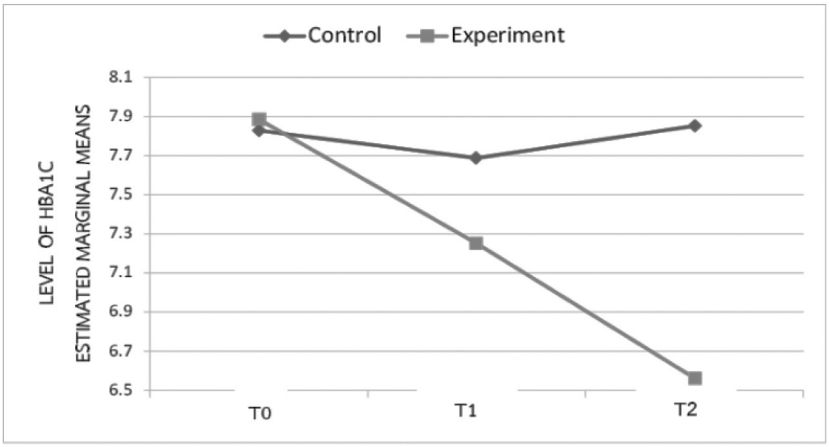

Figure 2 Mean level of HbA1c of the control and treatment groups across 3 time points

Quality of life

Generic QOL: The mean scores for the generic HRQoL measurements of both groups were similar in every dimension and overall ($p > 0.05$). **Table 3** shows the mean generic QOL scores of the T2DM participants in the control and treatment groups. Prior to the intervention, participants in the intervention group had fair overall mean generic HRQoL scores and in the four individual

domains of HRQoL — physical, psychological, social relationships, and environment. Upon the completion of the intervention, participants' overall mean generic HRQoL scores had increased. However, their physical domain mean scores reached a good level, while the remaining domains (psychological, social relationships, and environment) all remained at a fair level.

Using repeated measures ANOVA to compare the intervention groups' overall generic HRQoL mean scores at T0, T1, and T3 revealed statistically significant differences in their overall generic QOL ($p < .001$). When comparing the four domains of generic HRQoL, there were also statistically significant differences in those domains ($p < .001$). In contrast, the overall generic HRQoL mean score of the control group declined.

Disease-specific HRQoL (D-39): Using independent t-tests, the mean scores for disease-specific QOL of both groups were similar ($p > 0.05$). **Table 3** shows the mean disease-specific HRQoL score of the participants in the control and treatment groups across all three-time points. Prior to the intervention, participants in the intervention group had a poorer HRQoL than those in the control group. Using repeated measures ANOVA to compare the intervention groups' disease-specific QOL mean score at T0, T1, and T3, there were statistically significant differences in the disease-specific HRQoL of all five domains ($p < .001$).

Discussion

Findings from our study suggest that mHealth, a 2-Way SMS reminder system, is an effective strategy focusing on patients' preferences for improving medication adherence. Classical research in psychology suggests that individuals' attitudes can change their perceptions and guide their behaviors.[35] Preference reminders can be an effective tool for influencing attitudes and behaviors by reminding individuals of their preferences and values. This reminder can motivate individuals to act in ways that align with their preferences and increase their commitment to upholding their values. Furthermore, there are several studies reported that sending reminder messages effectively lowered blood glucose in patients with diabetes. For example, an RCT study[8] on telemedicine with 99 patients with T2DM who were randomly assigned to the intervention (telemedicine) and control groups found that, on day 22, the fasting blood glucose (FBG) in the intervention group was statistically significantly lower than that in the control group. In addition, at the end of three months, the HbA1c and FBG levels in the telemedicine group had decreased significantly compared with those in the control group. The findings of the present study are also supported by a study of the effectiveness of mobile-based education on self-care activities and glycemic control among the elderly with T2DM.[36] After the implementation of a 3-month intervention, there was no statically significant difference in self-care between the study groups, but the mean value of HbA1c of the intervention group was significantly less than that of the control group. An RCT study[37]on the efficacy of mHealth in patients with T2DM found that among 86 patients (41 using mHealth), the mHealth group's mean HbA1c level was lower than the control group's mean.[37] A prospective analysis that evaluated the effects of tele-pharmacy services on knowledge, self-care practices, medication adherence, and glycemic control in people with T2DM[38] found a significant difference in knowledge scores between the intervention and control groups. Self-care practices were also improved in the intervention group compared to the control group. Similarly, medication adherence and HbA1c were shown to have significantly improved between the group analysis. Furthermore, a systematic review revealed that telehealth-based interventions, such as remote monitoring of independent blood glucose levels, education through text messaging, and telephone and technological Surrogate Nursing (TSN), can effectively facilitate the self-management of people with DM, which in turn, would improve glycemic control and improve the individual's HRQoL.[39] To further explain this phenomenon, the researchers asserted that patients

tend to respond to text messages if they have expressed their preference for text reminder messages.

Thus, by reminding patients in a way they prefer, they are more likely to comply with their treatment and keep their appointments or at least call to cancel or reschedule them. The findings of our study are supported by the fact that mobile phones have become an integral part of daily life for many people. It is evident that SMS reminders are effective in directing our attention towards a specific decision and can be a powerful tool for motivation and behavioral change. One of the most effective tools for motivation and behavior change is the use of 2-way SMS reminders. The SMS reminder system offers new opportunities to provide precise, individualized, just-in-time interventions to support behavior change. Additionally, since the reminder messages were automatically sent from the SMS provider, it did not require caregivers to operate the system daily. Therefore, this mHealth approach was a friendly, cost-effective technology that eased the workload of the caregivers.

In contrast, a study[7] on the impact of a telehealth intervention on the metabolic profiles of patients with diabetes reported that at the end of the telehealth intervention, there were no changes in the individual's HbA1c levels in either the intervention or the control groups. Other researchers[40] also reported that, after using telehealth for three months to enhance self-management in patients with T2DM during the COVID-19 pandemic, there were no statistically significant differences in HbA1c between the intervention and the control groups. However, these researchers did observe an improvement in self-management in the intervention group.[40] Our data analysis unequivocally shows that mHealth is effective. However, it is essential to acknowledge that the conclusions drawn from other research findings are incongruent, which creates challenges in reaching a definitive conclusion regarding the effectiveness of mHealth. To address these inconsistencies and achieve a more comprehensive understanding of the topic, further research is warranted.

Limitations

The limitations of the studies must be addressed. This study has some limitations. First, this study solely focused on short-term effects and did not include any follow-up with participants beyond a limited timeframe. Therefore, a longitudinal study is highly recommended to track the changes in medication adherence and HRQoL among these participants over a longer period of time. Second, the participants in the present study were only recruited from three hospitals, which might limit the generalizability of the study. Lastly, although a 2-way text messaging system could increase medication adherence, there is a cost burden for patients. Therefore, it is recommended in future to use a different platform that is more cost-effective such as a free mobile application.

Conclusions and Recommendations for Nursing Practice

Our findings showed that using mHealth increased medication compliance and improved HRQoL among the study's participants. Healthcare providers should consider implementing mHealth interventions to help patients manage their illnesses and monitor symptoms, as well as providing ongoing support. Furthermore, the use of mHealth services can also potentially reduce healthcare costs by reducing admissions and readmissions, as well as increasing medication adherence, which can result in improved health outcomes for those receiving long-term medication for treatment.

Acknowledgements

We thank Suranaree University of Technology for providing financial support for this study.

Also, our gratitude goes to all participants in this study.

Conflict of Interest: The authors certify that they have no conflicts of interest that are known to them regarding the subject matter or materials discussed in this manuscript.

References

1. World Health Organization: WHO. Diabetes: key facts. 2023. [cited 2023 May 11]. Available from: https://www.who.int/news-room/fact-sheets/detail/diabetes
2. International Diabetes Federation. Deaths attributable to diabetes. 2021. [cited 2023 May 15]. Available from: https://diabetesatlas.org/data/en/indicators/7/
3. Waller K, Furber S, Bauman A, Allman-Farinelli M, van den Dolder P, Hayes A, et al. DTEXT - text messaging intervention to improve outcomes of people with type 2 diabetes: protocol for randomised controlled trial and cost-effectiveness analysis. BMC Public Health. 2019;19: 262. doi:10.1186/s12889-019-6550-6.
4. Nishimura R, Kato H, Kisanuki K, Oh A, Hiroi S, Onishi Y, et al. Treatment patterns, persistence and adherence rates in patients with type 2 diabetes mellitus in Japan: a claims-based cohort study. BMJ Open. 2019;9(3): e025806. doi:10.1136/bmjopen-2018-025806.
5. Yagome S, Sugiyama T, Inoue K, Igarashi A, Bouchi R, Ohsugi M, et al. Influence of the COVID-19 pandemic on overall physician visits and telemedicine use among patients with type 1 or type 2 diabetes in Japan. J Epidemiol. 2022;32(10):476-82. doi:10.2188/jea.JE20220032.
6. Zueger T, Gloor M, Lehmann V, Melmer A, Kraus M, Feuerriegel S, et al. White coat adherence effect on glucose control in adult individuals with diabetes. Diabetes Res Clin Pract. 2020;168:108392. doi:10.1016/j.diabres.2020.108392.
7. Franco DW, Alessi J, de Carvalho TR, Kobe GL, Oliveira GB, Knijnik CP, et al. The impact of a telehealth intervention on the metabolic profile of diabetes mellitus patients during the COVID-19 pandemic - a randomized clinical trial. Prim Care Diabetes. 2022;16(6):745-52. doi:10.1016/j.pcd.2022.09.011.
8. Yin W, Liu Y, Hu H, Sun J, Liu Y, Wang Z. Telemedicine management of type 2 diabetes mellitus in obese and overweight young and middle-aged patients during COVID-19 outbreak: a single-center, prospective, randomized control study. PLoS One. 2022;17(9): e0275251. doi:10.1371/journal.pone.0275251.
9. Ruksakulpiwat S, Zhou W, Chiaranai C, Vonck JE. Human travelling and COVID-19 pandemic. Siriraj Med J. 2021;73(9):562-9. doi:10.33192/Smj.2021.73.
10. Cobry EC, Wadwa RP. The future of telehealth in type 1 diabetes. Curr Opin Endocrinol Diabetes Obes. 2022; 29(4):397-402. doi:10.1097/MED.0000000000000745.
11. Galiero R, Pafundi PC, Nevola R, Rinaldi L, Acierno C, Caturano A. The importance of telemedicine during COVID-19 pandemic: a focus on diabetic retinopathy. J Diabetes Res. 2020;2020:9036847. doi:10.1155/2020/9036847.
12. Bae JW, Woo SI, Lee J, Park SD, Kwon SW, Choi SH, et al. mHealth interventions for lifestyle and risk factor modification in coronary heart disease: randomized controlled trial. JMIR Mhealth Uhealth. 2021;9(9): e29928. doi:10.2196/29928.
13. Mwansa-Kambafwile JRM, Chasela C, Levin J, Ismail N, Menezes C. Treatment initiation among tuberculosis patients: the role of short message service (SMS) technology and Ward-based outreach teams (WBOTs) [published correction appears in BMC Public Health. 2022 Mar 18;22(1):539]. BMC Public Health. 2022;22(1):318. doi:10.1186/s12889-022-12736-6.
14. Wan LH, Zhang XP, You LM, Ruan HF, Chen SX. The efficacy of a comprehensive reminder system to improve health behaviors and blood pressure control in hypertensive ischemic stroke patients: a randomized controlled trial. J Cardiovasc Nurs. 2018;33(6):509-17. doi:10.1097/JCN.0000000000000496.
15. Alipanah N, Jarlsberg L, Miller C, Linh NN, Falzon D, Jaramillo E, et al. Adherence interventions and outcomes of tuberculosis treatment: a systematic review and meta-analysis of trials and observational studies. PLoS Med. 2018;15(7):e1002595. doi:10.1371/journal.pmed.1002595.
16. Cavero-Redondo I, Saz-Lara A, Sequí-Dominguez I, Gómez-Guijarro MD, Ruiz-Grao MC, Martinez-Vizcaino V, et al. Comparative effect of eHealth interventions on hypertension management-related outcomes: a network meta-analysis. Int J Nurs Stud. 2021;124:104085. doi:10.1016/j.ijnurstu.2021.104085.

17. Chan A, De Simoni A, Wileman V, Holliday L, Newby CJ, Chisari C, et al. Digital interventions to improve adherence to maintenance medication in asthma. Cochrane Database Syst Rev. 2022;6(6):CD013030. doi:10.1002/14651858.CD013030.pub2.
18. Lee VW, Pang KK, Hui KC, Kwok JC, Leung SL, Yu DS, et al. Medication adherence: is it a hidden drug-related problem in hidden elderly? Geriatr Gerontol Int. 2013;13(4):978-85. doi:10.1111/ggi.12042.
19. So CF, Chung JW. Telehealth for diabetes self-management in primary healthcare: a systematic review and meta-analysis. J Telemed Telecare. 2018;24(5): 356-64. doi:10.1177/1357633X17700552.
20. Kunawararak P, Pongpanich S, Chantawong S, Pokaew P, Traisathit P, Srithanaviboonchai K, et al. Tuberculosis treatment with mobile-phone medication reminders in northern Thailand. Southeast Asian J Trop Med Public Health. 2011;42(6): 1444-51.
21. Songtaweesin WN, Kawichai S, Phanuphak N, Cressey TR, Wongharn P, Saisaengjan C, et al. Youth-friendly services and a mobile phone application to promote adherence to pre-exposure prophylaxis among adolescent men who have sex with men and transgender women at-risk for HIV in Thailand: a randomized control trial. J Int AIDS Soc. 2020;23 Suppl 5(Suppl 5): e25564. doi:10.1002/jia2.25564.
22. Chiaranai C. The effects of a medication taking reminder computer program on quality of life and adherence to treatment in elderly. Songkla Med J. 2014;32(3):173-84.
23. Wilkinson, L., & Task Force on Statistical Inference, American Psychological Association, Science Directorate. (1999). Statistical methods in psychology journals: Guidelines and explanations. Am Psychol. 54(8),594-604. https://doi.org/10.1037/0003-066X.54.8.594
24. Glass GV. Primary, secondary, and meta-analysis of research. Educ Res. 1976;5(10):3-8.
25. Kim SI, Kim HS. Effectiveness of mobile and internet intervention in patients with obese type 2 diabetes. Int J Med Inform. 2008;77(6):399-404. doi:10.1016/j.ijmedinf. 2007.07.006.
26. Polit D, Hungler B. Nursing research: principle and methods. 4th ed. Philadephia: J.B. Lippincott. 1995.
27. American Diabetes Association. 2. Classification and diagnosis of diabetes: *Standards of Medical Care in Diabetes—2019.* Diabetes Care. 2019 Jan;42(Suppl 1):S13-28. doi:10.2337/dc19-S002.
28. Galaviz KI, Narayan KMV, Lobelo F, Weber MB. Lifestyle and the prevention of type 2 diabetes: a status report. Am J Lifestyle Med. 2018;12(1):4-20. doi:10.1177/1559827615619159.
29. Pequeno NPF, Cabral NLA, Marchioni DM, Lima SCVC, Lyra CO. Quality of life assessment instruments for adults: a systematic review of population-based studies. Health Qual Life Outcomes. 2020;18(1):208. doi:10.1186/s12955-020-01347-7.
30. World Health Organization. Thai_WHOQOL-BREF, Thai_WHOQOL-BREF; 2020 [cited 2022 Nov 5]. Available from: https://dmh.go.th/test/whoqol/
31. Department of Mental Health, Ministry of Public Health, Thailand. WHOQOL - BREF - THAI. 2016 [cited 2022 Nov 11]. Available from: https://dmh.go.th/test/download/files/whoqol.pdf
32. Buran Çırak Y, Yılmaz Yelvar GD, Parlak Demir Y, Durukan BN, Elbaşı Dürüstkan N, Seyis AS. Cross-cultural adaptation and validation of diabetes-39 in Turkish patients with type 2 diabetes [published online ahead of print, 2022 Nov 30]. Disabil Rehabil. 2022;1-7. doi:10.1080/09638288.2022.2149864.
33. Uwizihiwe JP, Lygidakis C, Bia M, Dukundane D, Asiimwe-Kateera B, Nsanzimana S, et al. Cultural adaptation and psychometric evaluation of the Kinyarwanda version of the diabetes-39 (D-39) questionnaire. Health Qual Life Outcomes. 2022; 20(1):122. doi:10.1186/s12955-022-02034-5.
34. Khunkaew S, Fernandez R, Sim J. Health-related quality of life among adults living with diabetic foot ulcers: a meta-analysis. Qual Life Res. 2019;28(6):1413-27. doi:10.1007/s111 36-018-2082-2.
35. Festinger L. A theory of cognitive dissonance. Oxford, England: Row, Peterson; 1957.
36. Esferjani SV, Naghizadeh E, Albokordi M, Zakerkish M, Araban M. Effectiveness of a mobile-based educational intervention on self-care activities and glycemic control among the elderly with type 2 diabetes in southwest of Iran in 2020. Arch Public Health. 2022;80:201. doi:10.1186/s13690-022-00957-5.

37. Gómez AM, Cristina Henao D, León Vargas F, Mauricio Muñoz O, David Lucero O, García Jaramillo M, et al. Efficacy of the mHealth application in patients with type 2 diabetes transitioning from inpatient to outpatient care: a randomized controlled clinical trial. Diabetes Res Clin Pract. 2022; 189:109948. doi:10.1016/j.diabres. 2022.109948.
38. Khan YH, Alzarea AI, Alotaibi NH, Alatawi AD, Khokhar A, Alanazi AS, et al. Evaluation of impact of a pharmacist-led educational campaign on disease knowledge, practices and medication adherence for type-2 diabetic patients: a prospective pre- and post-analysis. Int J Environ Res Public Health. 2022;19(16):10060.doi:10.3390/ijerph191610060.
39. Putri AM, Mulyani S, Agustin A, Ulfah S, Fitri R. Telehealth potential to optimize self-management, education, and support for diabetes mellitus patients during COVID-19 pandemic. IJNHS. 2022;5(2),138-49. doi:10.35654/ijnhs. v5i2.557.
40. Leong CM, Lee TI, Chien YM, Kuo LN, Kuo YF, Chen HY. Social media-delivered patient education to enhance self-management and attitudes of patients with type 2 diabetes during the COVID-19 pandemic: randomized controlled Trial. J Med Internet Res. 2022;24(3): e31449. doi:10.2196/31449.

ผลของการส่งข้อความสั้นเตือนแบบสองทางต่อการติดตามการรับประทานยาและคุณภาพชีวิตของผู้ใหญ่ที่เป็นเบาหวานชนิดที่สอง : การทดลองแบบสุ่มและมีกลุ่มควบคุม

จันทร์ทิรา เจียรณัย ศรัญญา จุฬารี วาริธร ประวัติวงศ์ ศุจิรัตน์ ศรีทองเหลือง*

บทคัดย่อ: การไม่รับประทานยาตามคำสั่งการรักษามีผลกระทบด้านลบต่อผู้ป่วย ด้วยราคาที่สมเหตุสมผล หลายประเทศจึงใช้บริการส่งข้อความสั้นเพื่อลดอัตราการไม่รับประทานยาตามคำสั่ง ในประเทศไทย พบว่าการวิจัยที่ใช้บริการส่งข้อความสั้นเพื่อเตือนการรับประทานยามีไม่เพียงพอ การทดลองแบบสุ่ม โดยเก็บข้อมูลจากหลายแหล่งนี้เป็นการวิจัยแบบสุ่มเข้ากลุ่มทดลองและควบคุม มีวัตถุประสงค์เพื่อศึกษาผลของการส่งข้อความสั้นเตือนแบบสองทางผ่านมือถือต่อการติดตามการรับประทานยาและคุณภาพชีวิตของผู้ใหญ่ที่เป็นเบาหวานชนิดที่สอง เก็บข้อมูลจากผู้ร่วมการวิจัยที่เป็นเบาหวานชนิดที่สอง จำนวน 63 ราย (กลุ่มทดลอง 33 คน และกลุ่มควบคุม 30 คน) กลุ่มตัวอย่างประกอบด้วยผู้ใหญ่ไทยที่มีอายุมากกว่าหรือเท่ากับ 18 ปี ที่ได้รับการวินิจฉัยว่าเป็นเบาหวาน อาศัยในจังหวัดแห่งหนึ่งในภาคตะวันออกเฉียงเหนือของประเทศไทย กลุ่มควบคุมได้รับการดูแลตามมาตรฐานของโรงพยาบาล และกลุ่มทดลองได้รับบริการส่งข้อความสั้นเตือนแบบสองทางผ่านมือถือเพิ่มเติม เป็นเวลา 4 เดือน เครื่องมือที่ใช้ในการวิจัยประกอบด้วย ข้อความสั้นเตือนแบบสองทางผ่านมือถือ การติดตามการรับประทานยาวัดโดยใช้ระดับน้ำตาลสะสมในเลือด คุณภาพชีวิตวัดโดยใช้แบบสอบถามคุณภาพชีวิตภาษาไทยซึ่งพัฒนาโดยองค์การอนามัยโลก และใช้แบบสอบถาม Diabetes-39 วิเคราะห์ข้อมูลโดยใช้สถิติบรรยาย เปรียบเทียบค่าเฉลี่ยระดับน้ำตาลสะสมในเลือด และคะแนนเฉลี่ยคุณภาพชีวิต ทั้ง 3 ช่วงเวลา (0 เดือน, 2 เดือน และ 4 เดือน) โดยใช้ One-way repeated measures ANOVA ผลการวิจัยพบว่า เมื่อสิ้นสุดการศึกษา กลุ่มทดลองมีการรับประทานยาที่วัดด้วยระดับน้ำตาลสะสมในเลือดดีกว่ากลุ่มควบคุมอย่างมีนัยสำคัญทางสถิติ นอกจากนี้ยังพบว่ากลุ่มตัวอย่างในกลุ่มทดลองมีคุณภาพชีวิตที่ดีกว่ากลุ่มควบคุมอย่างมีนัยสำคัญทางสถิติ ผลการวิจัยนี้แสดงให้เห็นว่าการส่งข้อความเตือนแบบสองทางช่วยพัฒนาผลลัพธ์ของผู้ป่วยได้ อย่างไรก็ตามจากการพลิกโฉมอย่างรวดเร็วของเทคโนโลยี พยาบาลสามารถใช้เทคโนโลยีผ่านโทรศัพท์มือถือ เช่น การส่งข้อความสั้นเตือนแบบสองทางมาปรับให้เหมาะสมกับวิถีชีวิตประจำวันของผู้ป่วย ข้อเสนอแนะสำหรับการวิจัยในอนาคต ควรศึกษาเปรียบเทียบความคุ้มค่าและผลลัพธ์ของผู้ป่วยจากการนำเทคโนโลยีผ่านโทรศัพท์มือถือที่แตกต่างกันมาใช้

Pacific Rim Int J Nurs Res 2023; 27(3) 457-471

คำสำคัญ: โรคเบาหวาน การติดตามการรับประทานยา ระบบติดตามดูแลสุขภาพผ่านอุปกรณ์สื่อสารเคลื่อนที่ คุณภาพชีวิต การทดลองแบบสุ่ม บริการส่งข้อความเตือนแบบสั้น

จันทร์ทิรา เจียรณัย *รองศาสตราจารย์ สำนักวิชาพยาบาลศาสตร์ SFHEA-UKPSF มหาวิทยาลัยเทคโนโลยีสุรนารี ประเทศไทย E-mail: chantira@sut.ac.th*
ติดต่อที่ : ศรัญญา จุฬารี *ผู้ช่วยศาสตราจารย์ สำนักวิชาพยาบาลศาสตร์ SFHEA-UKPSF มหาวิทยาลัยเทคโนโลยีสุรนารี ประเทศไทย E-mail: saranya.c@sut.ac.th*
วาริธร ประวัติวงศ์ *อาจารย์ สำนักวิชาพยาบาลศาสตร์ มหาวิทยาลัยเทคโนโลยีสุรนารี ประเทศไทย E-mail: waritorn@sut.ac.th*
ศุจิรัตน์ ศรีทองเหลือง *อาจารย์ สำนักวิชาพยาบาลศาสตร์ AFHEA-UKPSF มหาวิทยาลัยเทคโนโลยีสุรนารี ประเทศไทย E-mail: sujirat@sut.ac.th*