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Effect of text messages to improve health literacy on medication adherence in patients with type 2 diabetes mellitus: A randomized controlled pilot trial

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ABSTRACT

It has been suggested that low health literacy (HL) is associated with poor medication adherence. This study aimed to examine the effect of a text message-based HL intervention to promote medication adherence, compared with text messages that only sent medication reminders, in patients with type 2 diabetes. This was a single-center, open-label, randomized (1:1) controlled pilot study. The study period was 6 months. Intervention group was sent HL related text messages, compared to the reminder messages that were sent to the control group. The primary outcome was the difference in the change rate of scores on the Morisky Eight-Item Medication Adherence Scale (MMAS-8). Forty-one participants were randomized into the intervention (n = 21) and control (n = 20) groups and completed the 6-month follow-up. Although almost participants read and understood the information provided in the messages, no significant difference was observed between groups for the primary outcome (p = 0.78). Our results suggested that medication adherence at 6 months after discharge in patients with type 2 diabetes did not significantly change by text messages, which aimed to improve their HL levels.

Keywords: medication adherence, health literacy, diabetes, text message

INTRODUCTION

In 2003, the World Health Organization suggested that increasing the effectiveness of interventions on medication adherence would favorably affect patient health, because only approximately 50% of patients with chronic diseases requiring long-term treatment take medication.[1)] Overall, 60% of patients with diabetes forget to take their medication in Japan.[2)] Low health literacy (HL) of patient-related factor is considered important to improve medication adherence, because it reflects patients' understanding of treatment and treatment strategies and patients' ability to

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make decisions.[1,3,4] Recent studies have shown that text messaging is one of the most accessible, feasible, and effective mobile phone-based technology for delivering health interventions, such as diabetes education.[5] Although direct intervention studies have examined the effect of improved HL on the promotion of medication adherence in patients with diabetes,[6] only a few intervention studies have been designed to examine the implementation and cost-effectiveness of interventions among diabetes patients.[7] Therefore, this study aimed to examine the effect of a text message-based HL intervention to promote medication adherence, compared to text message reminders only, in patients with type 2 diabetes.

MATERIALS AND METHODS

Design, sample, and setting

This was a single-center, open-label, randomized controlled study conducted at the 600-bed University Hospital in Yamanashi. This study population was hospitalized strictly for diabetes management education for at least two weeks. Patients were recruited from April 1, 2013, to March 31, 2014. Participants were randomly allocated (1:1) to the study groups by using the minimization method with respect to age and gender distributions. Follow-ups were done for 6 months after initial measurements were conducted. Eligibility criteria of participants were as follows: able to understand the questionnaire in Japanese, 18 years of age and more, diagnosed with type 2 diabetes, which is HbA1c 6.5% and more before measuring outcomes at baseline, receiving oral or injectable medication, in the possession of a mobile phone to receive text messages, and no symptoms of depression (assessed using the Quick Inventory of Depressive Symptomatology (QIDS-J) and a physician's diagnosis).[8] An exclusion criterion was not agreeing to participate in this study. This study was approved by the Ethics Review Board of the University of Yamanashi School of Medicine (Number: 1038), and registered in the University Hospital Medical Information Network-Clinical Trials Registry (ID: UMIN000014747). Participants provided informed consent after an explanation of the study had been provided orally and in written form.

Intervention

HL-related text messages and the reminder message "Please do not forget to take your medication" were simultaneously sent to participants in the intervention group. Only the reminder message was sent to the control group as an ethical consideration. The contents of the text messages were created by medical professionals, including physicians and a clinical psychotherapist, on the basis of the HL scales developed by Ishikawa *et al.*[9] For the intervention group, additional text messages were created that corresponded to the scales measuring three subcategories of HL—functional HL, communicative HL, and critical HL.[9,10] Books about diabetes and information and instructions on educational resources, such as websites, were provided to participants in the functional HL subcategory. One example of a text message is "Have you looked up information on diabetes by yourself? Please recheck the brochures on diabetes that you already have. There may be some new information." Information related to diabetes was supplied to participants in the communicative HL subcategory, and their learning behaviors and understanding were reinforced. An example of a text message is "Did you use the pharmaceutical products guide for patients? Please tell a pharmacist what you were able to understand. If the contents you talked about are correct, it means that you were able to understand the information." Participants in the critical HL subcategories were advised to review the educational materials they had received thus far, and were given a feedback channel: "It may be difficult to decide your treatment by yourself, but it's very important to manage the diabetes in your life. Therefore, we healthcare providers

support your treatment. Please talk to us anytime." Table 1 shows examples of sending text messages. Text messages were sent on Mondays and Thursdays at approximately noon for 6 months (total 48 text messages) after discharge. We created the contents of the text message to promote their behavior modification after receiving text messaging.[11-14] Participants were not able to reply to the text messages. A third-party messaging service (S.I.T. Corporation, Tokyo, Japan) was used to send the text messages.

Table 1 Examples of the contents of text messages for intervention

Titles	The contents of text messages
Treatment of diabetes_1	What kind of information source do you usually collect knowledge and information of the treatment of diabetes from? Including how to collect, I request you will reconsider once again?
Treatment of diabetes_2	It is placed clearly in the homepage of Ministry of Health, Labour and Welfare called the diabetes HP. Let's check it once.
Treatment of diabetes_3	Did you check up on the diabetes HP? It is listed about the basic information about diet, exercise, drug therapy. Please sort well it from basic information.
Worried about your medicine_1	Can you understand knowledge and information about your medicine which you usually collected? Please assess it closely by yourself in various ways.
Worried about your medicine_2	About your medicine, you can search it in the pharmaceutical products guides for patients. As well as an effect of your medicine, it is listed what you should confirm before use or that you are careful during use.
Worried about your medicine_3	Did you use the pharmaceutical products guide for patients? Please tell a pharmacist what you were able to understand once. If the contents you talked about are right, it means that you were able to understand.
To decide by yourself_1	I suppose that your blood sugar control does not go well very much recently. The doctor said that you needed to add new medicine. By the way, what will you think about then?
To decide by yourself_2	At first, it may be important that you look back about your conventional treatment. The basics of the diabetes treatment are diet and exercise. How was your lifestyle of diet and exercise? In addition, how about your medicine? Did you use appropriate medicine at appropriate time?
To decide by yourself_3	I suppose you that you can go together about a diet, exercise, medicine well. What will you think about if your medicine were changed or added from now on? Then, what kind of action will you take?
To decide by yourself_4	It is important to understand well about effect and cautions of your new or added medicine. You are able to utilize pharmaceutical products guide for patients. In utilizing these tools, you need to serve an answer at your life for yourself whether it is available.
To decide by yourself_5	It may be difficult to decide your treatment by yourself, but it's very important to go on with diabetes in your life. Therefore, we healthcare providers support your treatment. Please talk to us anytime.

Outcome measurements

The primary outcome was the difference in the change rate of scores on the Morisky Eight-Item Medication Adherence Scale (MMAS-8), which measured medication adherence, at 6 months after discharge. MMAS-8 is relatively simple and practical to use in clinical settings and can also be used to monitor adherence over the course of the treatment.[15] The original version of the MMAS-8 was developed by Morisky *et al.* and was translated into Japanese according to international guidelines.[16,17] Adherence was categorized as low (score, < 6), medium (score, 6 to < 8), and high (score, 8), according to MMAS-8 (0–8 points). The secondary outcomes were the difference in the change rate of each HL score, self-efficacy score, and HbA1c levels 6 months from initial measurement. HL was measured using scales developed by Ishikawa *et al.*[9] This scale can be used initially to identify patients with inadequate HL and can also be used to monitor the present situation, to plan the intervention, and to assess those effects.[9] These separately measure functional HL (five items), communicative HL (five items), and critical HL (four items). Each item was rated on a four-point scale, and a total HL score including all 14 items was used. Self-efficacy was measured using the Self-Efficacy Scale for Diabetes Self-care (SESD), which was developed by Akao *et al.*[18] These measures were administered at discharge which was baseline, and 1, 3, and 6 months later. Baseline measurements were collected at discharge not to reflect the educational effect during hospitalization.

Questionnaires about engagement checks and satisfaction

To ensure that participants receiving the text messages read, understood, and implemented the information provided, the questionnaire about engagement checks, which was three items, was used. One example of an item is "Did you read the receiving text messages?" The items of the questionnaire were measured on a four-point Likert scale (Never/Rarely, Once in a While, Often, Always). The questionnaire about engagement checks and satisfaction was sent to participants' home after the study period was completed.

Statistical analysis

As no previous randomized control trial (RCT) had been conducted using the MMAS-8, the sample size was determined by referencing a previous study.[11] The sample size required to perform a *t*-test between two independent groups with a power of 80%, at a two-sided significance level of 0.05, a mean difference effect size of 0.5, and a standard deviation of 1.5 was calculated to be 286. The pre-specified feasible sample size was 100 (50 per group), in consideration of the patient population that was hospitalized for diabetes management education over the duration of one year. The statistical approach used for comparison between groups was an intention-to-treat analysis. Participants were included in the analysis if their outcomes were collected more than once after discharge. Regarding participant demographics, the primary and secondary outcomes, an unpaired *t*-test or Welch's *t*-test was used for mean difference analysis, and a χ^2 test or Fisher's exact test was used to test independence. Missing values were managed using the last-observation-carried-forward method. All tests were two-sided; significance was set at 5%. R version 3.1.1 (The R Foundation for Statistical Computing, Vienna, Austria) was used.

RESULTS

Participants and baseline demographics

Forty-one patients were randomized into the intervention and control groups (21 and 20 participants, respectively, Fig. 1). Table 2 shows the characteristics of the participants at baseline.

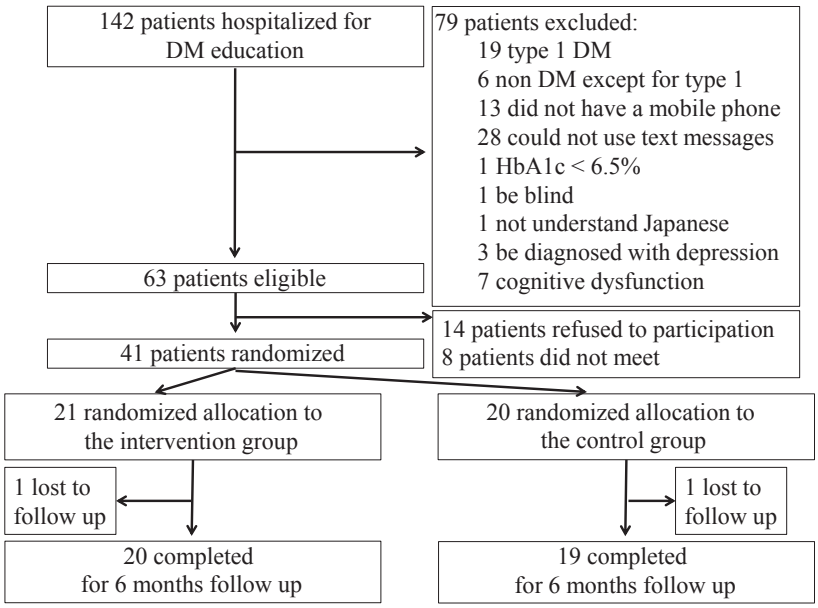

Fig. 1 Study flow
Abbreviations: DM, diabetes mellitus; HbA1c, glycosylated hemoglobin A1c.

Table 2 Main baseline characteristics[a)]

	Intervention (n = 21)	Control (n = 20)	*p*
Age (years)	55.6 (10.6)	56.3 (10.0)	0.82
Male	15 (71)	14 (70)	1.00
MMAS–8 (score)	6.10 (1.10)	5.69 (1.69)	0.36
HL (score)			
Functional HL	2.96 (0.68)	3.00 (0.75)	0.87
Communicative HL	3.10 (0.54)	3.36 (0.51)	0.12
Critical HL	2.58 (0.37)	2.71 (0.49)	0.34
Total HL	2.90 (0.32)	3.05 (0.45)	0.24
SESD (score)	23.2 (3.7)	22.4 (5.8)	0.61
HbA1c (%)	9.6 (2.4)	9.5 (2.0)	0.92
Duration of hospitalization (days)	27.8 (18.4)	16.4 (4.5)	0.01
Insulin injection, yes	10 (48)	10 (50)	1.00
OHA, yes			
Biguanaide	6 (29)	6 (30)	1.00
Sulfonylurea	1 (5)	2 (10)	0.61
Nateglinide	0 –	3 (15)	0.11
Alpha-glucosidase inhibitor	4 (19)	2 (10)	0.66
Thiazolidine	1 (5)	1 (5)	1.00
DPP4 inhibitor	13 (62)	13 (65)	1.00

Abbreviations: MMAS-8, morisky medication adherence scale 8–items; HL, health literacy; SESD, self–efficacy scale for diabetes self care; HbA1c, glycosylated hemoglobin A1c; DM, diabetes mellitus; OHA, oral hypoglycemic agent; DPP4, dipeptidyl peptidase 4.
[a)] All variables are presented as n (%) or mean (SD).

Outcomes

Mean change rates of the MMAS-8 scores between baseline and 6 months were 11.8% and 14.2% in the intervention and control groups, respectively (Table 3). No significant difference was observed between groups for the primary outcome (p = 0.78). Table 3 shows the difference in change rates as the secondary outcomes. No significant difference between groups was observed for the secondary outcomes. No adverse events were observed in other participants.

Table 3 The mean difference of the change rate for primary outcome and secondary outcomes[a)]

		Measured values, mean (SD)		Change rate from baseline to 6 months (%), mean (SD)	ΔIG – ΔCG[b)]	p
		Baseline	6 months			
MMAS-8 (score)	Intervention	6.15 (1.10)	6.66 (1.37)	11.8 (29.9)	–2.4	0.78
	Control	5.86 (1.55)	6.26 (1.28)	14.2 (39.0)		
Functional HL	Intervention	2.96 (0.70)	3.12 (0.77)	15.0 (68.7)	–0.5	0.98
(score)	Control	2.99 (0.77)	3.27 (0.48)	15.5 (29.7)		
Communicative	Intervention	3.15 (0.49)	2.84 (0.52)	– 8.5 (24.4)	–6.5	0.32
HL (score)	Control	3.36 (0.52)	3.25 (0.53)	– 2.1 (14.3)		
Critical HL	Intervention	2.60 (0.37)	2.50 (0.71)	– 2.2 (30.8)	–1.7	0.85
(score)	Control	2.67 (0.46)	2.61 (0.59)	– 0.4 (25.2)		
Total HL (score)	Intervention	2.93 (0.31)	2.84 (0.58)	– 2.1 (21.1)	–4.8	0.39
	Control	3.03 (0.46)	3.08 (0.36)	2.7 (12.6)		
SESD (score)	Intervention	23.4 (3.7)	23.1 (3.5)	– 0.6 (10.8)	–10.7	0.20
	Control	22.8 (5.6)	23.7 (3.8)	10.1 (33.4)		
HbA1c (%)	Intervention	9.4 (2.2)	6.6 (0.9)	– 26.9 (15.4)	–6.9	0.29
	Control	9.4 (2.0)	7.3 (2.2)	– 20.1 (23.7)		

Abbreviations: IG, intervention group; CG, control group; MMAS–8, morisky medication adherence scale 8–items; HL, health literacy; SESD, self–efficacy scale for diabetes self care; A1C, glycosylated hemoglobin.

[a)] 20 in the intervention group and 19 in the control group were included in the analysis.

[b)] The mean difference of the change rate from baseline to 6 months between intervention and control groups.

Questionnaires about engagement checks and satisfaction

Participants who replied "always" to reading the message and to understanding the contents of the messages were 88% and 97%, respectively. However, the implementation rate was 48% (data not shown). Participants who were satisfied with the contents of the messages were 75%, and preferred to receive them once or twice per week tentatively during noon (data not shown).

DISCUSSION

Although no significant difference was observed in the change rates of the MMAS-8 scores at 6 months, both groups showed a trend toward maintenance of diabetes. Furthermore, functional

HL scores were likely to increase, but no other HL scores showed a tendency to increase and stayed at near-constant levels. This result suggests that sending text messages had a maintenance effect on medication adherence, and at least prevented reductions in MMAS-8 scores for 6 months, in both groups. Somewhat consistent with our findings, previous studies have reported that medication adherence significantly improves or is likely to be improved via text messages.[11,12] On the other hand, studies that have tested message-based interventions have shown a significant difference between intervention and control groups as a result of decrease in adherence scores, which contradicts our findings.[11,12] This might be because control groups of previous studies provided only usual care without sending text messages. Possible explanations as to why there was no intervention effect on medication adherence include that the time spent on implementing according to the instructions in text messages might not have been enough to increase HL. In previous studies, functional HL scores improved by holding three-hour individual meetings four times over a period of 3 months.[19] The effect of this intervention may be shown by evaluating the process of receiving messages and the definiteness of the delivery of the intervention.[20] The primary limitation of this study was that neither participants nor researchers were blinded, which might have led to measurement bias in terms of outcomes. Second, the number of participants was less than the pre-specified feasible sample size. Because this was the first longitudinal study of diabetes patients assessed by MMAS-8, it was difficult to determine the actual effect size to be detected. A recent study reported that their sample sizes were calculated and conducted with at least 38 patients with cardiovascular disease.[21] Thus, the probability of type II error might be small. Third, these participants may not be representative of the general population. Since they were admitted to a relatively large and highly specialized University Hospital for educational purposes, characteristics of the participants may have been different from those admitted to community hospitals. Furthermore, not all patients hospitalized with diabetes were included in this study. Thus, the present participants may have had higher treatment motivation than other patients who refused participation. Finally, frequent administration of the questionnaire itself may have increased MMAS-8 scores. The MMAS-8 was originally designed to promote awareness of barriers to and behaviors affecting medication adherence.[15] Administering the questionnaire frequently over a short period may have resulted in higher scores on medication adherence in both groups because of practice effects. The primary strength of this study was the RCT design of the self-report MMAS-8 and HL affecting treatment efficacy. No previous RCT of medication adherence has assessed the effect of text messages to improve HL regarding medication adherence nor has any considered communicative and critical HL subcategories. Second, this study used the self-report MMAS-8 and HL scales simultaneously. MMAS-8 and HL scales are easy and economical to use in clinical settings,[9,15] even if considering various methods, such as pill counts and electronic medication packaging devices.[22-24] In conclusion, we suggested that medication adherence at 6 months in patients with type 2 diabetes was not significantly changed by text messages, which aimed to improve their HL levels, although this study was a kind of preliminary study. In clinical practice, sending text message reminders by mobile phone might assist individual diabetes patients in improving adherence with medication, as the study results revealed that it was beneficial for participants to receive the text messages. However, our findings suggest that this intervention might have inherent limitations in improving medication adherence. Thus, establishment of two-way communication channels that consider cost-effectiveness and social implementation, including confirmation of the process of behavioral modification via text messages, might be necessary to improve HL and medication adherence in patients with diabetes.

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CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest.

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