JDI Journal of Diabetes Investigation Open access
Official Journal of the Asian Association for the Study of Diabetes
ORIGINAL ARTICLE

Previous dropout from diabetic care as a predictor of patients' willingness to use mobile applications for self-management: A cross-sectional study

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Keywords
Diabetes mellitus, mHealth, Self-management

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J Diabetes Investig 2017; 8: 542–549

doi: 10.1111/jdi.12613

ABSTRACT

Aims/Introduction: Preventing dropout is crucial in managing diabetes. Accordingly, we investigated whether patients who had dropped out of diabetic care are suitable candidates for the use of mobile technologies – such as smartphone applications – to support self-management (mHealth), which might help prevent dropout.

Materials and Methods: We carried out a cross-sectional study in Tokyo, Japan. Patients aged 20 years or older who were clinically diagnosed as diabetic and who regularly visited the outpatient unit at the University of Tokyo Hospital were recruited between August 2014 and March 2015. Data were collected through face-to-face structured interviews, physical measurements and medical records. Participants were asked whether they were willing to use mHealth after being shown DialBetics – an mHealth application for diabetics – as an example, and about their history of dropout and previous mHealth experience. Data were analyzed by multivariate logistic regression models.

Results: Of 307 patients with type 1 and type 2 diabetes, 34 (11.1%) had previously dropped out from diabetic care. Multivariate analysis identified previous mHealth experience as a negative predictor of dropout (odds ratio 0.211, $P = 0.023$). Of those 34 patients, 27 (79.4%) expressed willingness to use mHealth, a significantly higher percentage than for those who had never dropped out (51.5%, $P = 0.002$). After adjusting for confounders, history of dropout remained a strong predictor of willingness (odds ratio 3.870, $P = 0.004$).

Conclusions: Patients who previously dropped out of diabetic care *are* suitable candidates for mHealth. Future studies must evaluate whether mHealth is effective for preventing repeated dropout and improving glycemic control among this population.

INTRODUCTION

Diabetes is a chronic condition requiring life-long management. Poor glycemic control leads to increased risk of complications including cardiovascular and cerebrovascular diseases, nephropathy, retinopathy, and neuropathy[1,2]. To prevent progression of such complications, patients must adhere to dietary/exercise regimens and medication[3]. Non-adherence results in greater morbidity[4] and higher all-cause mortality[5]. Specifically, dropping out from regular medical care is likely to result in uncontrolled glycemic status and a higher risk of complications[4,6].

Dropout rates of diabetes patients are quite high, reportedly ranging from 4% to 19% in Britain[4,6], and from 12% to 50% in the USA[7,8]. In Japan, a national survey estimated the dropout rate as 13.5% (2012 national health and nutrition survey), whereas other studies reported even higher rates of from 35% to 56.9%[9,10]. Furthermore, patients who previously dropped out

Received 8 September 2016; revised 24 November 2016; accepted 20 December 2016

are known to have a threefold higher risk of repeated dropout than those who never dropped out[11].

Clearly, preventing dropout is crucial in managing diabetes, and several studies have analyzed the predictors of dropout and reasons for dropout[5,7,8,12–17]. Reported predictors included young age, being employed, not taking medication, poor glycemic control, having high blood pressure and smoking[5,7,8,12–14]. The common reasons for dropout include conflicts with work, low perceived concern for the disease, lack of perceived necessity and financial issues[8,15].

Because diabetes does demand life-long medical care and self-management, it is difficult to *keep* patients motivated. Mobile technologies might help patients counter the common reasons for dropping out. Recently, mobile technologies, such as smartphone applications (mHealth), have been shown to be effective in supporting the self-management of diabetes patients[18]. We developed DialBetics, a smartphone-based self-management support system that provides real-time advice on diet and lifestyle based on the patients' measurements and input[19]. The system significantly improved hemoglobin A1c (HbA1c) in type 2 diabetes patients[19]. Other studies of mHealth technologies have also shown significant improvement of end-points including HbA1c and medication adherence[18,20].

Although these mHealth technologies evidently make self-management easier, patients' willingness to use such technologies is obviously crucial. The purpose of the present study was to investigate whether patients who have previously dropped out of diabetes care are suitable candidates for the use of mHealth.

MATERIALS AND METHODS

Study design and participants

Between August 2014 and March 2015, diabetes patients who visited the outpatient unit at the University of Tokyo Hospital, Tokyo, Japan, were recruited for the study either by their physicians or through wall posters. Eligibility criteria were being aged 20 years or older, being clinically diagnosed as having diabetes and regularly visiting the outpatient unit of the University of Tokyo Hospital. Exclusion criteria were being on dialysis, inability to communicate in Japanese, inability to participate physically/cognitively or having a condition their physicians judged too severe (e.g., patients who might have found a 1-h interview burdensome). Each patient was diagnosed with diabetes at the time of the diagnosis according to the latest Japan Diabetes Society Guideline. Typically, diagnosis for diabetes according to the Japan Diabetes Society Guideline in 2014[21] is made when: (i) HbA1c level is ≥6.5%; and (ii) fasting plasma glucose level is ≥126 mg/dL or 2-h value in an oral glucose tolerance test is ≥200 mg/dL or casual plasma glucose level is ≥200 mg/dL. No criteria were set for HbA1c levels at the time of recruitment or for diabetes duration. The study was approved by the institutional review board of the University of Tokyo and was carried out in accordance with the Declaration of Helsinki, and all participants provided written informed consent. Of the 317 patients who agreed to participate, four were excluded because they did not meet the diagnosis criteria of diabetes, and one did not complete the interview. Five whose diabetes was classified as neither type 1 nor type 2 were also excluded. In all, 307 patients with type 1 or type 2 diabetes were analyzed.

Interview and measurements

Four nurses carried out structured face-to-face interviews and took physical measurements, with weight, height, blood pressure, waist circumference and visceral fat area measured before the interview. The participants' answers were recorded on each participant's questionnaire during the interview by the nurse who carried it out.

Bodyweight, blood pressure and visceral fat area were measured using, respectively, the HBF-206IT Weight Scale (Omron Ltd., Kyoto, Japan), HEM-7081-IT Automatic Blood Pressure Monitor (Omron), and DUALSCAN (Omron). Clinical variables including type of diabetes, HbA1c, complications of diabetes (nephropathy, retinopathy, neuropathy) and medication for diabetes were taken from patients' medical records.

Participants were then asked about their work and details of their home life, about smoking, drinking, duration of diabetes, whether they had previously dropped out of regular medical care (history of dropout), family history of diabetes, medical history (hypertension, dyslipidemia, cerebral vascular disease, ischemic heart disease), stages of change in diet/physical activity according to the transtheoretical model[22], whether they kept a daily health record, and whether they had ever used mHealth (previous mHealth experience). In addition, participants were asked whether they were willing to use mobile applications for self-management, after being shown – as an example – DialBetics[19] on a smartphone (GALAXY Note; Samsung Electronics Co. Ltd., Suwon, Korea). The function of DialBetics was introduced to them by demonstrating how graphs of bodyweight, blood pressure and blood sugar levels could be displayed. Participants were also shown how to register daily meals, type and duration of exercise, and how advice on lifestyle would be given by the system.

For history of dropout, participants were asked if they had ever discontinued care of diabetes, and if so, the reason. Dropout was defined as intentional interruption of regular visits to the doctor. Occasional medication non-adherence (e.g., forgetting to take medication sometimes) was not counted as dropout.

The transtheoretical model posits that people progress through five stages of change when trying to modify their behaviors[22]. For stages of change according to the transtheoretical model, participants were asked about their readiness to make behavioral changes in terms of diet or physical activity. They were classified as being in precontemplation (stage 1) if they did not intend to take action in the next 6 months; in contemplation (stage 2) if they intended to make a change in the next 6 months; in preparation (stage 3) if they intended to make a change during the next month; in action (stage 4) if they had made changes within the past 6 months; in maintenance (stage 5) if they had maintained the changes for longer than 6 months[22].

Statistical analysis

For categorical variables, frequencies and percentages were calculated, and the differences between the two groups were tested for statistical significance using Fisher's exact test. For continuous variables, means and standard deviations were calculated, and the differences between the two groups were tested by Student's *t*-test or the Mann–Whitney test.

The variables were analyzed using univariate logistic regression models. Those variables with an alpha significance level of 0.20 were considered candidates for explanatory variables in multivariate analyses.

Multivariate logistic regression models were built by stepwise model selection using the Akaike information criterion. A propensity score for dropout was calculated using the multivariate logistic regression model of dropout shown in Table 2 to predict the probability of dropout for each patient (range 0–1). This score represents the patient background factors affecting dropout; it was used to determine whether it was the patient background factors affecting dropout or the experience of dropout itself that was associated with willingness to use mHealth.

The multivariate analyses included 300 participants with no data missing in the variables that comprised the final models.

All the statistical analyses were carried out using EZR (Saitama Medical Center, Jichi Medical University, Saitama, Japan)[23].

RESULTS

A total of 307 participants were analyzed. Their basic characteristics are shown in Table 1. Briefly, their mean age was 66.3 ± 11.6 years (range 27–91 years), with the mean duration of diabetes 15.4 ± 10.2 years (range 0.5–47 years) and mean HbA1c level 6.9 ± 0.9%. Of the 307 participants, 34 (11.1%) had previously dropped out of diabetes care. In order to investigate the patient characteristics associated with a history of dropout, patient demographics were compared between those who had previously dropped out ("dropouts") and those who had never dropped out ('non-dropouts'; Table 1). The mean age of the 'dropouts' was 63.8 ± 12.1 years vs 66.7 ± 11.5 years for the 'non-dropouts' (P = 0.227). Based on Fisher's exact test, history of dropout was associated with longer duration of diabetes ≥10 years (P = 0.035), family history of diabetes (P = 0.041) and habitual drinking (P = 0.044).

To identify factors predicting history of dropout, logistic regression analyses were carried out. Univariate logistic models showed that the positive predictors of dropout were duration of diabetes ≥10 years (odds ratio [OR] 2.630, P = 0.039), family history of diabetes (OR 2.430, P = 0.035), nephropathy (OR 2.110, P = 0.043) and habitual drinking (OR 2.170, P = 0.038; Table 2).

Multivariate logistic regression analyses were carried out, and the final model was selected by minimizing the Akaike information criterion. The final model identified younger age, being men, duration of diabetes ≥10 years, hypertension, family history of diabetes, HbA1c ≥8.0% and habitual drinking as positive predictors of dropout, whereas previous mHealth experience was identified as a negative predictor of dropout (OR 0.211, 95% confidence interval [CI] 0.055–0.810, P = 0.023; Table 2).

The reason previous mHealth experience was a negative predictor of dropout could be that mHealth use tends to keep patients with diabetes motivated for treatment by the very fact of their daily inputting of measured data, diet and exercise habits. That led us to the thought that mHealth might raise motivation for diabetes care among patients who were at risk of dropout, which in turn prompted us to wonder whether patients with a history of dropout might be suitable candidates for mHealth. Accordingly, we investigated whether those participants with a history of dropout were willing to use mHealth. We were surprised to find that of the 34 patients with a history of dropout, 27 (79.4%) expressed willingness to use mHealth, a significantly higher percentage than for those who had never dropped out (51.5%, P = 0.002). Indeed, univariate logistic regression models showed that the odds of being willing to use mobile applications were 3.640-fold higher for patients with a history of dropout (95%CI 1.530–8.630, P = 0.003) than for those who had never dropped out (Table 3). We wondered whether it was the patient background factors affecting dropout or the experience of dropout itself that was associated with willingness to use mHealth. To separate the influence of patient background factors affecting dropout from dropout itself, the propensity score for dropout was used. It was calculated to predict the probability of dropout for each patient based on the multivariate logistic regression model of dropout described in Table 2. The propensity score for dropout was not associated with willingness in a univariate logistic regression analysis (OR 2.170, 95% CI 0.235–20.100, P = 0.494), showing that it was not the background factors affecting dropout, but the dropout itself that was associated with willingness to use mHealth.

In univariate logistic analyses, other predictors for willingness to use mHealth were younger age (OR for every 10 years increase 0.616, P < 0.001), having type 1 diabetes (OR 3.830, P = 0.039), taking insulin (OR 1.770, P = 0.036), habitual drinking (OR 1.620, P = 0.038), being employed (OR 2.670, P < 0.001), keeping daily health records (OR 1.620, P = 0.047), previous mHealth experience (OR 2.630, P = 0.004) and having no hypertension (OR for patients with hypertension 0.554, P = 0.032; Table 3). After adjusting for confounders in multivariate analysis, history of dropout was still a strong predictor of willingness, with adjusted odds being 3.870-fold (95% CI 1.540–9.760, P = 0.004) higher for patients with a history of dropout than for those who had never dropped out (Table 3).

The participants who had previously dropped out were asked the main reason for dropout. The answers included lack of perceived necessity (35.3%), being too busy because of work

Table 1 | Basic characteristics of participants according to history of dropout

	Total (n = 307)	History of dropout		
		Yes (n = 34)	No (n = 273)	
	Mean ± SD or n (%)			P-value
Age (years)	66.3 ± 11.6	63.8 ± 12.1	66.7 ± 11.5	0.227
<65	106 (34.5)	16 (47.1)	90 (33.0)	0.126
≥65	201 (65.5)	18 (52.9)	183 (67.0)	
Sex (men)	194 (63.2)	26 (76.5)	168 (61.5)	0.094
Type of DM				
Type 1	16 (5.2)	4 (11.8)	12 (4.4)	0.087
Type 2	291 (94.8)	30 (88.2)	261 (95.6)	
Medical history				
Duration of DM, years (n = 306)	15.4 ± 10.2	17.8 ± 9.9	15.1 ± 10.2	0.085
<10 years	104 (33.9)	6 (17.6)	98 (36.0)	0.035*
≥10 years	202 (65.8)	28 (82.4)	174 (64.0)	
Hypertension	231 (75.2)	29 (85.3)	202 (74.0)	0.206
Dyslipidemia	256 (83.4)	26 (76.5)	230 (84.2)	0.326
CVD	28 (9.1)	3 (8.8)	25 (9.2)	1.000
IHD	77 (25.1)	12 (35.3)	65 (23.8)	0.148
Family history of DM: yes (n = 305)	181 (59.0)	26 (76.5)	155 (57.2)	0.041*
Complications				
Nephropathy	97 (31.6)	16 (47.1)	81 (29.7)	0.0501
Retinopathy				
No	84 (27.4)	10 (29.4)	74 (27.1)	0.249
Yes	86 (28.0)	13 (38.2)	73 (26.7)	
Unknown	137 (44.6)	11 (32.4)	126 (46.2)	
Neuropathy				
No	24 (7.8)	3 (8.8)	21 (7.7)	0.438
Yes	92 (30.0)	13 (38.2)	79 (28.9)	
Unknown	191 (62.2)	18 (52.9)	173 (63.4)	
Disease status				
HbA1c (%)	6.9 ± 0.9	7.2 ± 1.4	6.9 ± 0.8	0.291
<8	273 (88.9)	27 (79.4)	246 (90.1)	0.078
≥8	34 (11.1)	7 (20.6)	27 (9.9)	
BMI (n = 305)	25.8 ± 4.7	26.4 ± 4.4	25.7 ± 4.7	0.236
<30	258 (84.0)	28 (82.4)	230 (84.9)	0.623
≥30	47 (15.3)	6 (17.6)	41 (15.1)	
SBP (mmHg)	128.0 ± 16.6	131.2 ± 18.3	127.6 ± 16.4	0.288
DBP (mmHg)	68.8 ± 10.2	71.4 ± 10.8	68.5 ± 10.1	0.147
WC, cm (n = 306)	91.7 ± 12.3	92.7 ± 11.4	91.6 ± 12.4	0.420
VFA, cm^2 (n = 304)	92.8 ± 49.5	88.1 ± 43.5	93.4 ± 50.2	0.602
DM medication	274 (89.3)	30 (88.2)	244 (89.4)	0.772
Insulin	78 (25.4)	12 (35.3)	66 (24.2)	0.208
Lifestyle				
Current smoker	46 (15.0)	4 (11.8)	42 (15.4)	0.799
Habitual drinker (n = 306)	137 (44.6)	21 (61.8)	116 (42.6)	0.044*
Employment status: employed	149 (48.5)	19 (55.9)	130 (47.6)	0.371
Household: solitary	70 (22.8)	7 (20.6)	63 (23.1)	0.832
Daily health record: yes	204 (66.5)	25 (73.5)	179 (65.6)	0.442
Previous mHealth experience: yes	52 (16.9)	3 (8.8)	49 (17.9)	0.230
SOC: diet				
Stage 1	36 (11.7)	5 (14.7)	31 (11.4)	0.572
Stage 2–5	271 (88.3)	29 (85.3)	242 (88.6)	

Table 1 (*Continued*)

	Total (*n* = 307)	History of dropout		
		Yes (*n* = 34)	No (*n* = 273)	
	Mean ± SD or *n* (%)			*P*-value
SOC: physical activity (*n* = 302)				
Stage 1	38 (12.4)	6 (18.2)	32 (11.9)	0.277
Stage 2–5	264 (86.0)	27 (81.8)	237 (88.1)	

*$P < 0.05$. BMI, body mass index; CVD, cerebral vascular disease; DBP, diastolic blood pressure; DM, diabetes mellitus; HbA1c, hemoglobin A1c; IHD, ischemic heart disease; SBP, systolic blood pressure; SOC, stage of change; VFA, visceral fat area; WC, waist circumference.

Table 2 | Univariate and multivariate logistic models of dropout

	Univariate (*n* = 307[†])		Multivariate (*n* = 300)	
	OR (95% CI)	*P*-value	OR (95% CI)	*P*-value
(Intercept)			0.067 (0.004–1.140)	0.062
Age (every 10 years)	0.814 (0.607–1.090)	0.168	0.625 (0.425–0.918)	0.017*
Sex (men vs women)	2.030 (0.887–4.650)	0.094	2.290 (0.926–5.660)	0.073
Type of DM (type 1 vs type 2)	2.900 (0.880–9.560)	0.080	–	
Duration of DM (≥10 vs <10 years)	2.630 (1.050–6.570)	0.039*	3.370 (1.180–9.650)	0.023*
Hypertension (yes vs no)	2.040 (0.760–5.470)	0.157	2.360 (0.809–6.880)	0.116
Dyslipidemia (yes vs no)	0.608 (0.258–1.430)	0.254		
CVD (yes vs no)	0.960 (0.274–3.370)	0.949		
IHD (yes vs no)	1.750 (0.819–3.720)	0.149	–	
Family history of DM (yes vs no)	2.430 (1.060–5.570)	0.035*	1.960 (0.818–4.680)	0.131
Nephropathy (yes vs no)	2.110 (1.020–4.340)	0.043*	–	
HbA1c (≥8 vs <8%)	2.360 (0.940–5.940)	0.068	2.280 (0.839–6.220)	0.106
BMI (≥30 vs <30 kg/m^2)	1.200 (0.469–3.080)	0.702		
DM medication (yes vs no)	0.891 (0.293–2.710)	0.839		
Insulin (yes vs no)	1.710 (0.803–3.640)	0.164	–	
Current smoker (yes vs no)	0.733 (0.246–2.190)	0.578		
Habitual drinker (yes vs no)	2.170 (1.040–4.520)	0.038*	1.920 (0.879–4.210)	0.101
Employment (employed vs not employed)	1.390 (0.680–2.860)	0.365		
Household (family vs solitary)	1.160 (0.481–2.780)	0.744		
Daily health records (yes vs no)	1.460 (0.654–3.250)	0.356		
Previous mHealth experience (yes vs no)	0.442 (0.130–1.510)	0.192	0.211 (0.055–0.810)	0.023*
SOC: diet (stage 2–5 vs stage 1)	0.743 (0.268–2.060)	0.568		
SOC: physical activity (stage 2–5 vs stage 1)	0.608 (0.233–1.580)	0.308		

*$P < 0.05$. [†]Duration of diabetes mellitus (DM; *n* = 306), family history (*n* = 305), body mass index (BMI; *n* = 305), habitual drinker (*n* = 306) and stages of change (SOC): physical activity (*n* = 302). For all the other variables, 307 participants were analyzed. CVD, cerebral vascular disease; HbA1c, hemoglobin A1c; IHD, ischemic heart disease.

(26.5%), relocation (11.8%), other diseases (5.9%), poor relationship with the physician (5.9%) and no appointments received (2.9%).

DISCUSSION

To the best of our knowledge, this was the first study to investigate whether patients who have previously dropped out of diabetes care might be suitable candidates to use mHealth to support self-management. Dropout rates of diabetes patients are undesirably high[4,6–10], and preventing dropout is crucial because it is likely to result in poor glycemic control and higher risk of complications[4,6]. Furthermore, previous reports suggest that patients with a history of dropout have a higher risk of dropping out again[11,15]. Recent studies have shown that mHealth technologies are effective in improving glycemic control and medication adherence in diabetes patients[18–20], raising expectations that mHealth might be effective in preventing repeated dropout and improving glycemic control in patients with a history of dropout. However, it had not been determined whether patients who have previously dropped out could

Table 3 | Univariate and multivariate logistic regression models of willingness to use mobile application

	Univariate (*n* = 306†)		Multivariate (*n* = 300)	
	OR (95% CI)	*P*-value	OR (95% CI)	*P*-value
(Intercept)			2.970 (0.428–20.600)	0.270
History of dropout (yes vs no)	3.640 (1.530–8.630)	0.003**	3.870 (1.540–9.760)	0.004**
Propensity score for dropout	2.170 (0.235–20.10)	0.494		
Age (every 10 years)	0.616 (0.493–0.768)	<0.001***	0.788 (0.602–1.030)	0.082
Sex (men vs women)	1.130 (0.707–1.800)	0.613		
Type of DM (type 1 vs type 2)	3.830 (1.070–13.700)	0.039*	–	
Duration of DM (≥10 vs <10 years)	0.886 (0.550–1.430)	0.618		
Hypertension (yes vs no)	0.554 (0.323–0.952)	0.032*	0.518 (0.274–0.976)	0.042*
Dyslipidemia (yes vs no)	0.668 (0.360–1.240)	0.201		
CVD (yes vs no)	0.506 (0.229–1.120)	0.093	–	
IHD (yes vs no)	1.110 (0.661–1.880)	0.686		
Family history of DM (yes vs no)	1.230 (0.774–1.940)	0.385		
Nephropathy (yes vs no)	0.945 (0.583–1.530)	0.817		
HbA1c (≥8 vs <8%)	1.060 (0.518–2.180)	0.871		
BMI (≥30 vs <30 kg/m^2)	1.750 (0.913–3.360)	0.092	1.760 (0.846–3.680)	0.130
DM medication (yes vs no)	0.758 (0.363–1. 590)	0.462		
Insulin (yes vs no)	1.770 (1.040–3.030)	0.036*	1.610 (0.866–3.000)	0.132
Current smoker (yes vs no)	0.989 (0.527–1.860)	0.973		
Habitual drinker (yes vs no)	1.620 (1.030–2.570)	0.038*	–	
Employment (employed vs not employed)	2.670 (1.680–4.260)	<0.001***	2.170 (1.260–3.740)	0.005**
Household (family vs solitary)	0.775 (0.450–1.340)	0.359		
Daily health records (yes vs no)	1.620 (1.010–2.620)	0.047*	1.810 (1.020–3.210)	0.043*
Previous mHealth experience (yes vs no)	2.630 (1.360–5.090)	0.004**	1.810 (0.861–3.810)	0.117
SOC: diet (stage 2–5 vs stage 1)	1.800 (0.891–3.650)	0.101	–	
SOC: physical activity (stage 2–5 vs stage 1)	1.540 (0.778–3.060)	0.215		

*P < 0.05, **P < 0.01, ***P < 0.001. †Duration of diabetes mellitus (DM; n = 305), family history (n = 304), body mass index (BMI; n = 304), habitual drinker (n = 305) and stages of change (SOC): physical activity (n = 301). For all the other variables, 306 participants were analyzed. CVD, cerebral vascular disease; HbA1c, hemoglobin A1c; IHD, ischemic heart disease.

be suitable candidates for mHealth, as patients' willingness to engage in mHealth would be crucial.

Because we first had to ascertain what patient backgrounds were most associated with dropout, we identified the predictors of dropout. Multivariate analyses showed that younger age, being men, longer duration of diabetes, hypertension, family history of diabetes, poorer glycemic control and habitual drinking were all identified as positive predictors of dropout, whereas previous mHealth experience was identified as a negative predictor (OR 0.211, 95% CI 0.055–0.810, P = 0.023; Table 2). Although most of the dropout predictors our analysis identified were consistent with previous reports[5,11–13,15–17], the finding that previous mHealth experience is a negative predictor of dropout was novel. As the current study was cross-sectional, a causal relationship cannot be asserted; the result that participants with previous mHealth experience were less likely to have previously dropped out might be because these participants – who were, after all, motivated enough to use mHealth for self-management – had generally good adherence. Alternatively, mHealth might have had effects in preventing dropout in some of the patients. It could be that mHealth use keeps patients with diabetes motivated to continue treatment simply because it requires the daily input of measured data, diet and exercise habits. That continuous involvement in self-management might keep them from dropping out of care. In addition, mHealth might promote accessibility to care. In any case, the result prompted us to investigate whether patients with a history of dropout could be suitable candidates for mHealth. We therefore investigated whether these patients were willing to use mHealth.

To our surprise, patients who had previously dropped out from diabetes care were more likely to express willingness to use mHealth than those who had never dropped out (79.4% vs 51.5%, P = 0.002). Even after adjusting for confounders in multivariate analysis, the odds of being willing to use mHealth were 3.870-fold higher for patients with a history of dropout (95% CI 1.540–9.760, P = 0.004) than for those who had never dropped out (Table 3). Furthermore, patient background factors affecting dropout – represented by the propensity score for dropout – were not associated with willingness (Table 3). This led to the insight that the dropout experience itself influenced willingness. The finding that patients with a history of dropout are more likely to express willingness to use mHealth was unexpected. Given that patients were usually required to do more than just visit a clinic in order to use mHealth – they had to measure and input data, such as blood glucose, blood pressure, weight, physical activity and diet – we expected that patients who had been non-compliant and had dropped out would show less interest in mHealth than patients who had never dropped out. The present results showed the opposite. One can assume that the patients who previously dropped out have now recognized the importance of attendance, and would not drop out again if they think they can use such mHealth to support their self-management.

Previous reports had suggested that most non-compliant patients do realize that diabetes is a serious condition that could cause complications[15,24]. However, as a result of weighing the merits of continuing diabetes care (e.g., pursuit of health) and its demerits (e.g., barriers because of personal and social circumstances), it was thought that they might decide to discontinue the care[24,25]. In the present study, the main reasons for dropout were low perceived necessity (35.3%) followed by difficulties in taking time off work (26.5%) and relocation (11.8%); this was similar to previous reports[8,15]. It could be that mHealth can help overcome those barriers to continuous care by providing that care across space and time. Because conflict with work schedules had previously been reported as the most frequently given reasons for dropout[8,15] – and was the second leading reason in the current study – if clinic visits are complemented by mHealth, their frequency will be reduced.

As for the patients who cited low perceived necessity as a reason, the importance of continuous care might not have been sufficiently explained by healthcare providers or understood by the patients. So mHealth can be beneficial to these patients by providing them with information and education about diabetes. Furthermore, with mHealth, patients can take as much time as they need to attain a good understanding of general and personalized healthcare information, complementing the explanations by healthcare providers that necessarily have to be given within limited amounts of time. In addition, as mHealth is introduced to the patients by their physicians, it might help strengthen the physician–patient relationship, thereby enhancing the patient motivation that is especially necessary for continuous care by patients with mild glycemic status[24].

Because the current study included both type 1 and type 2 diabetes patients, possible differences between the groups in willingness to use mHealth must be considered, as type 1 diabetes is not a lifestyle disease, but an immune-mediated disease[3]. The results of univariate analysis showed that having type 1 diabetes is a positive predictor of that willingness; however, this finding was discarded in the final model of the multivariate analysis (Table 3). A larger study might be required to evaluate the differences between the groups, because just 16 patients (5.2%) with type 1 diabetes were included in the present study.

Some possible limitations to the present findings have to be considered. First, the questionnaire used in this study was newly developed by us; it had not previously been validated, as willingness to use mHealth has not been explored before. However, this was a scientific questionnaire, and our results showed that the questionnaire had competent validity and reliability. Second, the results necessarily reflect conditions only at the university hospital in Tokyo; and as Tokyo is the biggest city in Japan, those results might not be entirely valid for other regions because of different implementation and different degrees of literacy about information technologies. Comparisons with surveys in other regions should be explored in future studies. Third, as the study was of cross-sectional design, it cannot be determined whether the predictors are causes or consequences. Previous mHealth experience was identified as a negative predictor of dropout, although a causal relationship cannot be established. Also, the clinical effects of willingness on glycemic control could not be determined. Future study is required for measuring those effects – especially to evaluate whether long-term compliance and glucose control is improved by mHealth among the targeted population of patients who dropped out. Finally, the participants with a history of dropout in the current study represented only a subgroup of overall dropouts, because they had come back to regular diabetes care by the time the interviews took place. However, given the fact that most characteristics of the patients with a history of dropout in the current study were in accord with those of previous reports, the present findings are reliable enough to evaluate the characteristics of those patients.

In conclusion, we have shown that diabetes patients who have previously dropped out from medical care are likely to express willingness to use mHealth. Furthermore, previous mHealth experience was identified as a negative predictor of dropout. In order to retain patients in medical care and prevent progression of complications, it might be helpful to identify patients who are at high risk of dropout and provide them with mHealth tools to support long-term self-management.

ACKNOWLEDGMENTS

We thank Ms Tomomi Shibuta for her assistance with collection of the data; Dr Yoshihiko Izumida, Dr Takayoshi Sasako, Dr Masatoshi Kobayashi, Dr Ryo Suzuki and Dr Toshimasa Yamauchi for their help with recruitment of the participants; and members of the Department of Ubiquitous Health Informatics for helpful discussions. This study was funded by NTT DOCOMO, and was partly supported by JSPS KAKENHI Grant Numbers 26460858 to KW. Employees of NTT DOCOMO were not involved in any procedures of this study: design, collection or analysis of the data, or manuscript preparation.

DISCLOSURE

This study was carried out at the Department of Ubiquitous Health Informatics, which is engaged in a cooperative program between the University of Tokyo and NTT DOCOMO, the funder of the study. SY, KW and NT are members of the department.

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