A 7-Day Inpatient Diabetes Education Program Improves Quality of Life and glycemic control 12 months after discharge

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ORIGINAL ARTICLE

A 7 day inpatient diabetes education program improves quality of life and glycemic control 12 months after discharge

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Diabetes education hospitalization program, Diabetes treatment-related quality of life, Duration of diabetes

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ABSTRACT

Aims: For long-term management of diabetes, patients with type 2 diabetes mellitus require a high level of treatment adherence, which is associated with treatment satisfaction and their quality of life (QOL). To achieve it, patient education about diabetes self-management is essential. We routinely conduct a 7 day inpatient diabetes education program and administer the diabetes treatment-related (DTR)-QOL questionnaire to all participants, both before admission and at discharge. Here, we investigated whether our program improves QOL and post-discharge glycemic control.

Materials and Methods: This retrospective study utilized data from patients with type 2 diabetes mellitus who participated in our program between July 2017 and March 2020 and who had been treated in our outpatient department for more than 1 year. We evaluated the relationship between at admission and at discharge diabetes treatment-related quality of life scores and glycemic control after discharge.

Results: Data from 140 patients were analyzed in this study, which showed a significant improvement in the total, 'Anxiety and dissatisfaction with treatment', and 'Satisfaction-with-treatment' scores. A significant improvement was evident in HbA1c at 12 months after discharge. Multiple regression analysis showed that HbA1c after 12 months was independently associated with gender, duration of diabetes, and HbA1c at admission.

Conclusions: Our program effectively improves quality of life and post-discharge glycemic control in patients with type 2 diabetes mellitus. It is particularly effective in patients of the male gender, with a shorter duration of diabetes mellitus and higher HbA1c at admission.

INTRODUCTION

The number of people with diabetes is increasing worldwide. In Japan, the prevalence of type 2 diabetes mellitus remains high at about 10 million, even though the incidence of type 2 diabetes mellitus has not significantly increased in the past decade[1–3]. Diabetes treatment strategies aim to prevent characteristic sequelae and to ensure a quality of life (QOL) and life expectancy equivalent to what is seen in people without diabetes[4]. Achieving this requires adequate long-term glycemic control through a combination of diet and exercise therapy and, if necessary, drug therapy. Nonetheless, self-care is essential for successful management, and it is important to consider the patient's QOL while recommending long-term lifestyle modifications because it has been reported that the patient's QOL is related to glycemic control during treatment[5]. The diabetes therapy related QOL (DTR-QOL) questionnaire is a psychometrically validated tool that assesses the QOL of people with diabetes[6]. It has been proven to be sufficiently reliable and can assess patient QOL and treatment satisfaction with a range of therapies for diabetes.

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Inpatient diabetes education, which is part of diabetes care guidance, is one of the approaches used to improve self-care behavior. The purpose of inpatient diabetes education is to not only to strengthen treatment regimens but also to provide knowledge to patients on various aspects of the disease, including its treatment and behavior, self-management of blood glucose, and preventing the onset and progression of associated complications. Although inpatient diabetes education is effective to a certain extent[3,7–9], the target patients for whom it is most useful is unclear; hence, there are no uniform education programs. Further, as adequate treatment satisfaction and QOL of patients appear to be essential for sustainable diabetes self-management, it is possible that changes in the QOL after participation in such programs significantly improve subsequent glycemic control; however, the effect of inpatient diabetes education on QOL and long-term glycemic control has not been fully elucidated.

Thus, the purpose of this study was to investigate the efficacy of our inpatient diabetes education and to examine the relationship between glycemic control 1 year after the program, responses to the DTR-QOL questionnaire, and patient data acquired before and after participation in the program.

MATERIALS AND METHODS

Subjects

The program admitted 350 patients to the Department of Metabolism and Endocrinology, Juntendo University Hospital, between 1 July 2017 and 31 March 2020 for diabetes education. Participation in the inpatient diabetes education program was recommended to the patient when the outpatient physician deemed it necessary and was performed with informed consent. Exclusion criteria were type 1 diabetes, steroid-induced diabetes, severe liver cirrhosis, severe renal failure, and patients with cancer, dementia, or concomitant psychiatric disorders. Data from the first admission alone were included for patients hospitalized more than once during the study period. This study was granted ethical approval by the Juntendo University School of Medicine Clinical Research Review Committee (Approval No. 19-187) and was conducted in accordance with the principles outlined in the Declaration of Helsinki.

Inpatient education program

Our program at the Department of Metabolism and Endocrinology, Juntendo University Hospital, is depicted in Figure 1. It is a 7 day program during which pancreatic β-cell function and complications are assessed, treatment is accordingly adjusted, and diet and exercise therapy are provided. We performed dietary therapy based on age, target weight, usual physical activity, and food intake and also considered the feasibility of continuing the diet after discharge from the hospital. Nutritional guidance is given twice, i.e., group nutritional guidance and individual nutritional guidance. An exercise therapist provided exercise therapy three times, and physicians gave two group lectures on the prevalence, pathology, examination, complications, and treatment methods for diabetes to improve patient knowledge. Treatment methods included not only diet and exercise therapy, but also drug therapy. Furthermore, the general action and purpose of each oral or injectable drug were explained because such knowledge can help to instill a positive approach toward treatment and to promote adherence to the drug regimen. Additionally, the Conversation Maps during discussions among patients and the nurse helped to reinforce knowledge gained during the lecture[10]. The nurses also used this opportunity to check injection techniques and to teach self-care methods at home, such as foot checks. Before discharge, the pharmacists instructed patients on the precautions and treatment for hypoglycemia with the prescribed medicines. During hospitalization, patients measured their own blood glucose and were made aware of trends such as postprandial hyperglycemia.

DTR-QOL questionnaire

The DTR-QOL questionnaire is a validated diabetes-specific questionnaire developed to assess the impact of treatment on QoL[6]. The DTR-QOL questionnaire uses a 7 point Likert scale (1: strongly agree to 7: strongly disagree) and consists of 29 items divided into four domains, namely: Burden on social and daily activities; Anxiety and dissatisfaction with treatment; Hypoglycemia; and Satisfaction with treatment. The domain about 'Burden on social activities and daily activities' gleans information on the effects of diabetes on work and socializing, diet and appetite, time and effort, and pain and side effects. The 'Anxiety and dissatisfaction with treatment' domain covers the effects of treatment on weight, hyperglycemia, anxiety about complications, and psychological anxiety. The domain on 'Hypoglycemia' includes difficulties with hypoglycemia and associated psychological anxiety with it, and the 'Satisfaction with treatment' domain includes questions on satisfaction with glycemic control, confidence, and hope for the future. Scores for each of the four domains are converted to a 0–100 point scale. Here, the effects of the inpatient diabetes education program on quality of life and treatment satisfaction were assessed by comparing DTR-QOL scores obtained at admission (pre-intervention) and discharge (post-intervention).

Laboratory data

Information on laboratory investigations, the presence or absence of complications, and treatment before and after admission and at 12 months after discharge were retrieved. Laboratory tests analyzed include HbA1c on admission, fasting blood glucose, serum C-peptide, glucagon tolerance test, insulin resistance[11–13], and beta-cell function[14,15], as well as liver function, renal function, and serum lipid profile. HOMA2-IR and HOMA2-%β were calculated using fasting blood glucose and serum C-peptide data at admission by the HOMA2 Calculator (Available at: https://www.dtu.ox.ac.uk/homacalculator/download.php). The C-peptide Index (CPI) was calculated using the following formula: CPI = (fasting C-peptide/fasting plasma glucose) × 100[16].

Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Friday	Saturday	Sunday	Monday	Tuesday	Wednesday	Thursday
DTR-QOL						DTR-QOL
Medical examination Evaluation of retinopathy Evaluation of neuropathy Evaluation of atherosclerosis Evaluation of body composition	Evaluation of nephropathy Evaluation of insulin secretion capacity	Evaluation of nephropathy				Hospitalization summary
	Group lecture by medical doctors	Group lecture by videos	Group nutritional guidance by nutritional instructions	Group lecture by doctors	Individual nutritional instructions	Group lecture by nurses
			Exercise therapy	Diabetes conversation map program	Exercise therapy	Exercise therapy
Self-monitoring of blood glucose						

Figure 1 | The diabetes education hospitalization program at the Department of Diabetes and Endocrinology, Juntendo University Hospital.

The HbA1c levels were estimated every 3 months for 1 year after discharge from the hospital. An ophthalmologist diagnosed diabetic retinopathy. Diabetic nephropathy was defined as albuminuria of >30 mg/day or eGFR less than 30 mL/min/1.73 m^2. Diabetic neuropathy was determined based on the 'Simplified Diagnostic Criteria for Diabetic Polyneuropathy', provided by the Association for Diabetic Neuropathy[17].

Statistical analyses

All data are presented as mean ± SD or number (%). Pre- and post-intervention changes in each parameter were tested using the paired *t*-test or the Wilcoxon's signed rank test, as appropriate. The correlation between HbA1c at 12 months after discharge and each parameter was tested using Pearson or Spearman's correlation coefficient, as appropriate. Multiple regression analyses were performed to identify factors independently associated with HbA1c at 12 months after discharge. All statistical tests were two-sided with a significance level of 5%. IBM SPSS Statistics for Windows version 25.0 (IBM Corp., Armonk, NY, USA) was used for all data analyses.

RESULTS

Among the 350 patients admitted to the inpatient diabetes education program between 1 July 2017 and 31 March 2020, we excluded 50 patients who met the exclusion criteria, 12 patients who were admitted for multiple educational courses, and 17 patients with missing data in the DTR-QOL questionnaire. Of the remaining 271 patients, 111 were treated outside our hospital, 5 were transferred to other hospitals or clinics within 12 months after discharge, and 15 dropped out within 12 months after discharge. Finally, the data from 140 patients followed up as outpatients for more than 1 year after discharge were included for analysis (Figure 2).

The demographic characteristics of the 140 patients are shown in Tables 1 and 2. The cohort comprised 93 males and 47 females with a mean age of 61.8 ± 13.1 years. Mean values for important variables are as follows: duration of diabetes,

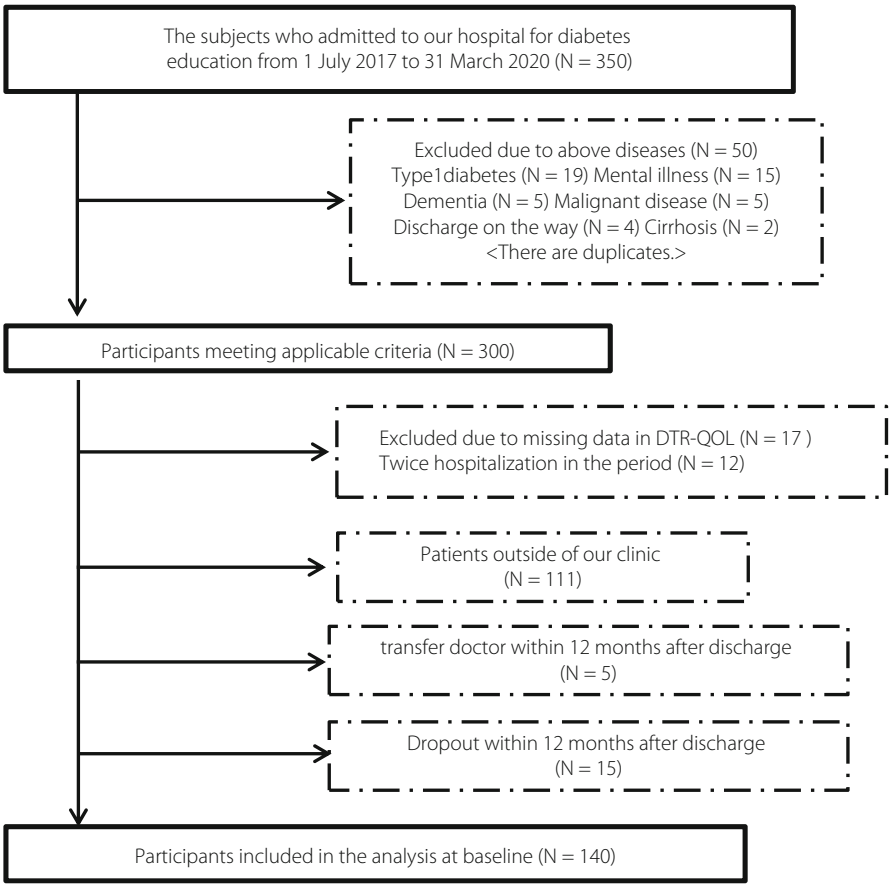

Figure 2 | Flowchart for selection of study subjects.

12.7 ± 9.6 years; HbA1c, 8.49 ± 1.53%; and body mass index (BMI) 26.4 ± 4.4 kg/m^2. The prevalence of diabetic complications was retinopathy in 25.7% (n = 36), nephropathy in 28.6% (n = 40), and neuropathy in 35.7% (n = 50) of the patients.

Biochemical data at admission and discharge are detailed in Table 2. The one-week inpatient diabetes education program significantly reduced body weight, BMI, fasting blood glucose, glycated albumin, γ-GTP, triglycerides, and HDL cholesterol.

Overall the DTR-QOL scores and those for each domain, both at admission and discharge, are shown in Table 3. The total score improved significantly from 67.42 ± 12.9 at admission to 70.39 ± 12.3 at discharge. Among the domain scores, those for 'Anxiety and dissatisfaction with treatment' and 'Satisfaction with treatment' were significantly higher at discharge than those at admission.

Table S1A,B shows the relationship between medications and the total score of DTR-QOL at admission and discharge. At admission, the total scores of DTR-QOL were significantly lower in patients with insulin or SGLT2 inhibitors than the patients without each medication, respectively. At discharge, the patients with insulin or GLP-1 receptor agonists showed lower scores than those without each medication, respectively.

The changes in HbA1c after the inpatient program are shown in Figure 3. While the mean HbA1c was 8.49 ± 1.53% at admission, it reduced to 7.14 ± 1.02% ($P < 0.001$) at 3 months after discharge and remained at this level at 6 months (7.26 ± 1.07%; $P < 0.001$), 9 months (7.31 ± 1.09%; $P < 0.001$), and 12 months (7.31 ± 1.04%; $P < 0.001$) after discharge. These trends indicate that diabetes education resulted in patients maintaining good glycemic control. Accordingly, the percentage of patients with HbA1c <7.0% increased significantly from 14.3% at admission to 50.7% at 3 months, 46.4% at 6 months, 43.6% at 9 months, and 40.0% at 12 months. The relationship between medications at discharge and HbA1c at 12 months after discharge is shown in Table S2. Patients with insulin, SGLT2 inhibitors, or GLP-1 receptor agonists at discharge had significantly higher HbA1c 12 months after discharge than those without each medication, respectively.

The correlation between HbA1c at 12 months after discharge and DTR-QOL scores at admission, discharge, and the degree of improvement in DTR-QOL scores (before vs after admission) are shown in Table 4. HbA1c at 12 months after discharge showed a significant negative correlation with scores of the domain 'Satisfaction with treatment' before admission

Table 1 | Characteristics of the study cohort at admission

Characteristic	Value
Number	140
Age, years	61.8 ± 13.1
Men	93 (66.4%)
Duration of diabetes, years	12.7 ± 9.6
Macrovascular complications of diabetes	29 (20.7%)
Diabetic microangiopathy	
Diabetic retinopathy	36 (25.7%)
Diabetic neuropathy	40 (28.6%)
Diabetic nephropathy	50 (35.7%)

Drug	At admission (%)	At discharge (%)
Sulfonylurea	27 (19.3)	11 (7.86)
Glinide	5 (3.6)	15 (10.7)
α-Glucosidase inhibitor	19 (13.6)	25 (17.9)
Biguanide	63 (45.0)	100 (71.4)
DPP-4 inhibitor	66 (47.1)	72 (51.4)
GLP-1 receptor agonist	22 (15.7)	33 (23.6)
Thiazolidinedione	12 (8.6)	14 (10.0)
SGLT-2 inhibitor	44 (31.4)	82 (58.6)
Insulin treatment	53 (37.9)	59 (42.1)

Data are shown as the mean ± SD or the number of patients (%).

Table 2 | Comparison of clinical and biochemical parameters at admission and at discharge

Item	At admission	At discharge	*P* value
Weight (kg)	70.6 ± 14.9	69.4 ± 14.6	**<0.001**
BMI (kg/m^2)	26.4 ± 4.4	25.9 ± 4.3	**<0.001**
FPG (mg/dL)	136.2 ± 35.8	113.3 ± 21.3	**<0.001**
HbA1c (%)	8.49 ± 1.53		
GA (%)	20.4 ± 5.3	19.5 ± 4.8	**<0.001**
Insulin (μU/mL)	8.43 ± 6.00	7.85 ± 5.84	0.146
C-Peptide (ng/mL)	1.81 ± 0.97	1.79 ± 1.04	0.692
CPI	1.38 ± 0.77	1.61 ± 0.92	**<0.001**
HOMA2-IR	1.69 ± 0.74	1.59 ± 0.78	**0.037**
HOMA2-%β	63.4 ± 29.6	83.5 ± 36.7	**<0.001**
AST (IU/L)	29.4 ± 17.6	27.7 ± 12.6	0.115
ALT (IU/L)	31.1 ± 19.9	31.8 ± 20.9	0.317
γGT (IU/L)	42.8 ± 36.8	38.7 ± 31.7	**<0.001**
Serum creatinine (mg/dL)	0.81 ± 0.35	0.90 ± 0.42	**<0.001**
eGFR (mL/min/1.73 m^2)	77.4 ± 26.3	70.4 ± 25.2	**<0.001**
Uric acid (mg/dL)	5.51 ± 1.51	5.76 ± 1.55	**0.002**
Total cholesterol (mg/dL)	184.9 ± 37.7	173.5 ± 36.7	**<0.001**
High-density lipoprotein cholesterol (mg/dL)	49.5 ± 11.6	45.4 ± 11.0	**<0.001**
Low-density lipoprotein cholesterol (mg/dL)	107.2 ± 30.1	104.1 ± 32.3	0.083
Triglyceride (mg/dL)	141.4 ± 128.9	118.8 ± 55.9	**0.006**
Urine albumin (mg/day)	225.8 ± 863.3		

The bold values represent statistically significant. Data are shown as mean ± SD. *P* values for paired *t* test or Wilcoxon's signed rank test. ALT, alanine aminotransferase; AST, aspartate aminotransferase; BMI, body mass index; CPI, C-peptide index; eGFR, estimated glomerular filtration rate; FPG, fasting plasma glucose; GA, glycated albumin; γGT, γ-glutamyl transpeptidase.

(P = 0.007), indicating that the higher the pre-admission satisfaction with treatment, the better are HbA1c values at 12 months after discharge. There was no significant correlation with HbA1c at 12 months and the other variables evaluated.

The correlation between HbA1c at 12 months after discharge and biochemical data at admission is shown in Table 5. Specifically, a significant correlation was found between HbA1c 12 months after discharge and the duration of diabetes, HbA1c at admission, CPI (an indicator of pancreatic beta-cell function), delta C-peptide of the glucagon stress test, urinary C-peptide, and HOMA2-%β.

Furthermore, multiple regression analysis to determine the association between the domain 'Satisfaction with treatment' on admission and HbA1c 12 months after discharge (Table 6) showed no independent association. In the final model, gender, duration of diabetes, and HbA1c on admission were independently associated with HbA1c at 12 months after discharge.

DISCUSSION

In Japan, inpatient diabetes education is sometimes provided to people as the initial treatment for type 2 diabetes mellitus. Although there have been many reports of improvement in blood glucose soon after inpatient diabetes education[18,19], few studies have evaluated the changes in quality of life and post-discharge blood glucose management after the education program. In this study, we investigated the relationship between changes in quality of life and post-discharge glycemic control, i.e., after the education program, and showed that DTR-QOL improved significantly after the program and that higher scores for the domain 'Satisfaction with treatment' at admission were associated with better HbA1c 12 months after discharge. However, we did not find an independent association between the quality of life and HbA1c 12 months after discharge.

Our results show a significant improvement in the total DTR-QOL scores between at admission and discharge. Specifically, an improvement in scores of the domain 'Anxiety and dissatisfaction with treatment' indicate that the patients correctly understood the meaning and purpose of their treatment and that they acquired a positive attitude toward treatment strategies. Additionally, improvement in blood glucose during hospitalization and simplification of regimens such as insulin withdrawal may have eliminated dissatisfaction with their management strategies. Scores for the domain 'Satisfaction with treatment' was also improved significantly, suggesting that the reduction in blood glucose during hospitalization and the ability to assess their own condition by examining and evaluating complications contributed to their improvement. The absence of improvement in scores for the 'Hypoglycemia' domain may be because patients who were previously unaware of hypoglycemia developed a fear of it based on information provided in the lecture about hypoglycemia. In terms of medication and

Table 3 | Total and individual domain scores of the diabetes treatment-related quality of life questionnaire

Domain	Admission	Discharge	*P* value
D1: Burden on social activities and daily activities	67.0 ± 20.1	66.7 ± 17.7	0.816
D2: Anxiety and dissatisfaction with treatment	55.8 ± 19.1	61.7 ± 19.6	**<0.001**
D3: Hypoglycemia	75.4 ± 24.7	75.4 ± 25.7	0.989
D4: Satisfaction with treatment	44.6 ± 18.0	58.9 ± 17.8	**<0.001**
Total score (/100 points)	67.4 ± 12.9	70.4 ± 12.3	**0.002**

The bold values represent statistically significant. Scores are shown as mean ± SD. *P* values for paired *t* test or Wilcoxon's signed rank test.

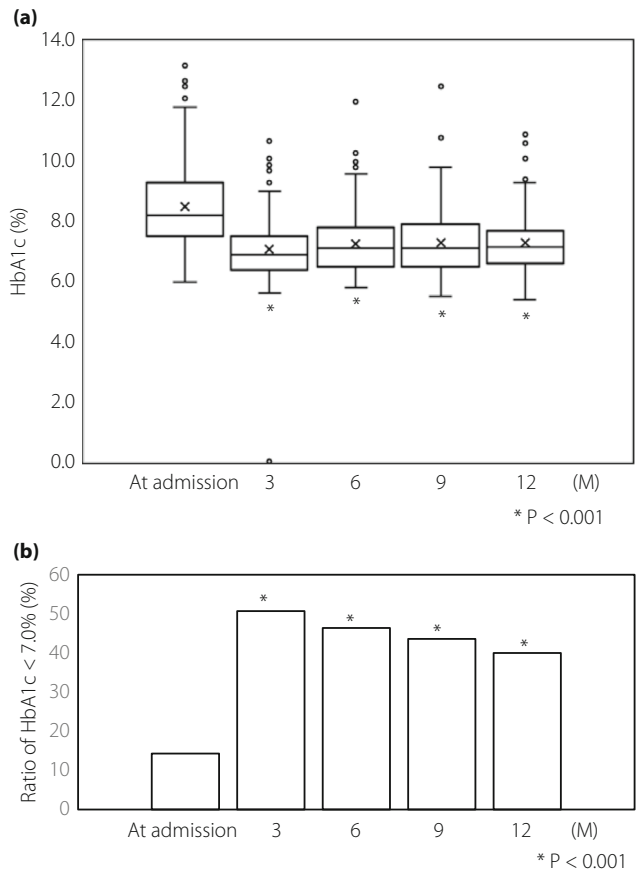

Figure 3 | (a) Trends in HbA1c after diabetes educational hospitalization and (b) achievement rate of HbA1c <7.0% during 12 months after discharge. (a) Values are presented as mean ± SD. *$P < 0.05$ for significant difference between with HbA1c at admission and the mean HbA1c from 3 to 12 months after discharge. (b) *$P < 0.05$ for significant differences between the achievement rate of HbA1c at admission with those from 3 to 12 months after discharge.

total DTR-QOL scores, patients with insulin, SGLT2 inhibitor, or GLP-1 receptor agonist scored lower than those without them, which we suppose is due to side effects such as hypoglycemia and frequent urination, as well as the inconvenience of injection. Physicians should take into consideration the results and be careful in prescribing those medicines.

In general, psychological interventions in type 2 diabetes have been shown to improve glycemic control[20]. For example, the DAWN study has shown the positive impact of well-being on factors determining the degree of self-management, and psychological treatment has been shown to have clinical benefits in improving HbA1c in adults with type 2 diabetes mellitus[21]. A good QOL has also been reported to be an independent predictor of lower mortality in people with type 2 diabetes mellitus[22], implying that interventions to improve QOL may not only directly benefit QOL but may also have other favorable effects, such as improving blood glucose, and reducing complications and mortality. Additionally, the results of DAWN2TM in Japan show that while objective indicators such as blood glucose, HbA1c, blood pressure, and weight are thoroughly tested, the psychosocial status of people with diabetes, is frequently overlooked[23]. Similarly, another study has revealed that patients and their families are indeed aware of the burden on their daily lives and that their anxiety about hypoglycemia is a major concern[24]. Therefore, support to improve QOL is considered necessary for adequate diabetes management, and we show that a 1-week inpatient diabetes education program resulted in a significant improvement in quality of life, indicating that such programs are quite useful.

We hypothesized that hospitalization would improve both quality of life and HbA1c at 12 months after discharge; however, these two variables were not independently associated, probably because DTR-QOL was not administered at 12 months after discharge. Thus, it is not known whether the improvement in quality of life persisted until 12 months after discharge, i.e., it is possible that this improvement gradually reversed after discharge.

A previous report has revealed that patients with low well-being and quality of life before an inpatient diabetes education program had poor glycemic improvement after discharge[25]. This is similar to the results described here, i.e., patients with high scores for 'Satisfaction with treatment' on admission had favorable glycemic control after discharge. Therefore, in the future, it is necessary to consider new approaches in patients with low QOL. In this study, there were 15 dropout cases within 12 months after discharge. A comparison between the DTR-QOL scores of the 15 dropout cases and those of the 140 patients adherent to our research for 1 year showed no significant differences in total score and individual area score (data not shown). However, dropout cases tended to have lower scores for 'Anxiety and dissatisfaction with treatment' both at admission and discharge. It is imperative to continue diabetes treatment even after hyperglycemia is well controlled, and it would be beneficial to figure out the characteristics of the patients who discontinue treatment for diabetes.

Additionally, a significant correlation was found between HbA1c 12 months after discharge and sex, duration of diabetes,

Table 4 | Correlation between HbA1c at 12 months after discharge and diabetes treatment-related quality of life total/domain scores (at admission, at discharge, and change from admission to discharge)

Domain	At admission		At discharge		Improvement	
	r	*P*-value	*r*	*P*-value	*r*	*P*-value
D1: Burden on social activities and daily activities	0.038	0.653	−0.015	0.856	−0.052	0.539
D2: Anxiety and dissatisfaction with treatment	−0.154	0.069	−0.149	0.078	0.000	0.996
D3: Hypoglycemia	−0.056	0.511	−0.113	0.185	−0.110	0.197
D4: Satisfaction with treatment	−0.228	**0.007**	−0.115	0.175	0.096	0.258
Total score	−0.068	0.427	−0.101	0.235	−0.033	0.700

The bold values represent statistically significant. Correlation coefficients and *P*-values are based on single-correlation analysis.

Table 5 | Correlation between HbA1c at 12 months after discharge and clinical and biochemical parameters at admission

Parameter	*r*	*P*
Age	0.015	0.858
Sex	−0.242	**0.004**
Duration of diabetes (year)	0.369	**<0.001**
HbA1c (at admission) (%)	0.289	**0.001**
Body weight	−0.159	0.061
BMI	−0.063	0.461
AST	0.110	0.194
ALT	0.024	0.780
γ-GT	−0.044	0.605
Serum albumin	−0.093	0.277
Blood urea nitrogen	0.100	0.241
Serum creatinine	−0.139	0.102
eGFR	0.012	0.884
Uric acid	0.011	0.900
Total cholesterol	0.071	0.402
High-density lipoprotein cholesterol	0.119	0.160
Low-density lipoprotein cholesterol	−0.040	0.638
Triglyceride	−0.039	0.646
CPI	−0.313	**<0.001**
△CPR	−0.353	**<0.001**
U-CPR	−0.323	**<0.001**
HOMA2-%β	−0.268	**0.002**
HOMA2-IR	−0.144	0.109

The bold values represent statistically significant. Sex; men: 1, women: 0. △CPR, difference between C-peptide at fasting and 6 min after glucagon injection (glucagon test); ALT, alanine aminotransferase; AST, aspartate aminotransferase; BMI, body mass index; CPI, C-peptide index; eGFR, estimated glomerular filtration rate; HOMA2-%β, homeostasis model assessment – β-cell function; HOMA2-IR, homeostasis model assessment of insulin resistance; U-CPR, urine C-peptide in 24 h; γGT, γ-glutamyl transpeptidase.

and beta-cell function. Nagata *et al.*[19] reported that the effects of inpatient education were more significant in patients with a shorter duration of diabetes, probably because such patients have preserved beta-cell function, which may allow early withdrawal of insulin due to recovery of glucose toxicity even if insulin therapy was initially introduced due to severe hyperglycemia. However, in our multiple regression analysis, HOMA2-%β was not independently associated with HbA1c at 12 months after discharge. The results were similar by analysis using insulin secretion indices such as CPI, delta C-peptide of the glucagon stress test, and urinary C-peptide other than HOMA2-%β (data not shown). In addition, a marked improvement in blood glucose levels may motivate patients to achieve the goals of their treatment strategy. It is also expected that patients who have recently developed the disease may be unfamiliar with the disease, which will help them understand it without false knowledge and encourage them to adhere to the recommended treatment. The DESMOND trial, a diabetes education program in drug naïve patients, demonstrated that glycemic control was improved in the educational intervention group, suggesting that drug naïve patients are sensitive not only to drugs but also to education[3]. Thus, the favorable results obtained in patients with a shorter duration of disease in this study are noteworthy.

The results of this study also reveal that there are gender differences in the effects of the inpatient education program on improving blood glucose, which agrees with previous reports[26]. One study examined the burden of diabetes care before and after an inpatient education program and reported a reduction in burden in both sexes after the program; however, the effect was more significant in women than in men[27]. Another study reported that, while knowledge of diabetes was similar among men and women, glycemic improvement after inpatient education was less in women, probably due to the absence of behavioral changes[28]. Another possible factor is the influence of food choices in diabetes care between the genders. A multinational study in 23 countries found that women place more importance on healthy eating than men and that health beliefs can explain a large proportion of dietary behavior[29]. Gender differences in behavior based on health information have also been reported in Sweden[30]. Generally, Japanese women are more

Table 6 | Effects of diabetes treatment-related quality of life (satisfaction) on HbA1c (12 months)

Dependent variable	Independent variable	*B*	Std. error	β	*P*
HbA1c (12 months)	Intercept	7.84	0.232		<0.001
Model 1	DTR-QOL questions (satisfaction)	−0.012	0.005	−0.205	0.015
HbA1c (12 months)	Intercept	8.143	0.408		<0.001
Model 2	DTR-QOL questions (satisfaction)	−0.004	0.005	−0.062	0.459
	Sex	−0.518	0.174	−0.236	0.003
	Age	−0.015	0.007	−0.192	0.033
	Duration of diabetes (year)	0.048	0.009	0.444	<0.001
HbA1c (12 months)	Intercept	6.19	0.623		<0.001
Model 3	DTR-QOL questions (satisfaction)	0.000	0.005	−0.008	0.925
	Sex	−0.621	0.167	−0.283	<0.001
	Age	−0.013	0.007	−0.161	0.060
	Duration of diabetes (year)	0.049	0.009	0.451	<0.001
	HbA1c (at admission) (%)	0.202	0.051	0.298	<0.001
HbA1c (12 months)	Intercept	5.808	0.796		<0.001
Model 4	DTR-QOL questions (satisfaction)	−0.001	0.004	−0.028	0.750
	Sex	−0.517	0.166	−0.262	0.002
	Age	−0.009	0.007	−0.124	0.190
	Duration of diabetes (year)	0.039	0.009	0.373	<0.001
	HbA1c (at admission) (%)	0.236	0.061	0.384	<0.001
	HOMA2-%β	−0.001	0.003	−0.032	0.765
	HOMA2-IR	−0.038	0.112	−0.031	0.733

B, unstandardized coefficients *B*; DTR-QOL questions (satisfaction), DTR-QOL questions scores of 'Satisfaction with treatment' domain at admission; HbA1c (12 M), HbA1c at 12 months after discharge; HOMA2-%β, homeostasis model assessment – β-cell function; HOMA2-IR, homeostasis model assessment of insulin resistance; Std. error, standard error of unstandardized coefficients *B*; β, standardized coefficients β.

involved in cooking than men, and the women in our study might have already followed diet therapy before admission or even got tired of it. In contrast, men may be able to engage in the therapy without much burden because they are not in charge of cooking or because they are naive to the therapy; either or both of these would have led to a significant improvement in HbA1c in our study.

There are several limitations to this study. First, there was no comparison with a population that did not undergo an inpatient diabetes education program, such as outpatients matched for age, gender, etc.; thus, it is unclear whether the results of the present study are indeed an effect of the program. Next, such programs vary considerably between hospitals, and it might not be appropriate to apply these observations to educational programs at other institutions. We started a 7 day inpatient diabetes education program more than 15 years ago and this time, we evaluated the effect of this program in this manuscript. Here, we showed the benefit of this program, however, as we have not shown the rationale of the 7 day program, we should improve this program and we believe that this is the next challenge. Finally, as diabetes is a chronic disease and our study followed up patients for only 1 year after admission, it would be desirable to observe the clinical course of these patients thereafter.

In conclusion, even though the inpatient diabetes education program improved quality of life, it was not independently associated with HbA1c at 12 months after discharge. As such programs are costly and time-consuming, it may be necessary to recommend them only to patients who are most likely to benefit from them, e.g., men with a shorter duration of diabetes. Active intervention early in the course of the disease may also be essential. Furthermore, as the goal of diabetes treatment is to maintain the same healthy life expectancy and quality of life as those without diabetes, the DTR-QOL evaluation of diabetes patients is useful. There are few studies using questionnaires specialized for quality of life of diabetes treatment, and we hope that more investigations to clarify the relationship between quality of life and glycemic control will be performed in the future.

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DISCLOSURE

The authors declare no conflict of interest.

Approval of the research protocol: This study was granted ethical approval by the Juntendo University School of Medicine Clinical Research Review Committee (Approval No. 19-187) and was conducted in accordance with the principles outlined in the Declaration of Helsinki; every effort was made to ensure patient anonymity.

Informed consent: The need for informed consent was waived owing to the retrospective nature of the investigation and the opt-out method of inclusion.
Registry and the registration no. of the study/trial: N/A.
Animal studies: N/A.

REFERENCES

1. Thompson DM, Kozak SE, Sheps S. Insulin adjustment by a diabetes nurse educator improves glucose control in insulin-requiring diabetic patients: a randomized trial. *Cmaj* 1999; 161: 959–962.
2. Goudswaard AN, Stolk RP, Zuithoff NP, *et al*. Long-term effects of self-management education for patients with type 2 diabetes taking maximal oral hypoglycaemic therapy: a randomized trial in primary care. *Diabet Med* 2004; 21: 491–496.
3. Davies MJ, Heller S, Skinner TC, *et al*. Effectiveness of the diabetes education and self management for ongoing and newly diagnosed (DESMOND) programme for people with newly diagnosed type 2 diabetes: cluster randomised controlled trial. *BMJ* 2008; 336: 491–495.
4. Araki E, Goto A, Kondo T, *et al*. Japanese clinical practice guideline for diabetes 2019. *J Diabetes Investig* 2020; 11: 1020–1076.
5. Ishii H, Anderson JH Jr, Yamamura A, *et al*. Improvement of glycemic control and quality-of-life by insulin lispro therapy: assessing benefits by ITR-QOL questionnaires. *Diabetes Res Clin Pract* 2008; 81: 169–178.
6. Ishii H. Development and psychometric validation of the diabetes therapy-related QOL (DTR-QOL) questionnaire. *J Med Econ* 2012; 15: 556–563.
7. Fritsche A, Stumvoll M, Goebbel S, *et al*. Long term effect of a structured inpatient diabetes teaching and treatment programme in type 2 diabetic patients: influence of mode of follow-up. *Diabetes Res Clin Pract* 1999; 46: 135–141.
8. Wexler DJ, Beauharnais CC, Regan S, *et al*. Impact of inpatient diabetes management, education, and improved discharge transition on glycemic control 12 months after discharge. *Diabetes Res Clin Pract* 2012; 98: 249–256.
9. Healy SJ, Black D, Harris C, *et al*. Inpatient diabetes education is associated with less frequent hospital readmission among patients with poor glycemic control. *Diabetes Care* 2013; 36: 2960–2967.
10. Yang Q, Fang P. Impact of the conversation map tools in patients with type 2 diabetes mellitus: a PRISMA-compliant meta-analysis of randomized controlled trials. *Medicine (Baltimore)* 2016; 95: e4664.
11. Mojiminiyi OA, Abdella NA. Effect of homeostasis model assessment computational method on the definition and associations of insulin resistance. *Clin Chem Lab Med* 2010; 48: 1629–1634.
12. Antuna-Puente B, Disse E, Rabasa-Lhoret R, *et al*. How can we measure insulin sensitivity/resistance? *Diabetes Metab* 2011; 37: 179–188.
13. Lann D, LeRoith D. Insulin resistance as the underlying cause for the metabolic syndrome. *Med Clin North Am* 2007; 91: 1063–1077 viii.
14. Wallace TM, Levy JC, Matthews DR. Use and abuse of HOMA modeling. *Diabetes Care* 2004; 27: 1487–1495.
15. Matthews DR, Hosker JP, Rudenski AS, *et al*. Homeostasis model assessment: Insulin resistance and beta-cell function from fasting plasma glucose and insulin concentrations in man. *Diabetologia* 1985; 28: 412–419.
16. Asano T, Kawamura M, Watanabe T, *et al*. Indices of urinary and serum C-peptide with fasting plasma glucose for decision-making of insulin therapy in type 2 diabetes-validation and comparison. *J Jpn Diabetes Soc* 2008; 51: 759–763.
17. Yasuda H, Sanada M, Kitada K, *et al*. Rationale and usefulness of newly devised abbreviated diagnostic criteria and staging for diabetic polyneuropathy. *Diabetes Res Clin Pract* 2007; 77(Suppl 1): S178–S183.
18. Tanikawa M, Mimura M. Follow-up study on HbA1c levels after an inpatient education program. *Jpn J Occup Med Traumatol* 2012; 60: 38–44. Japanese.
19. Nagata H, Murata K, Furuta M, *et al*. Long-term effect of 2-week educational program with critical path on blood glucose control in patients with type 2 diabetes mellitus. *J Jpn Diabetes Soc* 2005; 48: 777–781.
20. Ismail K, Winkley K, Rabe-Hesketh S. Systematic review and meta-analysis of randomised controlled trials of psychological interventions to improve glycaemic control in patients with type 2 diabetes. *Lancet* 2004; 363: 1589–1597.
21. Winkley K, Upsher R, Stahl D, *et al*. Psychological interventions to improve self-management of type 1 and type 2 diabetes: a systematic review. *Health Technol Assess* 2020; 24: 1–232.
22. Kleefstra N, Landman GW, Houweling ST, *et al*. Prediction of mortality in type 2 diabetes from health-related quality of life (ZODIAC-4). *Diabetes Care* 2008; 31: 932–933.
23. Hayashino Y, Ishimaru F, Kadowaki T, *et al*. Psychological aspects of treatment of diabetes mellitus in the world and the issues that need to be addressed in Japan: the consideration based on the second diabetes attitudes, wishes and needs (DAWN2™) study. *J Jpn Diabetes Soc* 2016; 59: 652–660.
24. Kalra S, Balhara YP, Verma K, *et al*. Asian paradox of psychological support: findings from the second diabetes attitudes wishes and needs study (DAWN-2). *Asia Pac Psychiatry* 2013; 5: 354–355.
25. Yamamoto R, Tamura Y, Hiraoka K, *et al*. Effectiveness of educational hospitalization and psychological and social factors in type 2 diabetes mellitus. *Practice* 2009; 26: 656–660. Japanese.
26. Katsuta H, Hori K, Nariki T, *et al*. Characteristics of patients who maintained HbA1c below 7.0% after discharge. *Practice* 2004; 21: 102–103. Japanese.

27. Takahashi Y, Otaki T, Yahata K, *et al*. Examination of changes in burden on diabetes care before and after an inpatient education program between men and women. *Niigata-ken Koseiren Med J* 2019; 28: 11–20. Japanese.
28. Genma R. Characteristics of patients with poor glycemic control after 1 year of educational hospitalization for 8 days using a clinical pathway. *Diabetes Front* 2008; 19: 109–112. Japanese.
29. Wardle J, Haase AM, Steptoe A, *et al*. Gender differences in food choice: the contribution of health beliefs and dieting. *Ann Behav Med* 2004; 27: 107–116.
30. Barebring L, Palmqvist M, Winkvist A, *et al*. Gender differences in perceived food healthiness and food avoidance in a Swedish population-based survey: a cross sectional study. *Nutr J* 2020; 19: 140.

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Table S1 | Total score of the DTR-QOL questionnaire at (A) admission and use of each medication at admission and (B) discharge and use of each medication at discharge

Table S2 | HbA1c at 12 months after discharge and use of each medication at discharge