Original Article

Diabetes Care: An Online Web-Based Tool for Improving the Health Outcomes of Type 2 Diabetes Mellitus Patients: A Longitudinal Study

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Abstract

Background: Diabetes is a chronic medical condition with severe complications, mainly caused by unhealthy lifestyles in genetically susceptible individuals. There has been a growing interest in the role of mobile health technologies in achieving better self-efficacy in managing diabetes. This study attempts to assess the impact of a web-based model on improving the diabetes status among Type 2 diabetic patients attending a tertiary care hospital in southern India. **Methods:** A longitudinal study was conducted among patients with type 2 diabetes attending the outpatient department of a tertiary care hospital in Mysuru, southern India, for 6 months. Diabetes Care (https://www.diabetes-care.co.in/), which is an online website that can be used as a risk prediction tool for uncontrolled diabetes and recommends lifestyle changes, was used by 456 diabetes patients for 6 months. We assessed the change in glycosylated haemoglobin levels at the beginning and after 6 months of using the software. **Results:** The mean HbA1c value at the start of the study was 8.039% ± 1.981. The HbA1c value assessed after 6 months post-intervention showed an improvement of 7.794% ± 1.853 with a mean difference of 0.245. A paired T-test showed a statistically significant association with a *P* value of 0.049. **Conclusions:** Evidence from this study suggests that intervention using a web-based model focusing on risk prediction and educational intervention showed an improvement in the diabetic status of the patients with T2DM.

Keywords: *Diabetes mellitus, lifestyle modification, medical technology, public health, risk prediction*

Introduction

In developed and developing countries, noncommunicable diseases have surpassed communicable diseases, and individuals over forty years of age are more vulnerable to NCDs.[1]

Diabetes mellitus is a chronic medical condition. It occurs when the pancreas does not produce enough insulin or the body is unable to effectively use insulin.[2] An estimated 643 million people worldwide suffered from diabetes in 2019. Two-thirds of people with diabetes live in urban areas, and 3 out of 4 are in the working age group. An estimated one hundred and thirty-six million people over the age of 65 years have diabetes, and the prevalence of diabetes in this age group varies significantly among the International Diabetes Federation regions.[3]

India is commonly regarded as the world's "Diabetic capital". Although urbanization is a major contributor to the Indian diabetes epidemic, numerous studies demonstrate that South Asians are more vulnerable to diabetes than other groups.[4] If no remedial measures are taken, the number of patients with diabetes will reach 134 million by 2045.[5]

Type 2 diabetes mellitus frequently requires treatment with multiple medications and long-term lifestyle modifications to prevent the onset of complications. Lifestyle modification has proven to be more effective and affordable than medication in the prevention and treatment of diabetes and its complications. However, such interventions are challenging to implement due to the high cost of face-to-face health expert information delivery, the overwhelming workload in the healthcare environment, and the lack of coverage for such expenses in health insurance.[6,7]

Patients find it challenging to control their diabetes mellitus and follow strict treatment and lifestyle recommendations. This includes monitoring blood sugar levels,

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adjusting dosages, and managing medications. Therefore, assistance is required to help patients adhere to their medication and lifestyle changes.[8]

One of the key elements in reducing patients' risk of developing diabetes, according to the American Diabetes Association (ADA), is how frequently they use personal health devices.[9] Adherence to smart wearables, health-based mobile applications, and software is inversely correlated with how much they value the observable insights that can be drawn from the data. It emphasizes the value of monitoring tools and the applicability of data-driven predictions in healthcare settings.[10,11]

This study attempts to assess the impact of a website model on improving the diabetes status of patients with type 2 diabetes over 6 months in the Mysuru district of southern India.

Methodology

A longitudinal study was conducted among 456 patients with type 2 diabetes attending the outpatient department of JSS Hospital, Mysuru, in southern India for a period of 6 months. All patients aged more than 18 years with type 2 diabetes mellitus receiving treatment with either insulin or OHA drugs and owning smartphones were included in this study. Patients less than 18 years old who do not own smartphones, with severe complications, and pregnant women were excluded from the study. The study protocol was approved by the Institutional Ethics Committee (JSS/MC/PG/5156 / 2020-21), and informed consent was obtained from the participants after explaining the purpose and procedure of the study.

We collected data from patients attending the outpatient department of JSS Hospital using purposive sampling until we reached the sample size. The glycemic status of type II diabetic patients was assessed by using HbA1c as the criterion.

After obtaining written informed consent, information from the participants was obtained using a prevalidated questionnaire. The questionnaire had 3 parts. Part 1 asked about sociodemographic details like age, sex, religion, socioeconomic status, education, occupation, and income. Part 2 asked about their behavioral habits (alcohol intake, smoking, exercise), diabetic history (symptoms, family history, complications, medications), and other medical histories (hypertension, dyslipidemia), and Part 3 included anthropometric measurements. A pilot study was conducted on 30 diabetic patients to validate the questionnaire, who were later removed from the study.

The patients were instructed to continue receiving regular care, including seeing their primary diabetes healthcare practitioner. Patients also received instructions on how to use Diabetes Care (https://www.diabetes-care.co.in/),[12] which is an online web tool created by the research team. Diabetes Care serves as a risk prediction tool for uncontrolled diabetes and suggests lifestyle changes for individuals with diabetes. The development and validity of this model have been published elsewhere.[13] Furthermore, it categorizes the patients based on their present body mass index (WHO Asian Pacific classification) and waist–hip circumference and calculates the calorie requirement of the patient.

The study participants underwent their initial evaluation from January to March 2022.

The study participants underwent their initial evaluation from January to March 2022. The data were collected, and the HbA1c of the participants was noted. Participants were required to use the software for 6 months. During the intervention period, the research team contacted the participants through a social media platform (WhatsApp) to ensure their regular use of the website and adherence to the recommendations. Between June and August 2022, a monthly visit to the OPD included an end-line assessment to determine how well the web-based health model was managing type II diabetes mellitus. The HbA1c levels were used to measure the outcome, which was the improvement in glycemic control [Figure 1].

Statistical Analysis: The data collected were entered into a Microsoft Excel 2019 spreadsheet, followed by analysis using SPSS version 26 (Statistical Package for Social Science) Windows, Version 26.0. (IBM Corp. Released 2019. IBM SPSS Statistics for Armonk, NY, USA). The demographic characteristics are represented using the arithmetic mean, standard deviation, and percentages. A paired sample T-test was done to assess the significance of the difference in HbA1c change before and after the study period. The differences were interpreted as statistically significant at $P < 0.05$.

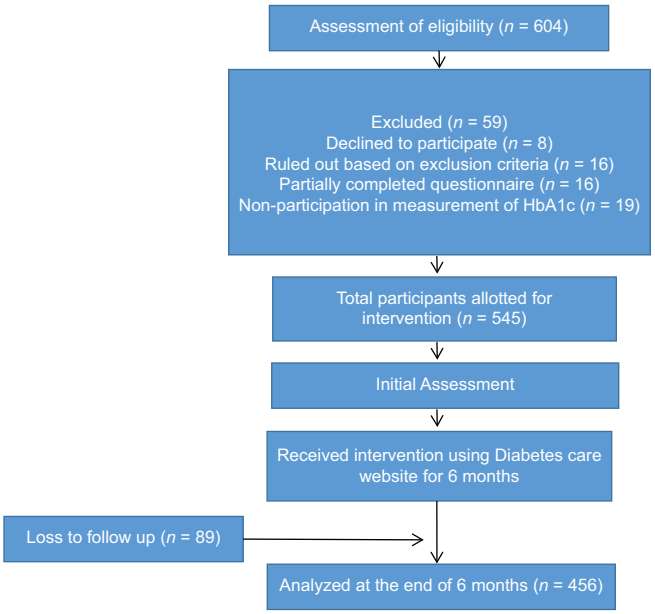

Figure 1: Flow diagram showing the study conduct

Results

The mean age of the study participants was 55.56 ± 12.12 years. Most were males (60.7%), and 179 (39.3%) were females. Among the patients, 408 (89.5%) were married, and 19 each (4.2%) were unmarried and widowed. In total, 419 (91.9%) participants were from the Hindu religion, 27 (5.9%) were Muslims, and 10 (2.2%) were Christians, respectively. In addition, 323 (70.8%) participants were on oral hypoglycemic agents (OHA), while 15.4% were on insulin therapy during the study [Table 1].

20% (91) of the participants were educated up till high school, 89 (19.5%) up till middle school, and 78 (17.1%) were illiterate. Among the 456 subjects, 132 (28.9) were doing business, while 117 (25.7%) were either unemployed or retired. The majority of the participants belonged to the upper middle class (31.8%) and 126 (27.6%) belonged to the upper class, according to the Modified BG Prasad Scale. Hypertension was a comorbidity in 60.3% of the participants, while 50.2% were diagnosed with dyslipidemia [Table 2].

Out of the 456 diabetic patients, 235 (51.5%) were not doing regular physical activity, while 221 (48.5%) subjects reported doing exercise regularly. 66.9% of the subjects had a positive family history of diabetes, and most participants reported following a proper diabetic diet (68.6%) and regular adherence to medication (87.7%). Among the 456 subjects, 91 (20%) subjects consumed alcohol and 73 (16%) were smokers. After the intervention, the number of participants regularly engaging in physical activity, taking regular medication, and following a diabetic diet increased, while the number of the number of participants consuming alcohol and smoking decreased [Table 3].

The mean HbA1c of the study participants at the beginning of the study was 8.039% ±1.981. The repeat HbA1c, 6 months after using the web-based model, was 7.794% ± 1.853. The values of the study participants showed a trend of 0.245% reduction in HbA1c. The paired T-test was used, and it revealed a statistically significant association (*P* value = 0.049) [Table 4 and Figure 2].

Table 1: Sociodemographic characteristics of the study participants

Characteristics		Frequency (*n*=456)	Percentage (%)
Gender	Male	277	60.7
	Female	179	39.3
Marital status	Married	408	89.5
	Unmarried	19	4.2
	Divorced	10	2.2
	Widowed	19	4.2
Religion	Hindu	419	91.9
	Muslim	27	5.9
	Christian	10	2.2
Diet	Vegetarian diet	185	40.6
	Mixed diet	271	59.4
Type of medication	Insulin	70	15.4
	Oral Hypoglycemic Agent (OHA)	323	70.8
	Insulin + OHA	55	12.1
	Ayurvedic medication	8	1.8

Table 2: Demographic profile based on education, occupation, socioeconomic status, family history, and other medical conditions of the study participants

Characteristics		Frequency (*n*=456)	Percentage (%)
Educational status	Graduate/PG	73	16
	PUC/Diploma	63	13.8
	High school	91	20
	Middle school	89	19.5
	Primary school	62	13.6
	Illiterate	78	17.1
Occupation	Professional or semi-professional	91	20
	Business	132	28.9
	Skilled worker	116	25.4
	Unemployed or retired	117	25.7
Socioeconomic status (Modified BG Prasad classification)	Upper class	126	27.6
	Upper-middle class	145	31.8
	Middle class	75	16.4
	Lower middle class	64	14
	Lower class	46	10.1
Family history	Yes	305	66.9
	No	151	33.1
Hypertension	Yes	275	60.3
	No	181	39.7
Dyslipidemia	Yes	229	50.2
	No	227	49.8

Discussion

The severity of diabetes mellitus (DM) as a public health issue has increased due to the prevalence of DM worldwide.[14] The actual beginning of the disease involves several risk factors. The main risk factors for prediabetes or diabetes mellitus are genetics, environment, loss of the initial phase of insulin release, sedentary lifestyle, lack of exercise, smoking, alcohol use, dyslipidemia, reduced cell sensitivity, hyperinsulinemia, and enhanced glucagon activity.[15] In the current study, we assessed the diabetic profile of patients with type 2 diabetes attending a tertiary care hospital before and after using a website model in southern India.

Ours is one of the first few studies using a website-based tool in India for predicting uncontrolled diabetes and recommending lifestyle changes among patients with type 2 diabetes. It revealed an improvement in diabetic status among the study participants compared with the initial assessment.

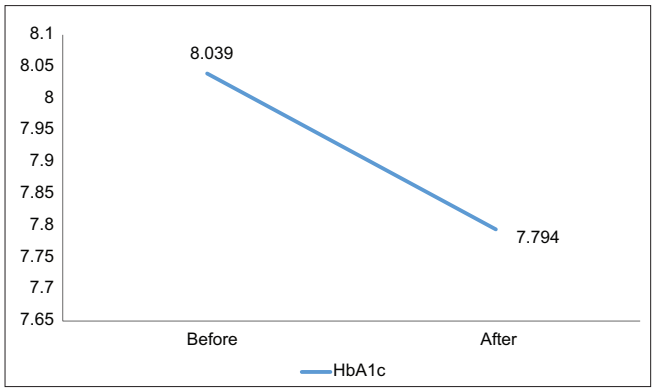

Figure 2: Comparison of HbA1c value among the study participants in the pre and post-test period

Table 3: Behavioral and medical history of the study participants before and after the intervention

Lifestyle or medical history		Before intervention	After intervention
Regular physical activity	Yes	221 (48.5)	316 (69.3)
	No	235 (51.5)	140 (30.7)
Regular medication	Yes	400 (87.1)	438 (93.1)
	No	56 (12.3)	28 (6.1)
Following a regular diabetic diet	Yes	313 (68.6)	364 (79.8)
	No	143 (31.4)	92 (20.2)
Alcohol intake	Yes	91 (20)	63 (13.8)
	No	365 (80)	393 (86.2)
Smoking history	Yes	73 (16)	50 (11)
	No	383 (84)	406 (89)

Table 4: HbA1c levels of the study participants before and after using the diabetes care website

HbA1c	Mean	Standard Deviation	Mean difference	*P*
Before	8.039	1.981	0.245	0.049*
After	7.794	1.853		

*-Paired *t*-test

Studies were conducted worldwide, mostly using mobile applications for lifestyle modifications, which showed improvements in glycemic status. Sunil Kumar *et al*.[8] conducted a randomized controlled study in southern India using a mobile application named DIAGURU. The participants in the intervention group showed an improvement in HbA1c (7.36% to 7.10%) compared to the nonintervention group (7.84% to 7.97%) after 6 months of using the application. Shantanu Nundy *et al*.[16] conducted a quasi-experimental study in Chicago among diabetic patients, demonstrating an average reduction of HbA1c from 7.9% to 7.2% over 6 months using a mobile application.

Can Hou *et al*.[17] conducted a meta-analysis that compared the findings of 14 studies from 1996 to 2015 and found that diabetic patients who used mobile applications as an adjunct to medical therapy had better glycemic control. Intervention groups had a mean HbA1c reduction of 0.49% compared to control groups. Subgroup analyses revealed that younger patients were more likely to benefit from using diabetes apps, and the magnitude of the effect was increased with feedback from healthcare professionals.

Another systematic review and meta-analysis of 13 studies found that intervention groups that used mobile applications for lifestyle modification and medication management had lower HbA1c levels overall. Six of the 13 studies included in the meta-analysis demonstrated a statistical difference in HbA1c reduction.[18]

Our study thus proves that type II diabetic patients who regularly used our website intended for predicting uncontrolled diabetes and offering lifestyle modifications and medication management similar to the above-discussed mobile applications had significantly improved glycemic status.

Limitations

The lack of scientific calculation of sample size is a limitation of this study. The absence of a control group limits the strength of this study by attributing the identified significant outcomes solely to the intervention. Furthermore, the follow-up period was shorter in our study. To see an improvement in diabetic status, a follow-up period of more than 1 year would have been better.

Conclusion

We conclude that risk prediction and educational intervention using a web-based tool saw an improvement in HbA1c values. The mean HbA1c value during the initial assessment was 8.039% ± 1.981, while the mean HbA1c value after 6 months showed an improvement (7.794 ± 1.853) with a mean difference of 0.245. Therefore, we can use technological approaches to improve the overall health outcome of patients with type 2 diabetes mellitus.

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Ethical approval

The study was approved by the Institutional Ethics Committee (JSS/MC/PG/5156/2020-21).

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Conflicts of interest

There are no conflicts of interest.

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