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IMPLEMENTATION OF SMARTPHONE APPLICATION FOR BLOOD GLUCOSE LEVELS AND SELF-CARE IN TYPE-2 DIABETES MELLITUS: A CONTEXTUAL TEACHING AND LEARNING MODEL

Winanda Rizki Bagus Santosa [1]*, Nisha Nambiar [2], Erlina Abdullah [3] and Sheylla Septina Margaretta [4]

[1,2,3] Lincoln University College, Petaling Jaya, Selangor Darul Ehsan, Malaysia.
[1,4] College of Nursing, Institut Ilmu Kesehatan Bhakti Wiyata Kediri, East Java, Indonesia.
Email: [1]winanda.rizki@iik.ac.id (*Corresponding Author), [2]nisha@lincoln.edu.my, [3]erlina@lincoln.edu.my, [4]sheylla.margaretta@iik.ac.id
ORCID ID: [1]https://orcid.org/0009-0008-0173-1645, [2]https://orcid.org/0000-0002-7910-451X, [3]https://orcid.org/0000-0002-6895-1991, [4]https://orcid.org/0009-0006-8695-1932

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Abstract

Background: The increasing number of smartphone application users in the community can be used as a new breakthrough in providing solutions to provide interventions. As the example in Educating Type-2 Diabetes Mellitus (T2DM) patients using the Contextual Teaching and Learning (CTL) model to reduce blood glucose and improve self-care at an affordable cost. This study aims to determine the effect of smartphone application education on self-care and blood glucose levels in T2DM patients with the CTL model. **Methods:** This study was a randomized controlled study pre-test and post-test design conducted on T2DM patients attending nine health centers in Kediri City, Indonesia. The research was on October 2, 2023 - January 2, 2024 by 131 intervention group and 131 control group. **Result:** Mean reduction in blood glucose levels in T2DM patients using the CTL model smartphone application pre-test was (158.7±17.4), post-test was (107.5±6.5) with a P-Value of 0.000. Mean self-care pre-test was (43.03±1.62) and post-test was (81.53±5.32) with a P-Value of 0.000. Domains of blood sugar monitoring, exercise, diet, foot care with blood glucose levels P-Value (0.028±0.000±0.002±0.182). **Conclusions:** There is an overall effect of smartphone applications in the CTL model on blood glucose levels and self-care in T2DM patients. There is an influencing effect of monitoring blood glucose level, exercise, and diet control on blood glucose level. Foot care does not affect blood glucose levels.

Keywords: Smartphone Application, Blood Glucose Levels, Self-Care, Type-2 Diabetes Mellitus, Contextual Teaching And Learning.

INTRODUCTION

Diabetes mellitus (DM) is a disorder that disrupts the body's physiology due to insufficient insulin production by the pancreas. The pancreas secretes the hormone insulin, which aids the glucose movement from the bloodstream into the cells (Yang et al. 2020). Type-2 Diabetes Mellitus (T2DM) is a chronic disease that impacts daily life. The number of people with T2DM is increasing due to unhealthy lifestyle changes, overweight, and lack of self-care (Riangkam et al. 2022). DM was ranked the ninth leading cause of death worldwide in 2019. DM is the leading cause of heart disease, neurological disorders, stroke, chronic kidney failure, blindness, and causes amputation (Mehraeen et al. 2022). T2DM is the most common disease in the community. Not all patients have an adequate level of technological expertise to use smartphone apps effectively, especially among the elderly.

Globally, The International Diabetes Federation (IDF) states that in 2019 the incidence of DM in the age group 20-79 years was 463 million people (9.3%), and is expected to increase to 700 million people by 2045 (10.9%) (Abd-alrazaq et al. 2021). Meanwhile, Kediri City has the highest number of DM diagnoses at 19 out of 38 cities and districts in East Java province, Indonesia. DM patients in East Java Province,

Indonesia ranked fifth with 867,257 reported cases (PERKENI 2021). To minimize the risk of complications in T2DM, patients should be provided with education and monitoring to improve self-care ability (Sunil Kumar et al. 2021). Contextual Teaching and Learning (CTL) is a learning method that places the learner as the center of the teaching and learning process so that it will develop a person's interest, motivation, and ability to be more active innovative, and responsible for the independent learning process applied in everyday life (Yulianita et al. 2023). The CTL model can be applied to nursing students. Nurses can help identify and solve patient health problems by accessing relevant information (Shahzad, Younas, and ALI 2022). Researchers tried to apply this CTL model to T2DM patients combined with smartphone applications.

Due to limited resources in community health services, the use of smartphone application technology can be recommended to improve self-care skills on a daily basis while at home (Patnaik et al. 2021). The use of smartphone apps is new and valuable for T2DM patients (Salari et al. 2021). Some smartphone apps are customized for specific age groups and their features suit the needs of specific age groups only. Apps designed specifically for adults and the elderly that are easy to use, as well as practical features will help patients in managing DM disease. Smartphone app features can be designed according to the purpose and needs of DM patients (Tews et al. 2022).

Patients with an initial diagnosis of DM often occur in adulthood, which is above the age of 35 years (Martos-Cabrera et al. 2020). Patients who are allowed to use smartphone applications are DM patients who are at least 40 years old (Yoon et al. 2022). The use of smartphone applications in DM management must be tailored to individual needs and abilities to assist in DM management (Jonusas 2023). This study aims to determine the effect of smartphone application education on self-care and blood glucose levels in T2DM patients with CTL model.

METHODS

Research Design

This study is a randomized controlled study pre-test and post-test design. This study was used to determine the effect of smartphone application education on self-care and blood glucose levels in T2DM patients with the CTL model for three months. The intervention group was given smartphone application education and the control group was given a booklet.

Place, Time Population, and Sample

This study was conducted in nine health centers in Kediri City, Indonesia. Smartphone applications that focus on reducing blood glucose levels and increasing self-care in T2DM were used on October 2, 2023 - January 2, 2024. According to (Chuah and Cham 2020), sample measurement can use the G-Power formula with a power analysis type of effect size of 0.5, α err prob 0.04, and power (0.95) resulting in a minimum sample of 105 respondents. To avoid type 2 error, the sample size needs to be increased by 25%. Thus, the total sample in this study was 131 intervention group and 131 control group. The intervention group was given a smartphone application, and the control group was given a booklet. Inclusion criteria were owning and utilizing a smartphone application, willing to participate in the study for three months, able to read, diagnosed with T2DM, fasting blood sugar > 126 mg/dl, and aged between 36-65 years.

Instrument and Data Collection

Blood sugar level and self-care are the two factorials that formed the instrument. If fasting blood sugar > 126 mg/dl, it is considered high (Supriyatno, Widigdo, and Rahmawati 2021). Questions on the Summary of Diabetes Self-Care Activity (SDSCA) questionnaires are about the self-care practices of T2DM patients. These practices include diet plan, exercise, blood sugar monitoring, and foot care. Using a cut-off point system classifies and gives a score ranging from 0-7 to evaluate self-care behavior during the last seven days days (Sh et al. 2019). The research time was conducted according to the schedule agreed between the researcher, T2DM patients, and the person in charge of T2DM patients at the public health center. During data collection, the researcher will be assisted by nurses and nursing students.

Data Analysis

Analysis of the normality test of smartphone application data on the CTL model and booklet on patient blood sugar levels with the Shapiro-Wilk test, normally distributed data, the measure annova test was carried out to show the mean blood sugar levels every month. Data normality test on smartphone applications in the CTL model and booklets on self-care in T2DM patients is not normally distributed, Friedman test is conducted to show the mean self-care of T2DM patients every month. Normality test of the relationship between self-care and blood glucose levels was normally distributed, Pearson test was used to show the relationship between self-care and blood glucose levels.

RESULTS

Figure 1: The "Rizki Diabetes" Smartphone Application

Figure 1 The "Rizki Diabetes" smartphone application is designed to manage T2DM patient information online by using an internet network that is available anywhere. The "Rizki Diabetes" smartphone application can be accessed through a personal android device. By using the customizable application, researchers can track the progress of self-care and blood glucose levels in nine health centers in Kediri City, Indonesia. Data submitted by patients as users can be reported in real time regardless of time and place. The contents of the smartphone application include a T2DM profile, recording

the results of blood sugar level checks and self-care for three months, WhatsApp and telephone consultations with researchers, an emergency button, music therapy, and education 1, 2, and 3 about DM.

Table 1: Respondent Characteristics

Respondent Characteristics		Intervention		Control	
		f	%	f	%
Gender	Male	50	38.2	57	43,5
	Female	81	61.8	74	56,5
Age (years)	36-45	23	17.6	14	10,7
	46-55	41	31.3	55	42,0
	56-65	67	51.1	62	47,3
Education levels	No formal education	16	12.2	9	6,9
	Elementary	26	19.8	33	25,2
	Junior high school	32	24.5	41	31,3
	Senior high school	38	29.0	29	22,1
	College	19	14.5	19	14,5
Occupation	Doesn't work	30	22.9	52	39.7
	Work	101	77.1	79	60.3
Duration DM (years)	≤ 1	36	27.5	47	35,9
	1 - 5	58	44.3	61	46,6
	≥ 5	37	28.2	23	17.6
Income per month (Rp)	≤ 2.300.000	70	53.4	81	61,8
	>2.300.00	61	46.6	50	38,2

Table 1 Characteristics of respondents of T2DM patients in the intervention group who were given CTL model smartphone application education were 131 respondents and the control group who were given booklets were 131 respondents. The characteristics of respondents in the intervention group were mostly female (61.8%), mostly aged 56 - 65 years (51.1%), almost half had a high school education level (29.0%), most respondents were gainfully employed (77.1%), almost half had suffered from diabetes mellitus for 1-5 years (44.3%), most had monthly income below ≤ 2,300,000 (53.4%).

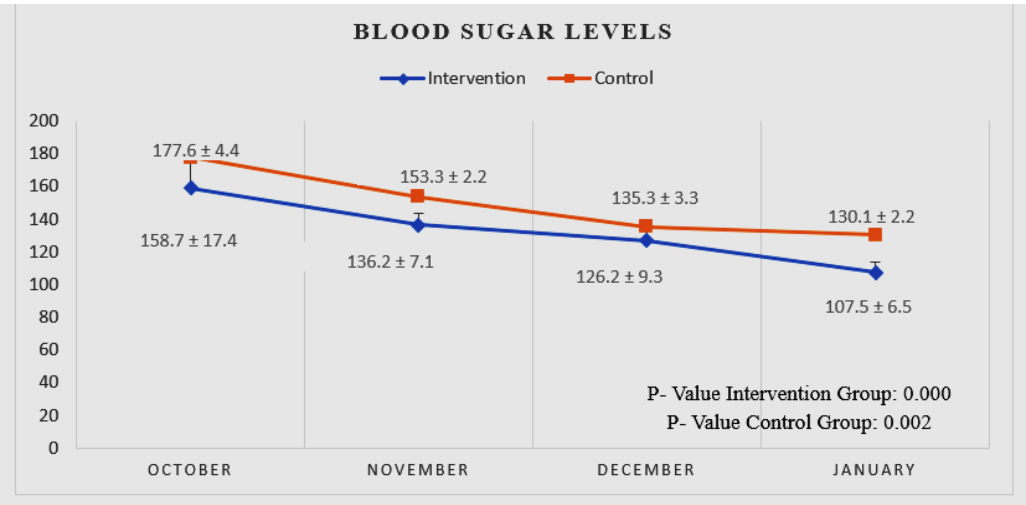

Figure 2: The Smartphone Application on the CTL Model for Blood Sugar Levels

Figure 2 shows the mean and standard deviation of the decrease in blood sugar levels of T2DM patients in the CTL model smartphone application group before and after the intervention. Pre-test before intervention amounted to (158.7±17.4) and post-test

amounted to (107.5±6.5) with a P-Value of 0.000, there was a difference in the average decrease in blood sugar levels in real time every month for three months using the CTL model smartphone application. Mean and standard deviation of blood sugar level reduction of T2DM patients in the booklet group before and after intervention. Pre-test before intervention amounted to (177.6±4.4) and post-test amounted to (130.1±2.2) with a P-Value of 0.002, there was a difference in the average decrease in blood sugar levels in real time every month for three months using the booklet.

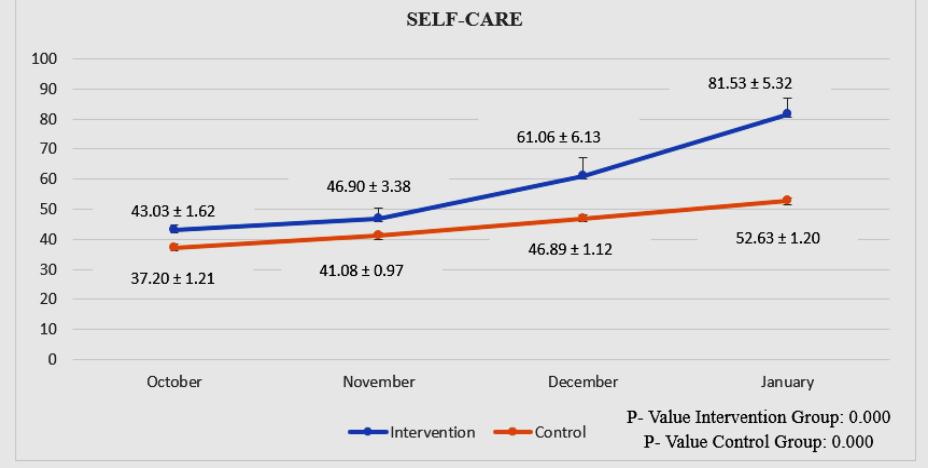

Figure 3: The Smartphone Application on the CTL Model for Self-Care

Figure 3 shows the mean and standard deviation of self-care improvement of T2DM patients in the CTL model smartphone application group before and after the intervention. Pre-test before intervention amounted to (43.03±1.62) and post-test amounted to (81.53±5.32) with a P-Value of 0.000, there was a difference in the average increase in self-care in real time every month for three months using the CTL model smartphone application. Mean and standard deviation of self-care improvement of T2DM patients in the booklet group before and after the intervention. Pre-test before intervention amounted to (37.20±1.21) and post-test amounted to (56.63±1.20) with a P-Value of 0.000, there was a difference in the average increase in self-care in real time every month for three months using booklets.

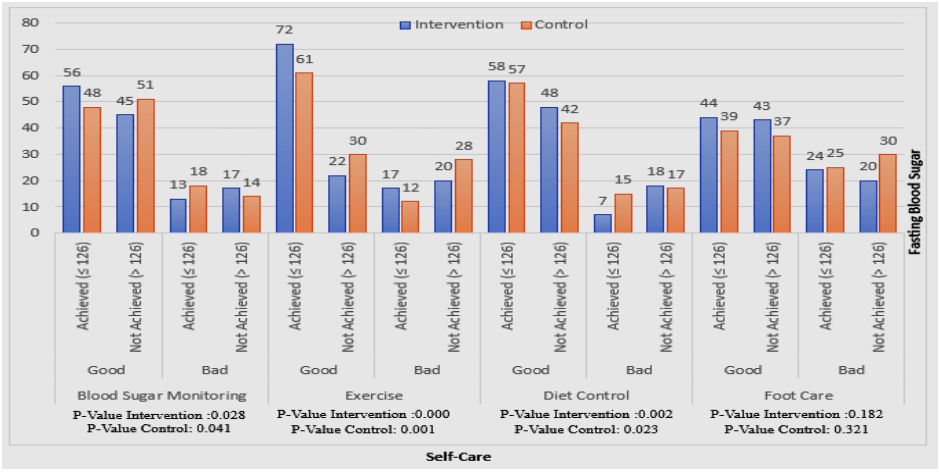

Figure 4: Relationship between the Self-Care and Blood Glucose Levels

Figure 4 shows the domain of self-care on Fasting Blood Sugar (FBS) in T2DM patients in the intervention group and control group is blood sugar monitoring with a

P-Value of (0.028 ± 0.041), Exercise with a P-Value of (0.000 ± 0.001), and Diet with a P-Value of (0.002 ± 0.023). Foot care has no relationship with blood glucose levels in T2DM patients with P-Value (0.182 ± 0.321).

DISCUSSION

The results showed that almost half had a high school education (29.0%) and most were aged 56-65 years (51.1%). The characteristics of the research respondents were similar to the data that most T2DM patients were >55 years old and had a high school education (Srywahyuni, Amelia, and Zulita 2021). M-Health education including diet and exercise programs can change the patient's lifestyle so that the application of M-Health management effectively shows a significant decrease in fasting blood sugar, HbA1c and improved quality of life for T2DM patients (Guo et al. 2023). M-Diabetes smartphone application that contains diet, physical activity, and clinical decision support systems, as well as monitoring blood sugar levels carried out for 24 weeks, decreased HbA1C < 7.0% (53 mmol / mol) by 41.1%, and in the P-Logbook group 20.7% (Kim et al. 2019). Smartphone application education for Friend diabetes was shown to reduce HbA1c after three months by -0.7±0.9% (P-Value 0.001) and fasting blood sugar by -25.0±71.4mg/dl (P-Value 0.02) (Hasanah, Ikawati, and Zainal 2021). During the study using the CTL model smartphone application, T2DM patients felt enthusiastic about learning interesting material independently and easily understood the material presented so that the patient's blood sugar levels decreased. The CTL model is a holistic learning process, aims to understand the material dynamically, and is flexible to actively build understanding (Hyun et al. 2020). The results showed that in 34 respondents who received booklet education about DM for four weeks P-Value 0.000, blood sugar levels in the control group with booklets fell from a mean of 327 mg/dl -181 mg/dl (Sabarudin, Kasmawati, and Sarmita 2019). Data were collected through education using booklets, interviews, and FBS tests. The study found that the knowledge of patients with T2DM and their adherence to treatment, such as insulin injections, physical activity, and diet increased during the pre-test and post-test (Sundari1 and Sutrisno 2023).

Smartphone applications can be used to improve self-care in T2DM. Incompliance in the use of diabetes applications can lead to poor glycemic control and decreased self-care in people with T2DM (Jafar et al. 2023). The results showed the duration of suffering from T2DM> 1 year and there was an increase in self-care in patients. The longer a person suffers from DM affects self-care management, the longer a person suffers from DM, the more accustomed to doing self-care (Zwane et al. 2023). Patients aged <65 years who actively use the M-Health application show high efficacy in glycemic control and self-care in T2DM patients (Lee et al. 2022). Based on the results of the study that all respondents were < 65 years old and were able to use smartphone applications so that they could improve self-care on themselves. That there is an increase in self-care using the M-Health Application gradually over time with a standardized mean difference of - 0.44 and a P-Value of 0.00 < 0.05 resulting in a decrease in HbA1c levels and fasting blood sugar levels (Liu, Xie, and Or 2020). The M-Health app can help people with T2DM better manage their own condition. This study serves as a guide for overseas self-care management, and M-Health management is a very promising approach to support health management of T2DM patients (Bults et al. 2023). The results showed that education through smartphone applications combined with the CTL model is a powerful tool to improve self-care and

enhance long-term skills related to DM management. The CTL model encourages respondents to be actively involved in solving problems related to self-care of people with T2DM such as decision-making regarding diet, medication, and lifestyle preferences (Harahap et al. 2021). The CTL model, creating collaboration in education encourages them to share their experiences and successes in managing DM (Bopape et al. 2020). Educational booklets given to T2DM patients will provide more knowledge so that they can perform better self-care. Self-care includes blood sugar measurement, self-foot care, and regular exercise. The mean before and after educational booklet was 15.68 ± 9.74, and the P-value was 0.001 (Trisda and Bakri 2021). The group using structured blood glucose monitoring with Tele-Care support once a month showed that after 12 months the primary outcome was HbA1c 1.2% (95% CI -1.40 to - 0.94; P-Value < 0.0001). There was an association between structured independent blood glucose monitoring and Tele-Care support on HbA1C (Parsons et al. 2019). Continuous blood glucose monitoring decreased FBS over 48 weeks with a P-Value of 0.01 (Kataoka et al. 2023). Self-monitoring of blood glucose is essential for the management of diabetic patients especially those on insulin. Self-monitoring of blood glucose supports treatment to prevent hypoglycemia (Ajjan, Slattery, and Wright 2019). Blood glucose monitoring is very important in reducing blood glucose levels in T2DM patients. Regular blood sugar level monitoring helps identify changes in blood sugar levels over time.

Regular physical and aerobic activities have a greater impact on HbA1c and blood glucose levels and quality of life in T2DM patients. Each patient's clinical condition and physical fitness level should be considered when choosing the type and intensity of exercise to treat T2DM. There is a relationship between physical activity and FBS reduction with a P-value of 0.001 (Fajriyah, Sudiana, and Wahyuni 2020). Twelve weeks of moderate intensity exercise is feasible and safe for T2DM patients who perform it. Measured blood glucose levels were also used to calculate the duration of exercise (e.g. morning, afternoon, or evening). Morning exercise resulted in greater blood glucose reduction than afternoon or evening exercise in T2DM patients without changing medication regimens. Overall, these preliminary findings provide insight into the best way to create an exercise training program for people with T2DM in the future (Chiang et al. 2019). Exercise can improve the body's insulin sensitivity, which means the body can use insulin more efficiently to help cells absorb glucose and thus help lower blood glucose levels. Exercise should be tailored to the right health condition and be safe. The results showed that respondents had an income below the minimum wage (53.4%). DM patients with financial limitations face difficulties in meeting the costs of personal care and diet, which can interfere with their ability to manage DM well. Nutrition and health management helps in regulating diet and lowering blood sugar levels in T2DM patients (Nabovati et al. 2023). They can gain a better understanding of the importance of maintaining a balanced diet, making healthy food choices, and managing their weight (Rondhianto et al. 2019). A low-sugar diet and a high-wheat fiber diet reduce HbA1c and FBS in T2DM with the results of meta-analysis and sensitivity tests showing significant differences of P-Value 0.001 and P-Value 0.02, respectively (Jing et al. 2023). To sustain a healthy diet, it is necessary to consume whole grains, fruits, and vegetables and reduce the consumption of sugar and saturated fats. There is an association between diet and blood glucose levels with a P-Value of 0.001 (Lee et al. 2019). A controlled diet is essential for managing T2DM, especially for FBS. Regular foot care can reduce diabetic foot disease. Foot care behaviors such as maintaining daily foot hygiene, cutting nails especially toenails

properly, using good footwear, and treating initial foot injuries (Goodall et al. 2020). After pre-test and post-test, there was no relationship between foot exercises and foot care on FBS in patients with T2DM with a P-value of 0.166 (Graciella and Prabawati 2020). There is no direct correlation between foot care and blood glucose in patients with T2DM. However, foot care in T2DM is very important to prevent major complications such as infection and hard-to-heal wounds.

It should be noted that blood glucose in DM patients involves many things, such as adjusting diet, doing physical activity, getting treatment, and monitoring blood sugar. Diabetes mellitus patients have a high risk of experiencing foot problems, such as wounds, and infections. Foot care aims to avoid complications such as nerve damage (neuropathy) or narrowing of blood vessels (angiopathy), which are common in diabetes sufferers and are not directly related to reduced blood sugar levels in T2DM patients. Most respondents never received instructions to care for their feet before measurement, they only carried out basic habits such as washing their feet when they were dirty and drying their feet using a mat. The smartphone application integrated into the CTL model is very helpful in the education and T2DM management in health conditions. Smartphone applications integrated into the CTL model can be used as an effective learning tool and support T2DM patients in managing their health conditions in the future.

CONCLUSION

There is an influence of CTL model smartphone applications and booklets on blood glucose levels and self-care in T2DM patients. The smartphone application in the CTL model had a greater influence on increasing blood glucose levels than the booklet during the three months of intervention. Mean blood sugar levels decreased and self-care behavior increased every month. Monitoring blood glucose levels, exercise and diet influence blood glucose levels in T2DM patients. Foot care does not affect blood glucose levels. Smartphone applications on the CTL model can be a very useful tool to help people better monitor and manage their health conditions. Patients can take a bigger role in managing T2DM themselves without having to rely on health facilities. The app can customize each user's profile to offer more relevant information and more efficient care solutions.

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Ethical Approval

On August 21, 2023, the Health Research Ethics Committee Institut of Health Science of the Indonesian STRADA accepted this study under reference number 000354/EC/KEPK/I/08/2023

Conflict of Interest

There are not conflicts of interest associated with the publication of this research article.

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