

Improving Self-Management of Type 2 Diabetes: Evaluating the Effectiveness of a Mobile App-Based Patient Education Approach

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Abstract— This study evaluates the impact of a mobile app-based educational program on self-management in Type 2 Diabetes Mellitus (T2DM) patients residing in rural areas, a demographic increasingly affected by T2DM and facing limited healthcare access and educational resources. The study adopts a one-group pre-test–post–test design, focusing on the use of the Diabetes Diary mobile app in conjunction with a modified questionnaire based on standardized proven diabetes self-care methodologies. Study participants, chosen through purposive sampling in Lampung, Indonesia, were T2DM individuals aged 18 and above who had access to mobile devices compatible with the app. Those with other types of diabetes or severe diabetic complications were excluded. The research methodology involved evaluating the variation in self-management skills of the participants before and after using the app. Data analysis, conducted via a paired sample t-test, revealed a notable enhancement in self-management capabilities post-intervention (t -value of -2.157, significance value of 0.036). This result supports the hypothesis that an educational program delivered through a mobile application significantly improves diabetes management. The study's findings are consistent with existing literature, which underscores the effectiveness of the diverse educational tools in enhancing patient knowledge and self-care practices. This research contributes essential insights into the utility of mHealth tools in managing diabetes, particularly in rural settings with limited resources.

Keywords— diabetes, health literacy, mobile app, patient education, self-efficacy, type 2 diabetes mellitus

I. INTRODUCTION

Type 2 Diabetes Mellitus, or T2DM for short, represents a significant global health challenge characterized by persistently high blood sugar levels [1] and a substantial impact on both individual health and healthcare systems [2]. Effective management of T2DM necessitates ongoing medical supervision and patient-centric education strategies to mitigate the risk of acute and long-term complications [3], [4], [5]. Among the various educational approaches, patient self-management education is essential in empowering individuals with T2DM to manage their condition effectively [6], [7], [8]. However, the traditional in-person methods of diabetes education often encounter significant challenges in rural settings, where geographic, economic, and logistical barriers can impede access to necessary care.

The emergence of mobile app technology offers a novel pathway to address these modern challenges. Mobile health (mHealth) apps have gained traction as a potential avenue to provide accessible [9], cost-effective [10], and personalized education for diabetes management [11]. All the mobile apps encompass functionalities such as blood glucose monitoring, dietary guidance, physical activity recommendations, and educational materials tailored to individual needs [12], [13], [14]. This study focuses on assessing the effectiveness of a

mobile app-based patient education approach in enhancing self-management among T2DM patients in rural areas. T2DM's increasing prevalence in rural populations is a growing concern. Rural residents frequently encounter distinct obstacles, including limited access to healthcare services [15], reduced health literacy [16], and a scarcity of educational resources compared to urban populations [17]. This disparity accentuates the necessity for innovative and effective diabetes care approaches in these regions [18], [19], [20]. While existing research has highlighted the potential benefits of mHealth tools in managing chronic conditions, there remains a notable lack of specific evidence about their efficacy in rural settings for T2DM management.

This study is prompted by the need to understand and evaluate the effectiveness of mobile technology in improving self-care for T2DM patients in rural settings. The implementation of mobile apps in health education and management is an emerging field with significant potential for impacting diabetes care [21], [22], [23]. By concentrating on rural populations, the study aims to provide insights into customizing mHealth solutions to meet these communities' unique needs effectively. It stands out for its focus on rural populations and the application of a mobile app-based approach specifically designed to cater to the needs and characteristics of this demographic. Despite the growing body of research on mHealth in diabetes management, few studies have concentrated on rural populations, where the need for accessible and impactful diabetes education is most pronounced.

The primary objective of this study is to ascertain whether education supported by mobile applications can enhance self-management in T2DM patients in rural areas. It is hypothesized that a mobile app-based educational method will improve glycemic control, heightened awareness and understanding of diabetes management, and an enhanced overall quality of life for these individuals. This research will utilize a mixed-methods approach, combining quantitative evaluation of clinical outcomes with qualitative participant feedback, to comprehensively understand the intervention's impact.

II. MATERIAL AND METHODS

This study is designed as a one-group pre-test – post-test intervention to evaluate the effectiveness of a mobile app-based patient education program in enhancing the self-management behaviors of individuals with T2DM residing in rural areas in the Province of Lampung, Indonesia. The study employs purposive sampling to select participants, targeting individuals diagnosed with T2DM, aged 18 years or older, living in rural locations defined by specific geographical criteria, and having access to a smartphone or tablet

compatible with the study's mobile application. The inclusion criteria further require participants to have the ability to read and understand the language of the app and study materials and to demonstrate a willingness to participate throughout the study duration and adhere to its requirements. Exclusion criteria are set to omit individuals with other forms of diabetes, such as Type 1 Diabetes Mellitus or Gestational Diabetes, those with severe diabetes complications that could impede participation (e.g., advanced diabetic retinopathy, severe neuropathy), anyone currently engaged in another diabetes education or management study, those without access to appropriate mobile technology, and individuals unable to provide informed consent or comply with study protocols due to cognitive impairments or other reasons.

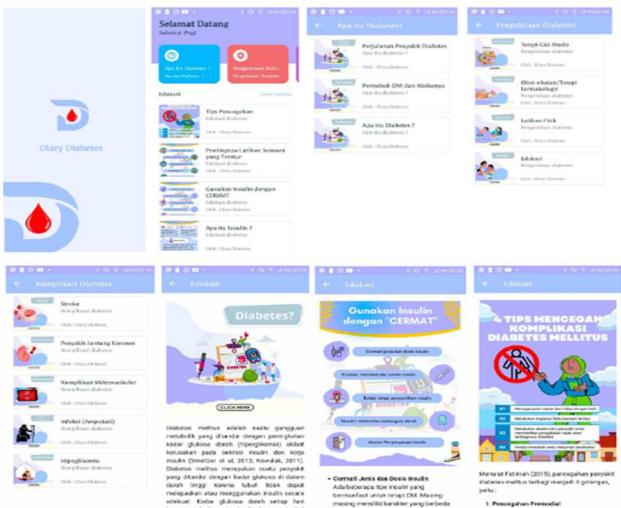


Fig. 1. Screenshots of the diabetes diary user interface

This study evaluated the effectiveness of a mobile app-based education program for enhancing self-management in individuals with T2DM living in rural areas using two main research instruments: the Diabetes Diary mobile app (illustrated in [Error! Reference source not found.](#)) and a modified questionnaire. The app is an app-based digital tool specifically designed for the daily management of diabetes, enabling its users to log various health-related parameters, including blood glucose levels, dietary habits, physical activity, and medication adherence. This app is essential for facilitating the active participation of the participants in managing their diabetes effectively. In conjunction with the app, a modified questionnaire has been developed. This questionnaire integrates components from The Summary of Diabetes Self-Care Activities (SDCA) measure [24] and the Diabetes Self-Management Instrument (SMI) [25]. It is mainly designed to assess the participant's behaviors and knowledge in managing their diabetes, focusing on aspects such as healthy diet, exercise, monitoring blood glucose, and medication adherence.

The data collection process in this research is divided into two main phases: before the intervention (pre-intervention) and after the intervention (post-intervention). Initially, the study participants are asked to complete the Modified Questionnaire to collect baseline data on their knowledge and behaviors regarding diabetes self-management. Concurrently, they are introduced to the Diabetes Diary app, which they are encouraged to utilize daily as a part of their diabetes

management routine. The modified questionnaire is administered once more at the end of the intervention period, characterized by consistent app use. The questionnaire assesses participant proficiency in self-managing T2DM, categorizing their abilities into three distinct scoring ranges: poor, medium, and good. Participants scoring in the 'poor' range (29 – 57) exhibit a basic or below-average understanding of diabetes self-management. This group often faces challenges in maintaining consistent care practices, such as regular blood glucose monitoring and appropriate dietary management, highlighting a potential need for targeted educational interventions to enhance their self-management capabilities. The 'medium' category, encompassing scores from 58 to 86, denotes a moderate level of proficiency. Individuals in this range possess a foundational understanding of diabetes care, yet they may experience difficulty consistently applying it daily. These participants show potential for improvement, particularly in routine monitoring and adherence to lifestyle recommendations. Scores falling in the 'good' range (87 – 116) indicate a high proficiency in diabetes self-management [26], [27], [28]. Participants within this category demonstrate an in-depth understanding of the necessary self-care practices and consistently follow recommended management guidelines. Their scores reflect a robust ability to manage their condition effectively, showcasing a comprehensive application of diabetes self-care knowledge. Data analysis in this study is centered on comparing responses from the questionnaire obtained before and after the intervention. This comparison uses the SPSS software, employing quantitative methods such as paired t-tests or repeated measures ANOVA to identify statistically significant changes in the scores of questionnaire.

III. RESULTS AND DISCUSSION

The demographic profile of all the study participants, all diagnosed with T2DM, offers valuable insights into the group's characteristics. Among the 50 participants (shown in Table I), there is a slight predominance of females, with 27 females (54.00%) and 23 males (46.00%). This balanced gender distribution ensures that the study's results represent both genders. In terms of age, the participants represent a diverse range of adult age groups, predominantly skewed towards older age categories. The group aged 25 to 35 comprises 6 participants (12.00%), and those between 36 and 46 years account for 5 participants (10.00%). A more significant proportion of the participants are in the 47 to 57 years (18 participants, 36.00%) and 58 to 65 years (21 participants, 42.00%) brackets. This age distribution underscores the higher incidence of T2DM in middle-aged and older adults. Various participant's educational backgrounds were also found, with 31 individuals (62.00%) reporting no higher education, while 19 participants (38.00%) attained higher education. This variance indicates a broad spectrum of educational levels within the study population. Regarding occupation, the group is nearly evenly divided, with 24 participants (48.00%) currently employed and 26 (52.00%) not employed, reflecting diverse socioeconomic statuses.

TABLE I. DEMOGRAPHIC INFORMATION OF THE INVOLVED STUDY PARTICIPANTS (N=50)

Demographic Information	N (%)
Gender	
a) Male	23 (46.00)

b) Female	27 (54.00)
Age (years old)	
a) 25 – 35	6 (12.00)
b) 36 – 46	5 (10.00)
c) 47 – 57	18 (36.00)
d) 58 – 65	21 (42.00)
Education (higher)	
a) Yes	19 (38.00)
b) No	31 (62.00)
Occupation	
a) Yes	24 (48.00)
b) No	26 (52.00)
Duration of diabetes (years)	
a) >5 tahun	33 (66.00)
b) <5 tahun	27 (54.00)
mHealth experience	
a) Yes	46 (92.00)
b) No	4 (8.00)

The duration of diabetes among the participants sheds light on the chronic nature of T2DM within this cohort. A notable majority, 33 participants (66.00%), have lived with diabetes for more than five years, suggesting a long-term management experience for most. 17 participants (34.00%), conversely, have been diagnosed with diabetes for less than five years, describing a considerable portion with relatively recent diagnoses. Meanwhile, the experience with mobile health apps is remarkably high in this group, with 46 participants (92.00%) having prior experience with such technology, while only 4 (8.00%) lack this experience. This widespread familiarity with mHealth solutions indicates a general receptiveness to technology-based interventions, a crucial factor for successfully implementing the mobile app-based education program being studied.

A. Descriptive Analysis

The modified questionnaire was administered before and after intervention. This questionnaire categorizes proficiency into three levels: poor, medium, and good. Initially, as shown in Table II, 43 out of 50 participants (86.00%), a significant portion of the study cohort, scored within the 'medium' range (58 – 86). This score suggested a moderate proficiency in diabetes self-management practices. A smaller segment, comprising 4 participants (8.00%), was categorized in the 'poor' range (29 – 57), which indicates a below-average understanding and implementation of essential diabetes self-care routines. Only a minimal number of participants, 4 (6.00%), initially scored in the 'good' range (87 – 116), showing high proficiency in managing their condition. However, the post-intervention results revealed a significant shift in these proficiency levels. The number of participants achieving scores in the 'good' category surged to 46 (92.00%), indicating a considerable enhancement in their diabetes self-management skills following the intervention. This improvement was further underscored by the notable reduction in participants scoring in the 'medium' range, which decreased to just 2 (4.00%). The 'poor' category also saw a slight decline, with the number of participants in this bracket dropping to 2 (4.00%) post-intervention.

TABLE II. THE SCORE OF MODIFIED QUESTIONNAIRE BEFORE AND AFTER INTERVENTION

Categories	Pretest	Posttest
	F (%)	F (%)

Poor (29-57)	3 (8.00)	2 (4.00)
Medium (58-86)	43 (86.00)	2 (4.00)
Good (87-116)	4 (6.00)	46 (92.00)
Total	50 (100.00)	50 (100.00)

B. Normality Test

The normality test is an essential statistical approach for verifying the normal distribution of a dataset. This study employs the Shapiro-Wilk test to assess data normality, focusing on two distinct phases: the pre-test and the post-test. The outcomes of these tests are systematically detailed in Table III. Upon analyzing the data using the Shapiro-Wilk method, it was observed that all variables' significance values (sig.) exceeded 0.05. This result unequivocally suggests that the data across all variables are normally distributed, conforming to the assumptions of normality.

TABLE III. THE RESULTS OF NORMALITY TEST USING THE SHAPIRO-WILK MODEL

Variables	Significance	Description
Pre-test	0.727	Normal Distribution
Post-test	0.436	Normal Distribution

C. Hypothesis Test

Hypothesis test is a crucial key to identifying significant relationships between independent and dependent variables. For this study, the paired sample t-test was selected due to the normal distribution of the data. This specific test is an effective model for evaluating the impact of an intervention or treatment, as evidenced by the variation in average scores before and after its application. The study utilizes the pre-test and post-test results from the respondents to conduct this test. The study's hypotheses are formulated as follows:

- a) H0 (Null Hypothesis): No significant change is observed in the self-management quality among T2DM patients following the smartphone app-based educational intervention.
- b) H1 (Alternative Hypothesis): A significant change is evident in the self-management quality among T2DM patients following the smartphone app-based educational intervention.

The paired sample t-test, positioned within comparative hypothesis test, is designed to determine if there are notable differences in the mean values of the same sample group across two points in time. This model involves calculating the average scores from the pre-test and the post-test. The subsequent section details the outcomes derived from the paired sample t-test. The t-test plays a role in comparative hypothesis testing, often called comparison testing. This method is utilized to determine whether there are significant differences in the mean values among the same groups of samples. It includes the computation of average scores from both pre-tests and post-tests. Table IV below is the findings from the conducted paired samples t-test.

TABLE IV. THE RESULTS OF PAIRED SAMPLES T-TEST

Variables	Mean ± SD	T	Significance
Pre-test	73.40 ± 1.232	-	
Post-test	74.60 ± 1.337	-2.157	0.036

The conducted paired samples t-test yielded a t-value of -2.157, signifying a significant increase in averages, further confirmed by a significance value of 0.036 (sig. 0.036 < 0.05).

Therefore, the hypothesis "There is a significant correlation between intervention efficacy and the efficient enhancement of management in diabetic patients" is supported. The data reveal that study participants answered more questions post-utilization of the Diabetes Diary mobile app. According to a literature review by Aida et al. (2020), educational materials such as images, texts, videos, and interactions can elevate an individual's knowledge [29]. Other positive studies by Dong (2019) and Ge (2023) note that human knowledge is primarily gained through direct experience (90%), reading and speaking (70%), listening and observing (50-60%), visual perception (30%), and auditory processes (20%) [30], [31]. This finding is consistent with a research by Mehraeen et al. (2021), showing that educational apps significantly improve the patients' and their families' understanding and capabilities in managing diabetes for self-care at home [32].

D. Strength and Limitation of the Study

This study outlines several notable strengths. Primarily, the application of the paired sample t-test, recognized for its statistical robustness, significantly bolsters the reliability of our findings. It is particularly relevant given the normal distribution of our data, facilitating a precise assessment of the intervention's impact on self-management in Type 2 diabetes patients. Additionally, the focus on smartphone app-based education is both timely and pertinent, mirroring the growing trend of incorporating technology into public healthcare practices. Nevertheless, the study is not without its limitations. A primary concern is the reliance on self-reported data, which may introduce bias due to subjective study participant perceptions and interpretations of the questionnaire. Moreover, the limited sample size as well as specific demographic profile of the participants could restrict the broader applicability of the results. It is a significant consideration if the participant pool is not diverse or is confined to a certain geographic area, potentially limiting the findings' relevance to the wider T2DM patient population. Furthermore, the relatively brief duration of the study may not adequately reflect the long-term effectiveness and sustained impact of the mobile app-based intervention in diabetes management.

IV. CONCLUSION

This study is designed as a one-group pre-test – post-test intervention to evaluate the effectiveness of a mobile app-based patient education program in enhancing the self-management behaviors of individuals with T2DM residing in rural areas in the Province of Lampung, Indonesia. The study employs purposive sampling to select participants, targeting individuals diagnosed with T2DM, aged 18 years or older, living in rural locations defined by specific geographical

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CONFLICT OF INTEREST

The author declares there are no any conflicts of interest regarding the publication of this paper.

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