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Digital Health Interventions to Support Self-Management in Patients with Type 2 Diabetes

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Abstract

This quantitative study examines how digital health interventions (DHIs), such as web-based platforms, telemonitoring, and mobile apps, affect patients with Type 2 diabetes mellitus (T2DM) in terms of self-efficacy, medication adherence, and glycemic control. 150 adults between the ages of 30 and 65 who had been using DHIs for at least three months were gathered from Makassar, Indonesia, outpatient clinics. A standardized questionnaire on digital usage, the Morisky Medication Adherence Scale (MMAS-8), the Diabetes Management Self-Efficacy Scale (DMSES), and clinical records of HbA1c were used to collect data. Multiple regression, t-tests, and Pearson correlation were among the statistical analyses carried out. The findings showed that self-efficacy, adherence, and engagement with digital tools were significantly positively correlated, and that regular users had reduced HbA1c levels. According to regression analysis, self-efficacy, adherence, and DHI use together accounted for 49% of the variance in glycemic control. When compared to infrequent users, regular users saw improvements in HbA1c that were clinically significant. All things considered, DHIs successfully improve clinical and behavioral outcomes in the management of diabetes. In order to improve long-term clinical results, empower self-management, and enhance patient-centered treatment, the study highlights the integration of digital tools into healthcare systems.

INTRODUCTION

Type 2 diabetes mellitus (T2DM) has become one of the most pressing chronic diseases globally, affecting hundreds of millions of people and straining healthcare systems worldwide. The International Diabetes Federation (IDF) reported that approximately 537 million adults were living with diabetes in 2021, and this number is projected to rise to 643 million by 2030. Among these, over 90% of cases are Type 2 diabetes, a condition strongly influenced by lifestyle factors such as diet, physical inactivity, and obesity (American Diabetes Association). Managing T2DM requires lifelong behavioral adjustments and continuous self-monitoring to prevent complications such as neuropathy, retinopathy, cardiovascular disease, and renal failure (Joseph et al., 2022; Bodhini et al., 2023). Despite extensive medical advances, effective self-management remains a key challenge, especially in low- and

middle-income countries where access to healthcare support is limited (Pillon et al., 2021; Siddiqui et al., 2024; Dadi et al., 2024; Davis et al., 2022).

Self-management refers to patients' ability to manage symptoms, treatment, and lifestyle changes associated with chronic illness (Das et al., 2025). In diabetes care, this includes blood glucose monitoring, dietary regulation, medication adherence, and physical activity (Ikwuka et al., 2023). However, adherence to these practices is often suboptimal due to factors such as low motivation, insufficient knowledge, and poor access to continuous education (Yang et al., 2022). Traditional face-to-face diabetes education programs have shown positive effects but are often constrained by time, distance, and availability of healthcare professionals (Ciumărnean et al., 2021; Catapan et al., 2021; Reis et al., 2022). As a result, there has been growing interest in leveraging digital health technologies to overcome these barriers and enhance patient self-management capacity.

Digital health interventions (DHIs) encompass the use of technologies such as mobile health (mHealth) applications, telemedicine, web-based platforms, and wearable sensors to deliver health services and promote behavioral change (Hossain et al., 2024). These technologies facilitate personalized communication, remote monitoring, and data-driven feedback that support patients in maintaining glycemic control. For instance, mHealth applications allow patients to track blood glucose levels, record dietary habits, and receive automated reminders for medication or exercise. Additionally, telehealth services provide real-time consultation and coaching from healthcare providers, which have been shown to improve adherence and reduce hospital visits (Janjua et al., 2021; Sharma et al., 2024). Emphasizes digital health as an essential component of sustainable healthcare systems, especially for chronic disease management where continuity of care is crucial.

A growing body of evidence supports the effectiveness of DHIs in improving outcomes among patients with Type 2 diabetes. Studies have demonstrated significant reductions in glycated hemoglobin (HbA1c) levels, improved medication adherence, and enhanced patient self-efficacy following digital intervention programs. A meta-analysis found that mobile app–based interventions significantly lowered HbA1c levels compared to standard care. Reported that patients using mobile coaching applications exhibited better glucose control and higher satisfaction. However, the effectiveness of DHIs varies depending on factors such as intervention design, frequency of use, user engagement, and technological literacy. While some studies have shown substantial benefits, others reported minimal or inconsistent outcomes, suggesting a need for further empirical evaluation in diverse settings.

Despite the promising evidence, the adoption of digital health technologies in diabetes management remains uneven across different populations. In many developing countries, technological accessibility, health literacy, and infrastructure limitations hinder the optimal use of such interventions (Ouédraogo, 2024). Moreover, variations in patients' engagement with digital platforms may influence the sustainability of behavior change (Ghorbanian et al., 2022). Hence, it is crucial to understand not only the potential effectiveness of digital health tools but also how their utilization patterns relate to key outcomes such as glycemic control and medication adherence. This perspective aligns with the growing emphasis on patient-centered care and personalized digital health strategies (Mustapha et al., 2021).

Another important consideration is the psychological dimension of self-management. Digital health tools do not merely deliver information they can also enhance motivation and confidence through feedback mechanisms, goal-setting features, and social support functions. Self-efficacy, defined as an individual's belief in their ability to perform specific health-related behaviors, has been identified as a major determinant of successful diabetes self-care (Warner & Schwarzer, 2024). Studies

have shown that digital interventions that foster self-efficacy lead to greater improvements in glycemic outcomes compared to those focusing solely on information delivery (Dolatabadi et al., 2022). Therefore, evaluating how digital interventions affect self-efficacy alongside clinical outcomes is vital to understanding their full impact.

Given this context, this study focuses on quantitatively examining the influence of digital health interventions on self-management among patients with Type 2 diabetes. Specifically, it investigates how engagement with digital tools affects glycemic control, medication adherence, and self-efficacy. The rationale for this study is grounded in the urgent need for scalable, cost-effective strategies to support patients in managing their condition autonomously while reducing dependence on healthcare systems. The findings aim to contribute to the empirical evidence base for digital health integration in diabetes care, particularly in contexts where healthcare accessibility remains a challenge.

By focusing on measurable outcomes such as HbA1c levels and validated behavioral scales, this research provides an evidence-driven understanding of how digital interventions can enhance chronic disease self-management. Ultimately, the study seeks to support health policymakers and practitioners in designing effective digital health programs tailored to patients' needs. In doing so, it responds to the global call for the digital transformation of healthcare systems and provides insights into how technological innovation can bridge gaps in chronic disease management and patient empowerment (Kırca & Kutlutürkan, 2021).

METHODS

This study employed a quantitative research design with a cross-sectional approach to examine the relationship between digital health interventions and self-management outcomes among patients with Type 2 diabetes. The quantitative approach was chosen because it allows the researcher to measure, analyze, and generalize relationships among variables numerically and statistically. The study aimed to assess the impact of digital health intervention use on key outcomes such as glycemic control, medication adherence, and self-efficacy in self-management. The cross-sectional nature of the research enabled the collection of data at a single point in time, providing an overview of how digital tools currently support diabetes management among the study population. This design was particularly suitable for evaluating associations among measurable indicators of self-management effectiveness.

Research Location and Population

The research was conducted at two major diabetic outpatient clinics in Makassar City, Indonesia, both of which provide regular follow-up programs for patients with Type 2 diabetes. These clinics were chosen because they have integrated digital health tools, such as mobile-based diabetes monitoring applications, into their patient education and follow-up services. The study population consisted of adult patients diagnosed with Type 2 diabetes for at least one year and enrolled in these digital health support programs. This population was considered appropriate because it provided access to individuals who were familiar with both traditional and digital modes of diabetes self-management.

Sampling Technique and Sample Size

A purposive sampling technique was applied to select participants who met specific inclusion criteria: (1) adults aged between 30 and 65 years, (2) diagnosed with Type 2 diabetes for at least one year, (3) registered users of digital health applications for diabetes management for a minimum of three months, and (4) willing to participate voluntarily. Patients with severe complications or cognitive impairments that could

interfere with their ability to self-report data were excluded. The sample size was determined using a statistical power analysis with a confidence level of 95% and a margin of error of 5%. Based on this calculation, a minimum of 150 participants was deemed sufficient to ensure reliable results for correlation and regression analyses. This number also aligns with recommendations for medium-effect quantitative studies involving multiple regression models.

Research Variables

This study included one independent variable and three dependent variables. The independent variable was the use of digital health interventions, operationalized as the level of engagement and frequency of use of mobile or online diabetes management applications. The dependent variables were: Glycemic control, measured through the most recent HbA1c levels obtained from medical records. Medication adherence, assessed through self-report instruments. Self-efficacy, reflecting the confidence level of patients in managing their diabetes care. These variables were chosen to comprehensively represent both clinical and behavioral outcomes of diabetes self-management.

Data Collection

Data collection involved both clinical records and standardized questionnaires. The HbA1c levels were obtained from the participants' latest laboratory results, recorded within the previous three months, ensuring the accuracy of glycemic data. Medication adherence was measured using the Morisky Medication Adherence Scale (MMAS-8), an eight-item validated instrument widely used in chronic disease management studies. This scale measures adherence behaviors such as forgetting doses, discontinuing medication when feeling better, and timing consistency. Scores range from 0 to 8, with higher scores indicating better adherence. Self-efficacy was assessed using the Diabetes Management Self-Efficacy Scale (DMSES), consisting of 20 items rated on a 5-point Likert scale. This instrument measures patients' confidence in performing various self-care tasks, such as controlling diet, managing stress, and adjusting insulin or oral medication. To measure digital intervention usage, the researcher developed a structured questionnaire based on existing digital health utilization frameworks. The questionnaire assessed frequency of use, types of features accessed, and perceived usefulness. Before administration, all instruments were translated into Bahasa Indonesia and reviewed by two diabetes educators to ensure contextual and linguistic validity.

Validity and Reliability

Prior to the main data collection, a pilot test was conducted with 20 participants who met the inclusion criteria but were not part of the main sample. The purpose was to test the clarity and reliability of the questionnaire items. The validity of each construct was verified through Pearson product-moment correlation, where all items with correlation coefficients above 0.30 were retained. Reliability testing using Cronbach's alpha indicated acceptable internal consistency: 0.82 for the MMAS-8, 0.88 for the DMSES, and 0.85 for the digital intervention usage scale. These results confirmed that the instruments were both valid and reliable for further data collection.

Data Collection Procedure

After receiving ethical approval from the institutional review board, data collection was conducted over a three-month period. Patients attending the diabetic outpatient clinics were approached by the researcher with the assistance of clinic nurses. After obtaining informed consent, participants were provided with a questionnaire packet and given time to complete it in a private room to ensure confidentiality and focus.

Participants' clinical HbA1c data were retrieved from electronic health records with authorization from the attending physicians. Each questionnaire took approximately 20–25 minutes to complete. All collected data were coded and stored securely for analysis.

Data Analysis

Data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 26. Descriptive statistics were used to summarize demographic characteristics, digital intervention usage, and mean scores for self-efficacy and adherence. Inferential statistical analyses were then performed to examine the study hypotheses. A Pearson correlation test was applied to identify relationships between digital health intervention usage and each of the dependent variables. To determine predictive relationships, multiple linear regression analysis was conducted with digital health intervention usage as the independent variable and HbA1c, medication adherence, and self-efficacy as the dependent variables. Additionally, an independent samples t-test was conducted to compare HbA1c levels between frequent and infrequent digital health users. All analyses used a significance level of $p < 0.05$, with results interpreted in accordance with standard statistical guidelines for behavioral and clinical studies.

RESULTS AND DISCUSSION

Prior to presenting the results, it is important to contextualize the analysis within the study's objective of evaluating the impact of digital health interventions on self-management among patients with Type 2 diabetes. The collected data encompass clinical outcomes, behavioral measures, and self-reported engagement with digital tools, providing a comprehensive picture of how technology supports patient adherence, confidence, and glycemic control. Descriptive statistics were first examined to understand the demographic characteristics and patterns of digital tool usage, followed by inferential analyses to assess relationships and predictive effects between digital health engagement, medication adherence, self-efficacy, and HbA1c levels. This structured approach allows for a detailed examination of both the behavioral and clinical dimensions of self-management, laying the foundation for interpreting the effectiveness of digital interventions in enhancing patient-centered diabetes care.

Descriptive Statistics

Table 1. Demographic Characteristics and Digital Health Intervention Usage

Category	Value
Total Participants	150
Age Range	30–65 years
Mean Age	56 years
Gender Distribution	53% Male, 47% Female
Digital Health Intervention Tools Used	Mobile Apps, Telemonitoring, Web-Based Platforms
Frequency of Digital Tool Usage	5–7 days per week
Most Frequently Accessed Features	Medication Reminders (80%), Blood Glucose Tracking (75%), Diet Management Tools (65%)

The data from 150 adult patients with Type 2 diabetes who engaged with digital health interventions (DHIs) for at least three months were analyzed. The cohort consisted of individuals aged 30 to 65, who were recruited from outpatient clinics in Makassar, Indonesia. Among the participants, 53% were male, and 47% were female,

with a mean age of 56 years. The demographic distribution indicates a typical middle-aged group, reflecting the population most affected by Type 2 diabetes.

Digital health tools, including mobile apps, telemonitoring systems, and web-based platforms, were utilized to enhance diabetes self-management. The most frequently accessed features were medication reminders (80%), blood glucose tracking (75%), and diet management tools (65%). On average, participants reported using the digital tools 5–7 days a week, suggesting a high level of engagement.

Pearson Correlation Analysis

A Pearson correlation analysis was conducted to explore the relationships between digital intervention usage, medication adherence, self-efficacy, and glycemic control (HbA1c levels). Table 1 presents the correlation matrix:

Table 2. Pearson Correlation Matrix

Variables	Digital Intervention Usage	Medication Adherence	Self-Efficacy	HbA1c Level
Digital Intervention Usage	1	0.624**	0.548**	-0.517**
Medication Adherence	0.624**	1	0.486**	-0.432**
Self-Efficacy	0.548**	0.486**	1	-0.471**
HbA1c Level	-0.517**	-0.432**	-0.471**	1

Note: $p < 0.01$ for all correlations.

The results indicate that digital health intervention usage had a significant positive correlation with both medication adherence ($r = 0.624$, $p < 0.01$) and self-efficacy ($r = 0.548$, $p < 0.01$). Additionally, digital health usage showed a significant negative correlation with HbA1c levels ($r = -0.517$, $p < 0.01$), suggesting that more frequent engagement with digital tools was associated with better glycemic control.

Multiple Regression Analysis

A multiple regression analysis was performed to examine the predictive relationships between digital health intervention usage, medication adherence, and self-efficacy on HbA1c levels. Table 2 presents the model summary:

Table 3. Multiple Regression Model Summary

Model	R	R^2	Adjusted R^2	Std. Error of Estimate	F	Sig.
1	0.701	0.491	0.481	0.542	46.52	< 0.001

The regression model explained approximately 49.1% of the variance in HbA1c levels ($R^2 = 0.491$, $p < 0.001$), indicating that digital health interventions, medication adherence, and self-efficacy are significant predictors of glycemic control.

Table 4. Regression Coefficients

Predictor Variables	B	Std. Error	β	t	Sig.
(Constant)	9.452	0.387	—	24.42	<0.001
Digital Intervention Usage	-0.321	0.062	-0.404	-5.18	<0.001
Medication Adherence	-0.287	0.078	-0.291	-3.68	<0.001
Self-Efficacy	-0.214	0.069	-0.227	-3.10	0.002

As seen in Table 3, digital intervention usage ($\beta = -0.404$, $p < 0.001$) was the strongest predictor of glycemic control. Medication adherence ($\beta = -0.291$, $p < 0.001$) and self-efficacy ($\beta = -0.227$, $p = 0.002$) also significantly contributed to improving HbA1c

levels, with all predictors showing inverse relationships with HbA1c, indicating that higher engagement in these behaviors results in better glycemic control.

Independent t-Test for HbA1c Levels

To compare glycemic control between frequent and infrequent users of digital health tools, an independent t-test was conducted. Table 4 shows the results of this comparison:

Table 5. Independent Samples t-Test for HbA1c Levels

Group	N	Mean HbA1c (%)	Std. Deviation	t	df	Sig. (2-tailed)
Frequent Users	80	6.85	0.58	-6.12	148	<0.001
Infrequent Users	70	7.48	0.63			

Frequent users of digital health tools had significantly lower HbA1c levels (M = 6.85, SD = 0.58) compared to infrequent users (M = 7.48, SD = 0.63) with a mean difference of 0.63%, which is clinically significant (t = -6.12, p < 0.001). This highlights the importance of consistent digital tool engagement in improving glycemic control.

The findings of this study underscore the pivotal role of digital health interventions in enhancing self-management among patients with Type 2 diabetes. By integrating technology into daily care routines, these interventions have demonstrated significant improvements in clinical outcomes, particularly glycemic control, medication adherence, and self-efficacy. This discussion delves into the implications of these results, emphasizing their relevance to management studies and offering a critical analysis of their broader impact (Kasmia & M'hamed, 2023). The substantial correlation between digital health intervention usage and improved self-management behaviors aligns with existing literature highlighting the efficacy of technology in promoting health behavior modifications. Studies have consistently shown that digital tools, such as mobile applications and wearable devices, facilitate continuous monitoring and personalized feedback, which are crucial for sustaining behavioral changes in chronic disease management. For instance, research indicates that digital interventions can lead to significant reductions in HbA1c levels, demonstrating their potential in enhancing patient engagement and adherence to treatment protocols. These findings suggest that integrating digital health interventions into routine care can serve as a catalyst for positive behavioral changes, thereby improving overall disease management.

Medication adherence remains a critical challenge in the management of Type 2 diabetes (Yeasmin, 2024). The positive association observed between digital health intervention usage and medication adherence in this study corroborates findings from other research that emphasizes the role of digital tools in improving adherence rates. Digital platforms offer features such as medication reminders, educational content, and real-time monitoring, which can address common barriers to adherence, including forgetfulness and lack of motivation. By providing patients with timely and relevant information, these interventions empower individuals to take an active role in their treatment, leading to better health outcomes. The evidence supports the integration of digital health interventions into clinical practice as a strategy to enhance medication adherence and, consequently, disease control.

Self-efficacy, or the confidence in one's ability to manage health behaviors, is a significant predictor of successful diabetes management (Susanty, 2024; Motamedimoghadam et al., 2025). The study's findings that digital health intervention usage correlates with increased self-efficacy are consistent with the theoretical framework that links self-management support to improved health

outcomes. Digital tools can enhance self-efficacy by providing patients with immediate feedback, goal-setting capabilities, and educational resources tailored to their individual needs (Limet al., 2023; Newby et al., 2021; Li & Alharbi, 2025). This personalized approach fosters a sense of competence and control, which is essential for sustaining long-term behavior changes. The evidence suggests that incorporating digital health interventions into diabetes care can bolster self-efficacy, thereby improving patient engagement and health outcomes.

From a healthcare management perspective, the integration of digital health interventions presents both opportunities and challenges (Angerer et al., 2022; Abernethy et al., 2022; Wang et al., 2021). On one hand, these technologies can streamline care delivery, reduce healthcare costs, and improve patient outcomes. On the other hand, their implementation requires addressing issues related to data privacy, equity of access, and the digital divide. Policymakers must consider these factors when developing strategies to incorporate digital health interventions into standard care practices. Ensuring that all patients have access to these technologies and the necessary support to use them effectively is crucial for maximizing their benefits. Moreover, healthcare providers must be trained to utilize these tools to their full potential, ensuring that they complement traditional care methods rather than replace them.

While this study provides valuable insights into the impact of digital health interventions on diabetes self-management, several limitations warrant consideration. The cross-sectional design limits the ability to establish causal relationships between digital health intervention usage and health outcomes. Longitudinal studies are needed to assess the long-term effects and sustainability of these interventions. Additionally, the study's reliance on self-reported data may introduce bias, as patients may overestimate their adherence to digital tools. Future research should aim to include objective measures of digital health intervention usage and explore the mechanisms through which these tools influence behavior and health outcomes. Investigating the effectiveness of different types of digital interventions across diverse populations can also provide a more comprehensive understanding of their impact.

CONCLUSION

This study demonstrates that digital health interventions play a critical role in enhancing self-management among patients with Type 2 diabetes by significantly improving glycemic control, medication adherence, and self-efficacy. The findings underscore that consistent engagement with technology-driven tools not only supports behavioral change but also strengthens patients' confidence and autonomy in managing their condition. From a management perspective, these results highlight the strategic value of integrating digital health solutions into healthcare delivery systems to optimize outcomes, reduce long-term costs, and promote patient-centered care. Ultimately, the study provides robust evidence that leveraging digital interventions is both a practical and necessary approach to modernizing diabetes management, offering scalable and sustainable pathways for improving chronic disease care in diverse clinical and organizational contexts.

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