

Digital Therapeutics in Type 2 Diabetes: Transforming Self-Management Through Technology-Driven Care

Alshada Sharf^{1*}; R. Divyadharshini²; S. Gopal²;
V. Gowrishankar²; P. Hemavathi²; U. Suriya²

¹Assistant Professor, Department of Pharmacy Practice -Shree Venkateshawara College of Paramedical Science Gobi-638455, Erode (DT), Tamil Nadu Affiliated to The Tamil Nadu Dr. MGR Medical University, Chennai

² Department of Pharmacy Practice -Shree Venkateshawara College of Paramedical Science Gobi-638455, Erode (DT), Tamil Nadu Affiliated to The Tamil Nadu Dr. MGR Medical University, Chennai

Corresponding Author: Alshada Sharf*

Publication Date: 2026/03/10

Abstract: Particularly in primary care settings, digital health interventions have shown promise in enhancing medication adherence in patients with Type 2 Diabetes Mellitus (T2DM). A highly customized text and voice messaging intervention was assessed in a feasibility randomized controlled trial carried out in the UK to help patients with hypertension and/or type 2 diabetes take their medications as directed. Based on each person's beliefs, obstacles, and clinical traits, the intervention provided tailored behavioral support messages. Results showed that this type of customized digital communication is doable, patient-acceptable, and could enhance medication compliance and associated clinical outcomes in the treatment of chronic illnesses.

The study also shown how individuals with type 2 diabetes can improve their self-management practices by incorporating theory-based behavioral approaches into mHealth platforms. When compared to conventional treatment, participants who received the intervention demonstrated increased engagement and good trends in adherence, suggesting that scalable digital messaging systems could improve long-term disease control. The study backs up the expanding importance of digital health technologies in routine primary care practice to enhance adherence and optimize outcomes for people with Type 2 Diabetes.

How to Cite: Alshada Sharf; R. Divyadharshini; S. Gopal; V. Gowrishankar; P. Hemavathi; U. Suriya (2026) Digital Therapeutics in Type 2 Diabetes: Transforming Self-Management Through Technology-Driven Care. *International Journal of Innovative Science and Research Technology*, 11(2), 3051-3060. <https://doi.org/10.38124/ijisrt/26feb1254>

I. INTRODUCTION

Insulin resistance and decreased insulin production are hallmarks of type 2 diabetes mellitus (T2DM), a chronic metabolic disease that causes persistent hyperglycemia. With its fast expanding prevalence brought on by ageing populations, sedentary lifestyles, and rising obesity rates, it constitutes a significant global public health concern. Serious microvascular and macrovascular consequences, including as retinopathy, nephropathy, neuropathy, cardiovascular disease, and an increased risk of death, are linked to poor glycaemic management in people with type 2 diabetes. Medication adherence is a key component of diabetes therapy since

constant adherence to prescribed medication and lifestyle changes are essential for the long-term effective control of type 2 diabetes^[1]. Among patients with type 2 diabetes, medication non-adherence is still very common, even with the advent of effective pharmaceutical therapy. According to studies, between 30 and 50 percent of people with diabetes do not take their prescription drugs as directed. A number of variables, including complicated prescription regimens, forgetfulness, ignorance of the condition, fear of adverse effects, the expense of therapy, and inadequate patient-provider communication, can contribute to non-adherence, which can be purposeful or inadvertent. Poor glycaemic control, an elevated risk of complications, a higher

hospitalization rate, and higher healthcare expenses are all consequences of suboptimal adherence, underscoring the pressing need for creative approaches to assist patients with long-term prescription use^[2].

Particularly in hectic primary care settings, traditional methods of enhancing drug adherence, such as in-person counseling and printed teaching materials, have demonstrated limited and uneven efficacy. These treatments frequently require a lot of resources and might not offer ongoing assistance outside of clinical visits. The need for continuous, scalable, and patient-centered adherence therapies is becoming more widely acknowledged since T2DM necessitates lifelong care. By facilitating continuous interaction, remote monitoring, and tailored feedback for individuals with diabetes, digital technology advancements have opened up new avenues for addressing these issues^[3]. A vast array of technologies are included in digital health interventions (DHIs), such as web-based self-management programs, electronic medication monitors, telemedicine platforms, short messaging service (SMS) reminders, and mobile health (mHealth) applications.

By addressing behavioral, cognitive, and motivational barriers through self-tracking, education, reminders, and real-time connection with medical professionals, these approaches seek to increase drug adherence. DHIs are becoming more widely available, especially in situations with low resources, because to the growing usage of cellphones and internet connection, making them attractive tools for managing chronic diseases^[4].

Research indicates that people with type 2 diabetes may benefit from digital health interventions in terms of glycaemic outcomes and medication adherence. Digital monitoring systems and telehealth-based interventions can improve adherence, increase patient engagement, and support better self-management of diabetes and related comorbidities like hypertension, according to randomized controlled trials and feasibility studies carried out in primary care settings. By reducing needless clinic visits, these initiatives may lessen the strain on healthcare systems and also help with fast clinical decision-making^[5].

Additionally, digital health interventions have the benefit of customisation, which enables them to be customized to meet the requirements, preferences, and health literacy levels of each patient. Automated reminders, inspirational messaging, and feedback on medication-taking behaviour are just a few examples of features that might strengthen adherence patterns and encourage patients to actively manage their health. It has been demonstrated that patient-centered digital solutions increase self-efficacy and satisfaction, two important factors that influence long-term adherence in chronic conditions like type 2 diabetes^[6]. Finally, it should be noted that medication adherence is still a major problem in the treatment of type 2 diabetes mellitus, with serious consequences for both patient outcomes and healthcare systems. Through the provision of ongoing, easily accessible, and patient-centered support, digital health treatments offer a creative and promising strategy for enhancing adherence. It

may be possible to improve glycaemic control, increase medication adherence, and lessen the burden of diabetes-related comorbidities by incorporating evidence-based digital solutions into routine diabetic treatment. To assess the long-term efficacy, cost-effectiveness, and implementation tactics of digital health interventions in various healthcare settings, more study is necessary^[7].

II. BURDEN ON MEDICATION ADHERENCE

A major problem in the treatment of Type 2 Diabetes Mellitus (T2DM) is medication non-adherence, which raises the risk of complications and results in poor glycemic control. Increased HbA1c levels are more likely to occur in patients who do not take their insulin or oral hypoglycemic medications as prescribed. This can result in microvascular and macrovascular problems such retinopathy, nephropathy, neuropathy, and cardiovascular disease. Additionally, non-adherence raises hospital stays and medical expenses, which puts a significant strain on individuals and healthcare systems. According to studies, adherence rates among T2DM patients are still below ideal because of things like forgetfulness, complicated treatment plans, adverse effects, and a lack of knowledge on how to manage the condition^[12].

In those with type 2 diabetes, medication non-adherence has a significant clinical and financial cost. Reduced quality of life, more ED visits, and the advancement of the disease are all linked to poor adherence. Uncontrolled diabetes causes avoidable complications that have a substantial financial impact on health systems. Better adherence is directly associated with better glycemic outcomes and lower healthcare utilization, according to evidence from studies of remote monitoring programs. Therefore, improving long-term diabetes outcomes requires addressing medication-taking behaviour^[13].

Digital health interventions have been a successful way to increase T2DM patients' adherence to their medications. Programs for remote monitoring combine automated reminders, linked glucose meters, and medical professional supervision to improve patient involvement and treatment adherence. In comparison to standard care, a study published in the *Journal of Managed Care & Specialty Pharmacy* showed that taking part in a digital remote monitoring program greatly enhanced glycemic control and medication adherence. These results demonstrate how technology-based interventions might lessen the burden of non-adherence in the treatment of diabetes^[14].

Promising outcomes have also been observed in mobile health (mHealth) applications created especially for diabetic self management. A digital health application that included glucose tracking, medication reminders, educational materials, and individualized feedback enhanced medication-taking behaviour and glycemic parameters in patients with type 2 diabetes, according to a pilot research published in the *Journal of Clinical Medicine*. By addressing typical obstacles like forgetfulness and a lack of awareness about the disease, these programs promote improved self-care and adherence^[13].

Additionally, compared to standard treatment, systematic reviews and meta-analyses assessing Diabetes Self-Management Education and Support (DSMES) provided via mobile applications have shown notable gains in medication adherence. These digital DSMES interventions make use of interactive modules, customized messaging, and ongoing involvement to support healthy lifestyle choices. According to the data, digital platforms can improve adherence among T2DM patients by offering scalable solutions and supplementing traditional healthcare services^[14].

In summary, poor glycemic control and more problems result from medication non-adherence in type 2 diabetes, which has a significant clinical and financial impact. Medication adherence and health outcomes have been shown to be improved by digital health treatments, such as mobile-based DSMES applications and remote monitoring programs. The burden of non-adherence can be lessened and overall diabetes treatment can be improved by putting these technology-driven strategies into practice^[12-14].

➤ *Overview of Digital Health Technologies in Improving Medication Adherence for Type 2 Diabetes Mellitus*

Lastly, it should be mentioned that medication adherence remains a significant issue in the management of type 2 diabetes mellitus, with grave implications for healthcare systems and patient outcomes. Digital health therapies present a novel and promising approach to improving adherence by offering continuous, conveniently accessible, and patient-centered assistance. By integrating evidence-based digital solutions into standard diabetic therapy, it may be able to improve glycaemic control, boost medication adherence, and reduce the burden of diabetes-related comorbidities. Further research is required to evaluate the cost-effectiveness, long-term effectiveness, and implementation strategies of digital health interventions in diverse healthcare settings^[15].

Effective management of type 2 diabetes depends on medication adherence because noncompliance can result in uncontrolled glucose levels, an elevated risk of complications, and increased medical expenses. Nearly 45% of people with chronic illnesses, such as diabetes, do not take their prescriptions as directed, according to studies. To overcome obstacles including forgetfulness, ignorance, and inadequate patient-provider communication, digital health solutions have been developed, including teleconsultations, mobile apps with prescription tracking capabilities, and automated reminders. By enabling people to actively participate in their treatment regimens, these technologies improve patient engagement^[8].

One of the most popular digital technologies for enhancing medication adherence in type 2 diabetes is mobile health (mHealth) treatments. Features like blood glucose monitoring, dosing reminders, educational resources, and feedback systems are all offered by smartphone applications. When compared to standard treatment, mHealth-based therapies have been shown in randomized controlled studies to dramatically enhance adherence rates and glycemic control.

Furthermore, SMS-based reminder systems have demonstrated benefits in encouraging consistent prescription

use, especially in environments with limited resources where smartphone access may be restricted^[16].

By facilitating constant communication between patients and healthcare professionals, telemedicine and remote patient monitoring technologies also improve drug adherence. Without the need for in-person visits, medical providers can check glucose readings, modify medicine, and offer counseling through virtual consultations. This method lowers the possibility of therapeutic inertia and enhances therapy follow-up. Research indicates that telemedicine interventions help patients with type 2 diabetes, particularly those living in remote or underserved locations, increase their HbA1c levels and adherence practices^[17].

Additionally, wearable technology and digital pill systems are examples of cutting-edge methods for tracking adherence. Digital sensors, linked glucometers, and smart insulin pens can all capture data on drug use and send it instantly to healthcare platforms. When non-adherence is identified, these devices enable prompt interventions and offer objective adherence tracking. Despite their potential, issues including data privacy, cost, digital literacy, and technological accessibility need to be resolved to guarantee that digital health solutions are implemented fairly^[18].

To sum up, digital health technologies provide all-encompassing and patient-centered methods for enhancing medication adherence in people with Type 2 Diabetes Mellitus. Healthcare systems can improve treatment compliance, glycemic control, and general quality of life by incorporating wearable technology, telemedicine, mHealth apps, and SMS reminders into standard care. However, interdisciplinary cooperation, policy backing, and methods to get over technology obstacles are necessary for successful implementation. Interventions in digital health are becoming more widely acknowledged as crucial elements of contemporary diabetic care^[15-18].

➤ *mHealth Interventions in Type 2 Diabetes Mellitus for Improving Medication Adherence*

The term "mobile health" (mHealth) describes the application of wireless technologies, cellphones, and tablets to support public health and medical procedures. mHealth therapies have become useful tools for enhancing glycemic control, promoting self-management, and improving medication adherence in the context of Type 2 Diabetes Mellitus (T2DM). Global smartphone adoption has increased quickly, allowing healthcare providers to give patients with individualized interventions, real-time monitoring, and educational support. In chronic conditions like type 2 diabetes, where long-term medication adherence is essential for preventing consequences including nephropathy, neuropathy, and cardiovascular illnesses, mHealth techniques are especially beneficial^[19].

Globally, medication adherence in type 2 diabetes is still a major problem. According to studies, between 30 and 50 percent of diabetic patients do not follow their treatment plans to the letter. Forgetting, complicated dosage regimens, ignorance, psychological resistance, or financial limitations

can all lead to non-adherence. Suboptimal glycemic control, higher hospitalization rates, and higher healthcare expenses are all consequences of poor adherence. By offering automatic reminders, interactive communication, behavioral reinforcement, and ongoing monitoring support, mHealth therapies seek to remove these obstacles^[8].

SMS-based medicine reminders are among the most popular mHealth tactics. Even in environments with limited resources, Short Message Service (SMS) interventions are accessible and reasonably priced. These systems remind patients on a daily or weekly basis to take their medications, check their blood sugar levels, and eat the right foods. Text messaging dramatically enhances clinical outcomes and medication adherence in patients with chronic conditions, including type 2 diabetes, according to meta-analyses. SMS interventions are particularly helpful for older people or those lacking access to sophisticated smartphone apps^[16].

A more complete type of mHealth intervention is represented by smartphone applications. Features including medication recording, glucose monitoring logs, dose calculating tools, advice on lifestyle modifications, and real-time feedback are common in diabetes care apps. Automatic data synchronization is made possible by the integration of numerous applications with wearable technology or glucometers. When compared to standard care, randomized controlled trials have shown that patients who use diabetes-specific mobile applications have better medication adherence and lower HbA1c values. By increasing self-efficacy and encouraging active involvement in disease management, these apps empower patients^[18].

Two-way communication between patients and healthcare providers is another crucial element of mHealth therapies. Clinicians may quickly monitor patient progress and modify treatment plans with the help of mobile technologies that provide data sharing, teleconsultation, and messaging. This ongoing interaction improves patient-provider connections and lessens treatment inertia. Research indicates that interactive mHealth therapies, which combine behavioral change strategies, tailored feedback, and motivational support, are more successful than one-way reminder systems^[17].

When creating successful mHealth therapies, behavioral theories are essential. Theoretical frameworks including the Self-Determination Theory, Social Cognitive Theory, and Health Belief Model serve as the foundation for many diabetes treatment programs. Features like goal-setting, progress tracking, reward systems, and peer support communities are all incorporated according to these frameworks. mHealth technologies that address psychological drivers of adherence help patients change their attitudes and beliefs about managing their diseases in addition to reminding them to take their meds^[20].

Medication adherence techniques are further strengthened by remote monitoring via mHealth platforms. Cloud-based solutions that provide alerts for aberrant levels allow patients to submit their lifestyle data, prescription intake information, and glucose measurements.

When non-adherence or inadequate glycemic control is identified, medical professionals can take early action. Research has indicated that the integration of mobile applications with remote monitoring greatly enhances adherence rates and metabolic outcomes in people with type 2 diabetes, especially in underserved or rural areas^[21].

Despite the encouraging advantages, there are still difficulties in putting mHealth solutions into practice. Widespread use may be restricted by issues with digital literacy, privacy, data security, application costs, and a lack of regulatory norms. Additionally, it can be challenging to maintain interest over time because some patients stop using the app once their initial enthusiasm wanes. In order to optimize long-term efficacy, successful mHealth initiatives necessitate user-friendly design, cultural adaptability, training assistance, and integration into standard healthcare procedures^[22].

To sum up, mHealth interventions are a game-changer for enhancing Type 2 Diabetes Mellitus patients' adherence to their drug regimens. mHealth improves therapeutic results and patient involvement through behavioral support systems, smartphone applications, interactive communication, SMS reminders, and remote monitoring technology. Although there are still issues with sustainability and accessibility, there is compelling evidence that mobile health techniques can be included into comprehensive diabetes treatment models to increase adherence and lower complications^[19-22].

➤ *Telehealth and Telepharmacy Interventions for Improving Medication Adherence in Type 2 Diabetes Mellitus*

Telehealth is the practice of providing healthcare services remotely by using digital communication technologies including video conferencing, mobile platforms, and remote monitoring devices. Telehealth has grown in significance in the treatment of Type 2 Diabetes Mellitus (T2DM) in order to promote long-term disease control and medication adherence. Telehealth offers a systematic and practical way for routine follow-up, patient education, and prompt professional intervention because diabetes necessitates ongoing monitoring and lifelong medication. Patients who live in underserved or rural areas and have limited access to specialized diabetic care will especially benefit from this strategy^[15].

Poor glycemic control, more complications, and higher healthcare expenses are all consequences of medication non-adherence, which is still a major problem in the management of type 2 diabetes. Barriers like poor patient-provider communication, restricted appointment availability, and transportation issues are addressed via telehealth therapies. Healthcare providers can evaluate adherence trends, modify medication, and strengthen self-management practices through planned virtual consultations. When compared to standard care, telemedicine interventions dramatically enhance HbA1c levels and adherence outcomes, according to evidence from systematic reviews^[17].

One essential element of telehealth services for diabetic management is remote patient monitoring, or RPM. RPM systems enable patients to electronically send medication

consumption information and blood glucose measurements to medical professionals.

Early intervention is made possible by automated warnings that can detect skipped medications or abnormal glucose levels. Research has demonstrated that by encouraging accountability and ongoing participation, combining remote monitoring and teleconsultation improves treatment adherence and metabolic results^[23].

An offshoot of telehealth, telepharmacy focuses exclusively on providing pharmacological care from a distance. Pharmacists who offer telepharmacy services use video or phone platforms to manage drug therapy, give medication counseling, check prescriptions, and assist with adherence. It has been demonstrated that telepharmacy treatments conducted by pharmacists increase drug adherence rates and lessen medication-related issues in T2DM patients. These services are especially helpful in places with limited access to clinical pharmacists^[24].

➤ *Role of Pharmacists in Digital Adherence Programs for Improving Medication Adherence in Type 2 Diabetes Mellitus*

Long-term medication and ongoing self-management are necessary for Type 2 Diabetes Mellitus (T2DM), a chronic metabolic disease. Glycemic management and the avoidance of consequences like nephropathy, neuropathy, and cardiovascular illnesses depend heavily on medication adherence. Non-adherence, however, continues to be a significant worldwide issue that frequently leads to subpar treatment results and higher medical expenses. In order to overcome adherence obstacles, digital adherence programs—which integrate technologies like telepharmacy, electronic reminders, mobile health applications, and remote monitoring systems—have proven to be successful. Because of their proficiency in patient counseling and drug administration, pharmacists are essential to the planning, execution, and monitoring of these digital interventions^[8].

By offering medication treatment management (MTM) via telehealth platforms, pharmacists make a substantial contribution to digital adherence programs. Pharmacists can evaluate pharmaceutical regimens, identify drug-related issues, evaluate adherence trends, and offer individualized counseling using private messaging platforms, video consultations, or phone conversations. Research indicates that telemedicine sessions conducted by pharmacists enhance glycemic results and medication adherence in individuals with type 2 diabetes. Their participation guarantees precise drug reconciliation and therapy optimization, improving the efficacy of treatment^[17].

Pharmacists actively assist adherence through the use of mobile health (mHealth) applications in addition to teleconsultation. Features including dose tracking, blood glucose logging, medication reminders, and educational modules are included in a lot of diabetes management apps. Pharmacists can monitor adherence data sent through these platforms, instruct patients on how to utilize them, and assist patients in choosing the right digital tools.

Research indicates that when compared to standard care, pharmacist-supported mHealth interventions greatly increase patient engagement and adherence^[21].

The pharmacist's role in digital adherence initiatives is further expanded via telepharmacy services. Pharmacists offer prescription evaluation, medication counseling, follow-up treatment, and remote dispensing verification through telepharmacy. Patients in underserved or rural locations, where access to community pharmacies may be limited, can especially benefit from this method. Studies show that among patients with chronic illnesses, including type 2 diabetes, telepharmacy treatments increase medication adherence rates and decrease prescription mistakes.^[24]

Additionally, pharmacists are crucial in deciphering data produced by digital adherence technologies like electronic pillboxes, smart insulin pens, and remote glucose monitors. Pharmacists can spot missing doses, erratic medicine use, or non-compliance tendencies by examining real-time adherence data. Timely interventions, including dose modifications or behavioral therapy, are made possible by early diagnosis. Patient safety is improved and glycemic control results are improved when pharmacist supervision is integrated with digital monitoring systems^[18].

Another essential element of adherence programs is behavioral counseling provided by pharmacists via online channels. To overcome social and psychological obstacles to adherence, pharmacists use patient-centered communication tools and motivational interviewing techniques. Frequent follow-up and reinforcement of adherence behaviors are made possible by digital communication tools. Research indicates that when digital technologies are integrated with pharmacist-led behavioral therapies, patients with type 2 diabetes exhibit long-lasting improvements in their medication-taking habits^[25].

Integrated digital health systems improve pharmacists' ability to collaborate with other medical providers. Multidisciplinary care coordination is made easier by secure communication systems, shared digital dashboards, and electronic health records (EHRs).

In these cooperative approaches, doctors oversee overall clinical care, and pharmacists provide their knowledge of medications. Research shows that when compared to fragmented care systems, team-based digital care models with pharmacists greatly enhance adherence and metabolic results^[26].

Despite the advantages, a number of obstacles hinder the adoption of digital adherence programs run by pharmacists. These include challenges with patients' digital literacy, restricted reimbursement regulations, technological impediments, and worries about data security and privacy. Furthermore, proper infrastructure support and training are necessary for the incorporation of digital platforms into standard pharmacy practice. To optimize the efficacy and durability of pharmacist-driven digital adherence programs, these issues must be resolved^[27].

To sum up, pharmacists are essential to digital adherence programs that help people with Type 2 Diabetes Mellitus take their medications as prescribed. Pharmacists optimize medication and improve patient involvement through data monitoring, behavioral counseling, mHealth assistance, telehealth consultations, and telepharmacy services. Their proactive participation in interdisciplinary digital care models greatly enhances glycemic control and lowers complications associated with diabetes. To advance contemporary diabetic care, pharmacist involvement in digital health initiatives must be strengthened^[8-27].

➤ *Clinical Effectiveness and Outcomes of Digital Health Interventions in Improving Medication Adherence in Type 2 Diabetes Mellitus*

The chronic progressive disease known as type 2 diabetes mellitus (T2DM) necessitates long-term medication and lifestyle changes in order to attain ideal glycemic control. In order to avoid microvascular and macrovascular problems, medication adherence is essential. To increase adherence and improve clinical results, digital health interventions including as telemedicine, SMS reminders, telepharmacy, remote patient monitoring, and mobile health (mHealth) applications have been used more and more. To ascertain how these therapies affect glucose control, patient involvement, and healthcare utilization, it is imperative to assess their clinical efficacy^[15].

Glycated haemoglobin (HbA1c) is one of the main metrics used to evaluate the success of digital adherence strategies in type 2 diabetes. When compared to normal care, patients undergoing digital health interventions showed significantly lower HbA1c levels, according to a number of randomized controlled trials and meta-analyses. Modest but clinically significant decreases in HbA1c were shown by a systematic assessment of telemedicine therapies, especially when those interventions included interactive feedback and routine monitoring. Better metabolic regulation is closely correlated with increased adherence made possible by digital tools^[17].

Applications for mobile health (mHealth) have demonstrated beneficial benefits on glycemic outcomes and medication adherence. Features like glucose monitoring, medication reminders, and real-time feedback greatly improve self-management habits, according to studies assessing app-based therapies. When compared to conventional treatment methods, mHealth programs were linked to considerable HbA1c reduction and better medication adherence, according to a meta-analysis of digital interventions for type 2 diabetes. These results imply that long-term disease management is well supported by digital platforms^[18].

Clinically effective telehealth strategies have also been shown to improve diabetes outcomes, such as remote monitoring and video consultations. Healthcare professionals can detect non-adherence early and make prompt therapy modifications by communicating and transmitting data continuously. Patients who take part in structured telehealth programs report better glycemic control and increased treatment compliance, according to data from randomized

trials. These results emphasize how crucial it is to incorporate digital follow-up into regular diabetic management^[23].

Customized digital messaging interventions and SMS-based reminder systems also enhance adherence and clinical results. Research shows that patients who receive text message reminders for their medications on a regular basis had better adherence rates and slightly lower HbA1c levels. SMS interventions are especially successful in low-resource environments because of their accessibility and ease of use. Personalized and engaging messages have a greater effect on adherence and glycemic control^[16].

Digital health interventions have a significant impact on secondary clinical outcomes such as body weight, lipid profiles, and blood pressure in addition to glycemic management. Better overall cardiometabolic risk management is frequently associated with better adherence to antidiabetic treatment. Additionally, several studies have shown that patients who participate in digital diabetes management programs experience fewer ED visits and hospital admissions. These results suggest that digital interventions help to improve health and healthcare utilization more broadly^[29].

Digital adherence programs also show improvements in quality of life metrics and patient-reported outcomes. People who use digital tools frequently report improved illness knowledge, more self-efficacy, and enhanced patient engagement. Digital health interventions promote long-term adherence habits and increased treatment satisfaction by giving patients the tools they need to actively engage in their care. These psychological advantages go hand in hand with clinically significant improvements in metabolic markers^[21].

Notwithstanding the generally encouraging results, the degree of clinical efficacy varies according to the patient demographic, duration, design, and degree of interaction. Multi-component interventions, such as mHealth apps with teleconsultation and pharmacist assistance, typically yield better and longer-lasting results. However, careful interpretation is required due to study heterogeneity and differences in outcome measures. To prove long-term efficacy and cost-efficiency, further excellent randomized controlled trials are needed^[27].

In summary, individuals with Type 2 Diabetes Mellitus benefit greatly from digital health interventions in terms of bettering glycemic outcomes and medication adherence. Their importance in managing chronic diseases is demonstrated by lower HbA1c levels, better cardiometabolic parameters, more patient participation, and lower healthcare utilization. The inclusion of digital adherence techniques into comprehensive diabetes care models is supported by current data, while more research is required to optimize intervention design and scalability^[15-27].

➤ *Barriers and Challenges of Digital Health Interventions in Improving Medication Adherence in Type 2 Diabetes Mellitus*

Among patients with Type 2 Diabetes Mellitus (T2DM), digital health interventions such as telemedicine, SMS reminders, telepharmacy, remote patient monitoring, and mobile health (mHealth) applications have shown promise in enhancing medication adherence. Nevertheless, a number of obstacles prevent their broad use and sustainability, even in spite of their therapeutic efficacy. Patients, providers, technology, organizations, and policies all face these difficulties. For digital adherence initiatives in diabetes treatment to be implemented fairly and successfully, these challenges must be recognized and addressed^[15].

Limited digital literacy is one of the main obstacles pertaining to patients. Many people with type 2 diabetes, especially older patients, might not have the abilities needed to properly use cellphones, mobile apps, or remote monitoring equipment. Digital platform navigation issues can cause annoyance, decreased interest, and usage termination. Additionally, patients' capacity to benefit from digital interventions may be further limited by cognitive impairment, visual difficulties, and low educational attainment. Improving adoption rates requires addressing digital literacy gaps through training and streamlined application design^[30].

Another important element limiting access to digital health technologies is socioeconomic status. Not every patient has access to the data plans needed for telehealth services, cellphones, or dependable internet connectivity. The cost of devices and digital infrastructure can be significant obstacles in low- and middle-income environments. Because people from underprivileged backgrounds would not be able to take advantage of digital adherence initiatives, this digital divide can make health inequities worse. Therefore, ensuring accessibility and affordability is a significant implementation difficulty^[22].

Another major obstacle to the adoption of digital health is privacy and data security concerns. Concerns about data breaches, illegal access, or misuse of private information may make patients reluctant to divulge personal health information online. Building patient trust requires adherence to regulatory norms, such as data protection legislation and safe encryption methods. Digital adherence initiatives may encounter opposition from patients and healthcare providers in the absence of strong data governance standards^[31].

Barriers relating to healthcare providers also affect how successful digital adherence initiatives are. Integrating digital tools into normal practice may be limited for many doctors due to a lack of training or confidence. Adoption of telehealth or digital monitoring systems may also be hampered by increasing workload, time constraints, and opposition to change. Adequate training, institutional support, and workflow integration are necessary for successful implementation in order to guarantee that digital interventions enhance healthcare providers rather than burden them^[32].

Implementing digital health is made more difficult by technological obstacles such as software bugs, interoperability concerns, and system integration issues. Electronic health records (EHRs) and many digital platforms are not completely integrated, which leads to fragmented data management and job duplication. Technical issues and erratic internet connectivity can interfere with remote communication and monitoring. Standardized interoperability protocols and dependable infrastructure are necessary for long-term digital health solutions^[29].

In digital adherence initiatives, maintaining patient participation is another difficulty. Even while there may be a lot of initial excitement for telehealth services or mobile applications, long-term commitment to digital technologies frequently decreases over time. Repetitive reminders, message weariness, or a lack of personalization can all lower user motivation. Compared to static reminder systems, research indicates that interventions that include interactive elements, personalization, and behavioral change strategies have a higher chance of sustaining long-term engagement^[20].

The scalability of digital health interventions is also impacted by policy and payment concerns. Reimbursement strategies for telehealth or telepharmacy services are either ambiguous or inadequate in many healthcare systems. Uncertainty about professional obligations and responsibility may result from a lack of uniform rules and regulations. To promote the broad use of digital adherence tactics, policymakers must create enabling laws and long-term financing sources^[26].

In conclusion, a number of obstacles prevent digital health treatments from reaching their full potential, despite the fact that they present encouraging ways to enhance medication adherence in people with Type 2 Diabetes Mellitus. To guarantee fair and long-lasting implementation, issues pertaining to digital literacy, socioeconomic inequality, privacy concerns, provider preparedness, technology infrastructure, patient participation, and policy frameworks must be resolved. To maximize the benefits of digital health in diabetes management, healthcare professionals, legislators, technology developers, and patients must work together to overcome these challenges^[15-26].

III. FUTURE DIRECTIONS AND RECOMMENDATIONS

➤ *Digital Health Interventions in Improving Medication Adherence in Type 2 Diabetes Mellitus*

When it comes to helping patients with Type 2 Diabetes Mellitus (T2DM) adhere to their treatment regimens, digital health interventions have shown encouraging results. However, enhancing long-term sustainability, customization, and integration into standard healthcare systems must be the main goals of future growth. Innovative digital solutions are required to improve overall treatment results, decrease complications, and promote self-management as the prevalence of diabetes continues to climb globally. Future projects should focus on addressing present implementation

and scalability constraints as well as expanding on the evidence now in place^[15].

The incorporation of predictive analytics and artificial intelligence (AI) into digital adherence systems is one of the main future directions. In order to provide individualized suggestions and early warnings for non-adherence, AI-based systems can evaluate patient data, such as glucose readings, medication patterns, and behavioral trends. Healthcare professionals can take pre-emptive measures by using predictive models to identify high-risk patients. Intelligent algorithm integration could improve the accuracy and responsiveness of digital adherence programs in the treatment of type 2 diabetes^[22].

Another crucial suggestion is to enhance the compatibility of electronic health record (EHR) systems with digital health solutions. Effective communication amongst healthcare professionals is limited by the fact that many modern digital applications function independently. Coordinated treatment, thorough medication control, and real-time data sharing would all be made easier by a smooth interaction with EHRs. Interoperable technologies can enhance interdisciplinary cooperation between doctors, pharmacists, and diabetes educators, which will ultimately improve adherence results^[26].

Future digital health initiatives should prioritize behavioral science concepts and patient-centered design. Patient engagement can be greatly increased by content personalization, culturally appropriate messaging, and literacy level adaption. Digital platforms may improve adherence behaviors by integrating goal-setting tactics, motivational interviewing techniques, and feedback mechanisms. Increased usability, acceptance, and long-term adherence can be achieved by involving patients in the co-design and assessment of digital solutions^[20].

One of the top priorities for the future is addressing the digital divide and health disparities. For some people, especially the elderly and those from low socioeconomic backgrounds, limited access to cellphones, internet connectivity, and digital literacy continues to be a major obstacle. To guarantee fair access, policymakers and healthcare institutions should put policies like device subsidies, streamlined user interfaces, and digital literacy training initiatives into place. Without these safeguards, digital health initiatives could unintentionally increase diabetes care inequities^[30].

Another crucial suggestion is to strengthen the participation of interdisciplinary teams and pharmacists in digital adherence programs. Pharmacists can assist with medication optimization, offer telepharmacy counseling, and keep an eye on digital adherence data. Digital platforms that facilitate collaboration between patients and medical teams can enhance therapeutic results and accountability. Research indicates that digital technology-enabled integrated care models result in longer-lasting gains in glycemic control and medication adherence^[24].

Future policy decisions must be guided by cost-effectiveness analysis and long-term clinical evaluation. Although numerous studies show improvements in HbA1c and adherence rates in the short term, more thorough longitudinal research is needed to evaluate long-term advantages and economic implications. High-quality randomized controlled trials and standardized outcome measures will bolster the body of evidence and facilitate the widespread adoption of digital adherence initiatives^[23].

Future innovations will also depend critically on ensuring cybersecurity, data privacy, and regulatory compliance. Participation and patient trust can be increased by establishing transparent governance frameworks and keeping safe data management systems. Furthermore, in order to include digital adherence treatments into traditional healthcare delivery systems, regulatory requirements and appropriate payment policies are necessary^[31].

In summary, technology innovation, system integration, patient-centered methods, equitable access, and supporting regulatory frameworks are critical to the future of digital health treatments for promoting medication adherence in people with Type 2 Diabetes Mellitus. The potential of digital technologies in diabetes treatment will be maximized by integrating artificial intelligence, improving interoperability, fortifying interdisciplinary collaboration, and making sure long-term evaluation is done. To make digital adherence programs a standard part of all-encompassing diabetes care, strategic planning and consistent funding are needed^[15-31].

IV. CONCLUSION

For patients with Type 2 Diabetes Mellitus (T2DM), digital health interventions have become a novel and successful way to enhance medication adherence. Mobile health apps, SMS reminders, telehealth, telepharmacy, and remote patient monitoring systems are examples of technologies that improve patient involvement, encourage self-management, and enable ongoing follow-up. Randomized controlled trials and comprehensive reviews have shown evidence that these interventions lead to better adherence practices and clinically significant drops in HbA1c levels. Digital health tools are essential for improving glycemic control and averting complications from diabetes by encouraging consistent medication use and prompt therapy modifications.

Additionally, patient-centered care and interdisciplinary collaboration are promoted by digital adherence programs. Medication management is strengthened and treatment results are improved when pharmacists, doctors, and other healthcare professionals are integrated through digital platforms. Even though there are still issues like infrastructure constraints, privacy concerns, and digital literacy, these can be resolved with sustained innovation, legislative backing, and fair implementation techniques. All things considered, digital health treatments are a game-changer for contemporary diabetes care and have a great deal of promise to enhance long-term clinical results for people with type 2 diabetes.

REFERENCES

- [1]. World Health Organization. Global report on diabetes. Geneva: WHO; 2016.
- [2]. Jimmy B, Jose J. Patient medication adherence: measures in daily practice. *Oman Med J.* 2011;26(3):155–159.
- [3]. Nieuwlaat R, Wilczynski N, Navarro T, et al. Interventions for enhancing medication adherence. *Cochrane Database Syst Rev.* 2014;11:CD000011.
- [4]. World Health Organization. WHO guideline: recommendations on digital interventions for health system strengthening. Geneva: WHO; 2019.
- [5]. McManus RJ, Mant J, Franssen M, Nickless A, Schwartz C, Hodgkinson J, et al. Efficacy of self-monitored blood pressure, with or without telemonitoring, for titration of antihypertensive medication (TASMINH4): an unmasked randomised controlled trial. *Lancet.* 2018 Mar 10;391(10124):949-959. doi:10.1016/S0140-6736(18)30309-X.
- [6]. Can Hou, Carter B, Hewitt J, Francisa T, Mayor S. Do mobile phone applications improve glycemic control (HbA1c) in the self-management of diabetes? A systematic review, meta-analysis, and GRADE of 14 randomized trials. *Diabetes Care.* 2016 Nov;39(11):2089–2095. doi:10.2337/dc16-0346.
- [7]. Vrijens B, De Geest S, Hughes DA, et al. A new taxonomy for describing and defining adherence to medications. *Br J Clin Pharmacol.* 2012;73(5):691–705.
- [8]. Sabaté E. Adherence to long-term therapies: evidence for action. Geneva: World Health Organization; 2003.
- [9]. Polonsky WH, Henry RR. Poor medication adherence in type 2 diabetes: recognizing the scope of the problem and its key contributors. *Patient Prefer Adherence.* 2016;10:1299–1307.
- [10]. Ho PM, Rumsfeld JS, Masoudi FA, McClure DL, Plomondon ME, Steiner JF, et al. Effect of medication nonadherence on hospitalization and mortality among patients with diabetes mellitus. *Arch Intern Med.* 2006;166(17):1836–1841.
- [11]. Kassavou A, et al. A highly tailored text and voice messaging intervention to improve medication adherence in hypertension and type 2 diabetes: feasibility randomized controlled trial. *J Med Internet Res.* 2020;22(5):e16629. doi:10.2196/16629.
- [12]. KD, et al. Impact of a diabetes remote monitoring program on medication adherence. *J Manag Care Spec Pharm.* 2021 Jun;27(6):724-731. doi:10.18553/jmcp.2021.27.6.724.
- [13]. Effectiveness of a Digital Health Application for the Treatment of Diabetes Type II—A Pilot Study. *J Clin Med.* 2023;12(19):6317.
- [14]. Nkhoma DE, Soko CJ, Banda KJ, Greenfield D, Iqbal U, et al. Impact of DSMES app interventions on medication adherence in type 2 diabetes mellitus: systematic review and meta-analysis. *BMJ Health Care Inform.* 2021 Apr;28(1):e100291. doi:10.1136/bmjhci-2020-100291.
- [15]. World Health Organization. Global strategy on digital health 2020–2025. Geneva: World Health Organization; 2021.
- [16]. Thakkar J, Kurup R, Laba TL, et al. Mobile telephone text messaging for medication adherence in chronic disease: a meta-analysis. *JAMA Intern Med.* 2016;176(3):340–349.
- [17]. Lee SWH, Ooi L, Lai YK. Telemedicine for the management of glycemic control in patients with type 2 diabetes: systematic review and meta-analysis. *J Med Internet Res.* 2017;19(8):e275.
- [18]. Kebede MM, Zeeb H, Peters M, Heise TL, Pischke CR. Effectiveness of digital interventions for improving glycemic control in persons with poorly controlled type 2 diabetes: a systematic review, meta-analysis, and meta-regression analysis. *Diabetes Technol Ther.* 2018;20(11):767-782. doi:10.1089/dia.2018.0216.
- [19]. World Health Organization. mHealth: New horizons for health through mobile technologies. Geneva: World Health Organization; 2011.
- [20]. Holmen H, Wahl AK, Cvancarova Småstuen M, et al. Tailored communication within mobile apps for diabetes self-management: a systematic review. *J Med Internet Res.* 2017;19(6):e227.
- [21]. Bonoto BC, de Araújo VE, Godói IP, et al. Efficacy of mobile health interventions for diabetes treatment: systematic review and meta-analysis. *JMIR Mhealth Uhealth.* 2017;5(3):e4.
- [22]. Marcolino MS, Oliveira JAQ, D'Agostino M, et al. The impact of mHealth interventions: systematic review of systematic reviews. *JMIR Mhealth Uhealth.* 2018;6(1):e23.
- [23]. Tchero H, Kangambega P, Briatte C, Brunet-Houdard S, Retali GR, Rusch E. Clinical effectiveness of telemedicine in diabetes mellitus: a meta-analysis of 42 randomized controlled trials. *Telemed J E Health.* 2019;25(7):569–583.
- [24]. Poudel A, Nissen LM. Telepharmacy: a pharmacist's perspective on the clinical benefits and challenges. *Integr Pharm Res Pract.* 2016;5:75–82.
- [25]. Odegard PS, Capoccia K. Medication taking and diabetes: a systematic review of the literature. *Diabetes Educ.* 2007;33(6):1014–1029.
- [26]. Martínez-González NA, Berchtold P, Ullman K, Busato A, Egger M. Integrated care programmes for adults with chronic conditions: a meta-review. *Int J Qual Health Care.* 2014;26(5):561–570.
- [27]. Kruse CS, Krowski N, Rodriguez B, Tran L, Vela J, Brooks M. Telehealth and patient satisfaction: a systematic review and narrative analysis. *BMJ Open.* 2017;7(8):e016242.
- [28]. Dobson R, et al. Diabetes text-message self-management support program (SMS4BG): a pilot study. *JMIR Mhealth Uhealth.* 2015;3(1):e32. doi:10.2196/mhealth.3988.
- [29]. Marcolino MS, Maia JX, Alkmim MBM, et al. Telemedicine application in the care of diabetes patients: systematic review and meta-analysis. *PLoS One.* 2013;8(11):e79246.
- [30]. Kruse CS, Mileski M, Moreno J. Mobile health solutions for the aging population: a systematic narrative analysis. *J Telemed Telecare.* 2017;23(4):439–451.

- [31]. Kruse CS, Frederick B, Jacobson T, Monticone DK. Cybersecurity in healthcare: a systematic review of modern threats and trends. *Technol Health Care*. 2017;25(1):1–10.
- [32]. Gagnon MP, et al. m-Health adoption by healthcare professionals: a systematic review. *J Am Med Inform Assoc*. 2016;23(1):212–220. doi:10.1093/jamia/oc