

Telemedicine for diabetes care: An Indian perspective - Feasibility and efficacy

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ABSTRACT

Diabetes is a chronic and costly disease. In India, the usual practice among patients is to visit the doctor once in every 2–3 months to get advice on changes in the dosages of medications. The Diabetes Tele Management System (DTMS[®]) is a telemedicine based follow-up program originally introduced at Jothydev's Diabetes Research Centre at Trivandrum South India in 1998. It is a chronic disease management system which enables patient to interact lively with a professionally trained multidisciplinary team comprising of diabetes educators, nurses, dieticians, pharmacists, psychologists, physicians, etc., in modifying the dosages of medications, diet, and physical activity either through telephone/email/secure website. The uniquely designed software and the trained multidisciplinary team overcomes the globally recognized major barriers to diabetes management namely fear of hypoglycemia, polypharmacy, discontinuation of stains, and antihypertensives or wrong injection techniques. DTMS is designed to provide individualized therapy advices on glycosylated hemoglobin, blood pressure, and low density lipoprotein customized to multiple patient characteristics which help attain goals of therapy. The system has been tested on various platforms over a decade and was shown to be a patient friendly approach with successful outcomes due to a live "round-the-clock" interactive communication in contrast to text or recorded messages. The major challenge to the widespread use of DTMS[®] is seeking a source of funding this unique telemedicine program.

Key words: Cost-effectiveness, diabetes, follow-up, hypoglycemia, technology, telemedicine

INTRODUCTION

Diabetes mellitus (DM) and its costly complications have attained epidemic proportions across the globe and are currently considered as one of the most challenging public health problems. The prevalence of diabetes is on the rise with 67 million patients in India compared to 24.1 million in the USA.^[1-3] Diabetes irrespective of the type, ethnicity, and age of onset is a progressive disease culminating in a multitude of complications. Rising prevalence, shortage of trained diabetologists, and complexity of treatment

translates to poor health outcomes and failure to reach desired therapeutic targets.^[4] A systematic, organized, and co-ordinated approach is crucial for the optimal management of diabetes where both clinicians and patients play a critical role. Strong evidence demonstrates beneficial effects of patient monitoring and education, focused on a prominent role of the individual self-care with the support of healthcare professionals. This brings into focus the great advances in telecommunication technology and information technology, which can be exploited to improve diabetes management. Telemedicine can be a strategy for closer monitoring and intervention to achieve not only better metabolic control, but also to help in the global care of individuals with concomitant chronic diseases. Over the last decade, several studies have addressed the feasibility

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and efficacy of telemedicine strategies on the management of diabetes patients. Many studies have proved it to be feasible, but the real impact of this intervention in general and specific clinical situations is still unknown and poorly documented, as the results are not consistent among different studies. In this perspective, the present review has been conducted to explore the scope and impact of telemedicine in the management of DM in Indian scenario.

THE CHRONIC NATURE OF DIABETES AND PATIENT EMPOWERMENT

The recent years have noticed a major escalation in the treatment strategy of diabetes with the evolution of newer antidiabetic drugs. However, many patients could not reap the progress of this development and still experience complications that jeopardize length and quality of life. In general, the health system is equipped to deliver acute, symptom-driven care during emergencies and is poorly configured to effectively treat chronic diseases such as diabetes that require the development of a collaborative daily self-management plan. Traditionally, the success of patients to manage their diabetes has been judged by their ability to adhere to a prescribed therapeutic regimen. However, patients would require very frequent changes in dosage regimens and cannot adhere to a fixed prescription, either because of hyperglycemia or hypoglycemia. Majority of patients continue suboptimal prescription dosages due to the fear of hypoglycemic emergencies. A study by Chan *et al.*, observed that only 3.6% of Type 2 diabetes patients attain all three recommended targets.^[4] A great deal of effort has been spent in developing methods for measuring compliance and techniques and strategies to promote adherence. The serious and chronic nature of diabetes, the complexity of its management, and the multiple daily self-care decisions that diabetes requires mean that being adherent to a predetermined care program is generally not adequate over the course of a person's life with diabetes. To manage diabetes successfully, patients must be able to set goals and make frequent daily decisions that are both effective and fit their values and lifestyles, while taking into account multiple physiological and personal psychosocial factors. Intervention strategies like telemedicine that empower patients to make decisions about goals, therapeutic options, and self-care behaviors and to assume responsibility for daily diabetes care are effective in helping patients care for themselves.

Telemedicine in simple terms may be defined as the use of telecommunications to support healthcare.^[5] The simplest telecommunication equipment is an ordinary telephone. Conventionally, telemedicine has been popular among cardiology,^[6] ophthalmology,^[7] radiology,^[8] etc., for

transfer of videos, images, and other data from remote areas. Telemedicine may also be utilized to facilitate communication between the physician and the patient who are separated by any distance. Two modalities of telemedicine interventions are commonly practiced.^[9]

Long-term

Where physicians, hospitals, and pharmacies will be connected by a single distributed regional healthcare delivery network as a part of chronic disease management.

Short-term

Designed for a particular class of patients such as those starting treatment for newly detected Type 1 diabetes, brittle diabetes, patients started on insulin pump therapy, etc.^[10]

In the past, telemedicine technology was limited mostly to Type 1 diabetes patients. With the introduction of concepts like “user modeling” and “context awareness”^[9] in telemedicine technology, wearable computers, personal digital assistants,^[11] laptops^[12] mobile phone platforms, automated dialogue systems, etc., have been advocated even in the management of Type 2 diabetes.^[13] The paradigm of visit-by-visit systems has been changed to day-by-day systems satisfying both the physician and patient requirements.^[14,15] From a mere tool to monitor lifestyle, physical activity, and drug compliance and a set algorithm to titrate insulin, the latest technology integrates guidelines and decision support systems as well.^[16] Telemedicine initiatives can have a profound impact on different aspects of patient care including informational, clinical, behavioral, structural, and economic. The informational impact is a better quality of dynamic information than handwritten records, which may be lost unknowingly. The clinical impact is a more frequent communication of information and instructions to patients which can lead to improved outcomes with lower A1C levels or fewer adverse sequelae. In the Western world, many programs have been undertaken to explore the impact of telemedicine in diabetes management notably the Columbia University Informatics for Diabetes Education and Telemedicine (IDEATel) Project and the diabetes interactive diary initiative. In India, diabetes is on escalation with more than 67 million diabetic individuals currently diagnosed with the disease. However, it may be prudent to mention here that a literature search revealed that there is a dearth of any telemedicine initiative for diabetic patients in Indian scenario. In this perspective, the authors take the opportunity to state that a concept of telemedicine program in vogue since 1999 in a chronic outpatient diabetes follow-up care center in Trivandrum, India where simple telecommunication gadgets provide space for two-way interaction between patients and the healthcare delivery team at the hospital.^[17-19]

Telemedicine in diabetes: Principles of operation

According to Klonoff *et al.*,^[20] the five essential components of a functioning telemedicine system should include (1) a process for accurate data collection, (2) an electronic medical record for data incorporation and remote transmission, (3) a set of protocols for distant data analysis, (4) a variety of communication tools to permit effective dialogue between patients and health care providers, and (5) a system for automatically flagging and providing feedback for outlier data.

The telemedicine interventions currently used can be communicated from handheld hardware devices to a remote web server. Data may be transmitted in the form of (1) voice messages over the phone, (2) text messages (short message services) over wireless networks to web interfaces, (3) E-mail messages over the internet, or (4) live streaming audio or video over the internet. Data are then incorporated into the patient's electronic medical record, analyzed, flagged if necessary, and responded to by way of automatic or personalized treatment recommendations, which are transmitted to the patient's computer, cell phone, or other handheld device.

The successful treatment of diabetes requires normalization of fasting blood glucose, postprandial blood glucose, glycosylated hemoglobin (HbA1c), blood pressure, low density lipoprotein (LDL) cholesterol, body weight, and waist circumference. To attain multiple goals of therapy in a single patient, continuing education, motivation, empowerment and advice on healthy food habits, physical activity, and accurate use of monitoring and injection devices, are required.

DIABETES TELE MANAGEMENT SYSTEM

In our center, telemedicine in diabetes care, termed Diabetes Tele Management System (DTMS[®]) is a simple and cost-effective tool, practiced since 1997.^[17-19]

Diabetes Tele Management System[®] has five components

- A customized software which includes Electronic Medical Records with different user interfaces
- A decision support system provided by the multidisciplinary team^[20]
- Telecommunication with the help of telephones, E-mails, and internet using a secure website
- Telemedicine enabled customized empowerment, education, and troubleshooting
- Ensuring multidrug compliance in diabetes by linking DTMS[®] with diabetes pharmacy.

DTMS[®] consists of a multidisciplinary team of physicians, nurses, dieticians, diabetes educators, pharmacists,

and psychologists who with the help of a customized software and user friendly interface titrates the dosages of medications and provides advice on diet, lifestyle, etc., In DTMS[®], insulin and oral drug dosages are titrated, not based on any fixed algorithm, but on several patient specific characteristics. In the usual hospital set up, the drug dosages are modified only during a consultation to the doctor's office based on the fasting glucose and postbreakfast blood glucose. These brief physical physician visits may be scheduled once in every 2–3 months. Consequently, blood glucose will either remain significantly elevated for several years or the patient might experience recurrent episodes of hypoglycemia. Insulin may be initiated by the physician but not intensified due to fear of hypoglycemic episodes that ultimately results in treatment failure. This vicious circle causes weight gain, consistently high HbA1c, drug non adherence, and subsequently other costly complications of diabetes. Quite often, patients might discontinue all the coexisting medications like lipid lowering drugs, antihypertensives, etc. [Figure 1].

Once the patient reports blood glucose values, that is, fasting, 2 hrs after breakfast, lunch, and dinner and 3 am whenever necessary, through the telephone/email/secure website, the DTMS (R) team titrates the dosages of the medications based on the individualized targets. Education modules on insulin injection technique, diet, exercise, use of a glucometer, hypoglycemia, and compliance to medications are also administered to the patient during every teleconsultation customized to the patient specific characteristics. DTMS[®] thus precludes frequent physical visits to the hospital, saving the time and money spent in travelling, waiting, consulting the physician and dietician, and the number of working hours/days which would have otherwise been lost.

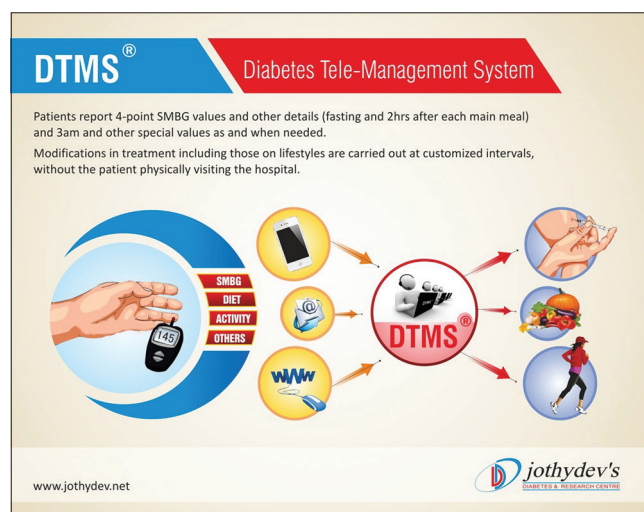


Figure 1: A schematic representation of Diabetes Tele Management System (DTMS[®])

There are several telemedicine programs in existence elsewhere which provides facilities such as E-mail/telephone/SMS, etc., and help patient titrate insulin dosages based on a fixed algorithm.^[21-24] However, the uniqueness of DTMS[®] is the individualization of therapeutic goals based on the following parameters [Table 1].

The interfaces are designed for easy traversing through the patient data and blood sugars reported over several months to years. Targets for fasting blood glucose, post prandial blood glucose, bed time blood glucose, HbA1c, blood pressure, and LDL are reviewed and reassessed once in every 3–6 months for each patient.

Advantages of telemedicine in diabetes

Impact on glycemic control

Telemedicine ensures achievement of treatment targets of glycemia, in motivated patients adhering to the instructions of the telemedicine program. Hypoglycemia has been identified as the major barrier to attaining the targets of therapy in the management of diabetes. Hypoglycemia is most often caused by defective and deficient counter regulatory responses, relative hyperinsulinization owing to a missed meal, excessive or unplanned exercise, erroneous insulin dosages or excessive insulinotropic effects of oral antidiabetic agents, etc.^[25,26] A recently published systematic review (which included 13 studies, 4207 patients) conducted by Marcolino *et al.*^[27] indicated that in diabetes patients, telemedicine strategies concomitant to the usual care are associated with a mean HbA1c decline of -0.44% (-4.8 mmol/mol) when compared to the usual care alone. HbA1c is recognized as a valuable indicator of glycemic control in patients with diabetes, because it reflects average glycaemia over several months and is strongly correlated with diabetes complications. In an earlier study, we also found that the telemedicine based program (DTMS[®]) could achieve glycemic controls at par with internationally accepted treatment goals with minimal incidence of hypoglycemia. This success could be due to multiple components of the system. Each teleconsultation offers an opportunity for continuing diabetes education and drug compliance. The teleconsultations offer not

only a chance for the doctor to fine-tune treatment, but also a chance for patients to develop more awareness and knowledge by interacting with diabetes educators, nurses, and dieticians. Frequent telemedicine follow-ups based on self-monitoring of blood glucose (SMBG) enable slow and steady titration of drug doses, reducing the risk of hypoglycemia. Patients enrolled in DTMS[®] have reported significantly low instances of serious hypoglycemia despite achieving treatment goals. This overcomes a primary barrier in stricter glyceemic control.^[17]

Impact of telemedicine on reduction in microvascular and macrovascular complications

The long duration of diabetes is associated with the development of microangiopathy which eventually leads to chronic complications like retinopathy, leg ulcers, and increased cardiovascular morbidities and mortalities. Diabetic retinopathy has been one of the leading causes of blindness in the developed countries.

Landmark clinical trials like UKPDS^[28] and DCCT^[29] have shown a reduction in A1c translating to a reduction in macrovascular complications and statistically significant reduction in microvascular complications. DTMS[®] based care in our center have helped sustain the glyceemic goals in subjects since several years; translating to the prevention of vascular complications.

Cost-effectiveness of Diabetes Tele Management Systems

In an earlier study, the cost-effectiveness of DTMS[®] was analyzed in 1000 Type 2 DM patients with a 6 months follow-up data where the recurring cost to the patients on follow-up via DTMS[®] was equivalent to 9.66 US dollars/month not considering the cost of oral drugs and insulin. The effectiveness and safety of this telemedicine program was also assessed. There was a statistically significant reduction in the glyceemic and nonglyceemic parameters including lipid profile, serum creatinine, fasting blood glucose, blood pressure, and body mass index. The patients showed a significant reduction in HbA1c from baseline at 3 months and 6 months. The mean standard deviation \pm HbA1c value was $8.5\% \pm 1.4\%$ at the initial visit and thus reduced to $6.3 \pm 0.6\%$ at 6 months ($P < 0.0001$). The rate of SMBG values < 70 mg/dL was approximately 0.04/patient/month with no reported hypoglycemia in 84% of the patients.^[30] In this retrospective study, all patients were eligible for a HbA1c target below 6.5%. Although there are extra costs involved in SMBG and teleconsultation, the money and time saved in physical visits to the clinic that would have been needed in a traditional healthcare delivery model alone make up for the extra costs. Furthermore, it was proven that better glyceemic control

Table 1: Factors considered for deciding the glyceemic goals (these goals are also periodically reset)

Patient characteristics	Disease characteristics
Age of the patient	Type of diabetes
Level of education and motivation	Duration of diabetes
Presence of a caregiver at home/ staying alone	Basal glycosylated hemoglobin value
Socio economic status	Previous history of serious hypoglycemic episodes
Continuous glucose monitoring data if available	Comorbid illnesses

is very cost-effective in the long run to delay or prevent the complications of DM.

Any diabetes patient can avail the DTMS[®] program since the minimal requirement for a patient is to have a land phone/cell phone. The patient saves time and money, staying at the comfort of his/her home/office. This translates to more quality adjusted life years and to cost-effectiveness of this technology.^[31]

Ensuring multidrug compliance

Loss of multidrug compliance in the long-term is one of the major reasons for the development of complications in diabetes. Virtual communications via DTMS[®] ensure compliance to not only drugs for the treatment of glycemia but also for associated comorbidities.

CHALLENGES OF TELEMEDICINE IN DIABETES CARE

- Communication errors, inefficiency to respond to questions, unavailability of the physician to attend the phone, etc., can be provoking to the patients. Rigorous and continuous training and supervision of the multidisciplinary team are required to ensure quality and expertise in answering the queries and interacting with the patient
- Despite the multiple benefits, patients may not be willing to pay extra for the teleconsultations. Since telemedicine is based on patient centered approach, in the absence of a definite payment model, alternate funding resources need to be explored. One viable solution may be to ensure patients buy all medications from hospital pharmacy which can benefit the institution to partly support the telemedicine program and to benefit the patient by assuring quality of the product and sustaining multidrug adherence^[32]
- Even the slightest error in communication during a telemedicine consultation can result in serious consequences. Before responding to patient's queries, telemedicine team should make multiple checks on the existing drugs and their dosage. Periodic raining program should have specific focus to avoid the commonly committed errors
- Patients in India are conventionally used to physical visits to the hospital and receiving treatment advice only from the physician. It may take some time for the professionally trained multidisciplinary team to gain the confidence of the patients and to convince them on the active role of the physician in reviewing their data and modifying medication dosages. One to one and group patient education programs should include benefits and cost-effectiveness of telemedicine in diabetes in short- and long-term

- A universally recommended telemedicine protocol is yet to be created. Scientific organizations may consider formulating consensus guidelines to implement recommendations for telemedicine in diabetes customized to geographical and clinic specific variables.

CONCLUSIONS

Though technology is widely used in the treatment of complications of diabetes, it is seldom used in the prevention of complications. The DTMS[®] provides a live, interactive platform for two-way communication either via the telephone, internet, or secure website between the patient and the multidisciplinary diabetes team at specified intervals for an unlimited period. The system ensures reaching all the major targets and enable troubleshooting with devices, drug adherence, reminders on vaccinations, laboratory investigations, and hospital visits. The system has been successful in proving its effectiveness and in overcoming the major barriers of hypoglycemia and noncompliance to therapy in more than 75% patients enrolled with it. Since the telemedicine programs may be considered as an "organizational approach," randomized controlled trials may not be possible to evaluate clinical outcomes, long-term effects, and cost-effectiveness. The existing evidence using DTMS[®] technology for more than 17 years is a testimony to its efficacy in bringing down the long-term vascular complications of diabetes and thereby reducing the overall cost and improving the quality of life makes it the best possible option to be integrated to a comprehensive diabetes care program.

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Conflicts of interest

There are no conflicts of interest.

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