

Role of Telemedicine in Diabetes Management

Journal of Diabetes Science and Technology
2023, Vol. 17(3) 775–781
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DOI: 10.1177/19322968221081133
journals.sagepub.com/home/dst



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Abstract

Introduction: Telemedicine is a growing arena that may increase access to care for patients with diabetes. It has more relevance for rural populations or those with limited physical access to health care, for improving diabetes care. Telemedicine can also be used to offer diabetes self-education and transportation barriers for patients living in under-resourced areas or with disabilities.

Method "This review explores the landscape of telemedicine approaches and evidence for incorporation into general practice.

Results & Discussion: Telehealth platforms have been shown to be both feasible and effective for health care delivery in diabetes, although there are many caveats that require tailoring to the institution, clinician, and patient population. Research in diabetes telehealth should focus next on how to increase access to patients who are known to be marginalized from traditional models of health care.

Keywords

blood glucose monitoring, diabetes, HbA1c, telemedicine, TELESAGE study

Introduction

Telemedicine is defined by World Health Organization (WHO) as

the delivery of health care services, where distance is a critical factor, by all health care professionals (HCP) using information and communication technologies for the exchange of valid information for the diagnosis, treatment and prevention of disease and injuries, research and evaluation, and for the continuing education of health care providers, all in the interests of progressing the health of individuals and their communities.¹

Telemedicine is the remote exchange of medical information or services through electronic communication technologies between patients and clinicians.² In the field of diabetology, telemedicine is increasingly used to improve access to health care and clinical outcomes in patients with diabetes. As most of the aspects of life have become automated and addressed online, so will routine medical care of chronic diseases.³

Telemedicine use improves self-management processes and clinical outcomes of a patient with diabetes.³ Mobile devices and apps provide many benefits for health care professionals (HCPs), perhaps most significantly increased access to point-of-care tools, which has been shown to support better clinical decision making and improved patient

outcomes.⁴ Patient's ability to manage the disease and keep the blood glucose levels under control also improves.²

Benefits of Telemedicine in Diabetes Management

Glycemic Control

In randomized controlled trial (RCT) of telemedicine consultation to manage 199 patients with diabetes mellitus (DM), although no significant difference in HbA1c was found between patients with or without teleconsultation groups (telemedicine consultation 1.01% vs usual consultation 0.68%, $P = .19$), better satisfaction was reported by patients and health care providers.⁵ In network meta-analysis of 107

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Table 1. Different Strategies of Telemedicine.

Strategies	Description
Teleeducation	Delivery of distance learning, teaching, or training to remote participants
Teleconsultation	Consultation
Telemonitoring	Monitor health status of a patient from distance which is then transmitted back to clinician
Telecase-management	Beneficiary services provided in collaboration with or supplementary to primary care for improving efficiency, depth, or breadth of clinical care
Telementoring	To provide individual guidelines, mentorship, or direction to another person who is new to the experience

studies involving 20 501 participants, telemedicine strategies were effective in reducing HbA1c significantly compared with usual care, with mean difference (MD) ranging from 0.37% and 0.71%. Ranking indicated that teleconsultation was the most effective telemedicine strategy, followed by telecase-management plus telemonitoring, and finally teleeducation plus telecase-management (refer to Table 1 for definition of different telemedicine strategies).⁶ In another meta-analysis (42 RCT with 6170 participants) by Tchero et al,⁷ significantly greater HbA1c reduction was observed in patients with telemedicine care compared with usual care (Hedges's $g = -0.37$, $P < .001$). Subgroup analysis revealed greater HbA1c reduction in patients with type 2 diabetes mellitus (T2DM) compared with those with type 1 diabetes mellitus (T1DM), older age group (41-50 years) compared with younger patients, and those with telemedicine program lasting more than six months. In meta-analysis of four clinical studies, telemedicine in patients with gestational diabetes mellitus (GDM) was associated with significantly fewer unscheduled clinical visits.⁸ These findings revealed that telemedicine has potential place in diabetes management.

Diabetes Self-Management

Telemedicine is a powerful tool for health information exchange between patients and the health care team. Telehealth facilitates partnerships with patients to promote positive lifestyle changes, personalized self-care measures, and evidence-based health interventions in the management of diabetes. Telehealth is a promising approach to positively impact diabetes self-management behaviors.⁹ Meta-analysis of four clinical studies showed positive effects of telemedicine for glycemic control self-management in the short term in primary health care.¹⁰ However further evidence is needed to support the long-term effect of telemedicine on self-management of blood glucose in people with diabetes.

Safety (Risk of Hypoglycemia)

Meta-analysis of 14 RCTs ($n = 1324$) evaluated the effect of telemedicine intervention on hypoglycemic events, HbA1c, and body mass index (BMI). The study results reported that telemedicine improves HbA1c and reduces the risk of

moderate hypoglycemia in patients with diabetes (odds ratio [OR] = 0.42, $P < .00001$) but without a significant difference in BMI compared with usual care.¹¹ Reducing Emotional Distress for Childhood Hypoglycemia in Parents (REDCHiP) study was conducted to assess the novel group-based telemedicine intervention to reduce fear of hypoglycemia (FH) in 43 parents of young children (one to six years) with T1DM. Intervention completers reported high satisfaction with the treatment groups (89% average satisfaction rating). Parent-reported positive influencers of the REDCHiP intervention were increased knowledge, fear awareness, coping strategies, confidence, behavioral parenting strategies, and support, whereas intervention challenges included feeling fearful or overwhelmed, family stress, lack of trust, and difficulty connecting with other group members. This study will assess the clinical outcome in long term.¹² Thus, telemedicine would have place to reduce the risk of FH in diabetes management.

Cost-Effectiveness

In economic evaluations of telemedicine in diabetes care which included 14 clinical studies, use of telemedicine for retinal screening was beneficial and cost-effective for diabetes management, with an incremental cost-effectiveness ratio between US\$113.48/quality-adjusted life year (QALY) and US\$3328.46/QALY (adjusted to 2017 inflation rate). Similarly, the use of telemonitoring and telephone reminders was cost-effective in diabetes management.¹³ A retrospective cohort study of 1000 patients with T2DM assessed the effectiveness, safety, and costs of Diabetes Tele Management System (DTMS). Mean HbA1c was significantly reduced by 2.2% at the end of six months. The recurring extra cost to patient for DTMS, not considering cost of oral drugs and insulin, was equivalent to 9.66 US dollars per month. Thus, DTMS appears to be cost-effective in the intensive treatment of T2DM without serious comorbidities.¹⁴

Telemedicine in Diabetes Management

A chronic disease like diabetes requires frequent visits to the physician for lifestyle advice and adjustment of treatment. Physicians can interact with the patient and analyze history,

self-monitored blood glucose (SMBG) charts, and self-monitored blood pressure (SMBP) values to give advice.¹ Telemedicine has potential value in diabetes management during COVID-19. It helps patients to get in touch with the physician from the comfort of their home and away from hospitals, which could increase chances of coronavirus infection. A phased approach for telemedicine adaptation in the management of diabetes helped identify 13 components involving diabetes care. The components are vital taking (VT), blood glucose monitoring (BGM), eye examination (EE), foot examination (FE), neuropathy detection (ND), pathology test (PT), electrocardiography (ECG), echocardiography (ECH), hospitalization (HOS), diet consultation (DC), diabetes education (DE), exercise consultation (EC), and psychology consultation (PC). These elements were divided into two groups:

1. Appropriate for telemedicine (ATM)
2. Not appropriate for telemedicine (NATM)¹⁵

The study observation states that the components falling under group 1 (ATM) need less physical interaction and can be performed by the patient or a less skilled HCP, while the components under group 2 (NATM) require more physical interaction.

The health care team can implement telemedicine first for the components falling under group 1 (ATM). The education category components can be easily provided through video conferencing in real time or through asynchronous mode using Web-hosted videos and blogs. Other components in group 1 are VT and BGM which can be recorded after going through self-management education and can be shared with a specialist in asynchronous or synchronous mode. This will further decrease the cost of care and increase the patient's motivation in achieving the health care goals. The components ND and ECG in group 2 can also be outsourced to an allied HCP near the patient's location. Thus, telemedicine in diabetes care can be executed in a phased manner.¹⁵

Different Strategies of Telemedicine

For improving quality of care among type 2 diabetes patients, a wide variety of interventions had been tested which were characterized as per the telemedicine strategies as described in Table 1.¹⁶

Comparison of Different Telemedicine Strategies

TELESAGE Study

A six-month open-label parallel-group, multicenter study enrolled 180 adult patients with diabetes which compare:

- Control group (group 1 [G1]: usual follow-up) with two Diabeo™ telemedicine systems

- G2: Physician-assisted telemedicine
- G3: Nurse-assisted telemonitoring and teleconsultations by a diabetologist's task delegation.¹⁷

The study reported that:

- Mean HbA1c levels were significantly different between the three arms of TELESAGE study: 8.41% \pm 1.04% in G3 versus 8.63% \pm 1.07% in G2 versus 9.10% \pm 1.16% in G1 ($P = .0019$ for G1-G3 comparison) at six months.
- Diabeo™ system had 0.91% greater improvement in HbA1c compared to controls and a 0.67% greater HbA1c reduction when used without teleconsultation.
- Patients in G1 and G2 spent nearly five hours more than G3 patients attending hospital visits.

TELESAGE study demonstrated that the combination of teleconsultation along with electronic database had greater effect of HbA1c reduction.¹⁷

Paramedical Staff Assisted Telemedicine

ENHANCED (diEtitiaNs Helping pAtieNts CarE for Diabetes) Telemedicine Randomized Controlled Trial investigated the efficacy of a registered dietitian nutritionist led telemedicine program compared with that of a control group in terms of diabetes optimal care goals (HbA1c, blood pressure, not using tobacco, and taking a statin and aspirin as appropriate) in 118 adults with T2DM. For those assigned to the intervention, registered dietitian nutritionists used a treatment protocol to initiate and titrate therapies for blood glucose, hypertension, and lipid levels in addition to providing medical nutrition therapy; telemedicine visits supplemented usual care. Control group received usual diabetes care with primary care provider which may include referral to DE program. The study reported modest but significantly greater improvement in the number of diabetes optimal care measures met for the intervention group (Telemedicine), relative to control group ($P = .017$). Also, a significantly greater increase in medication uses of statin and aspirin as appropriate in the intervention group (compared with the control group) was reported in the study.¹⁸

Telemedicine in Complex Diabetes Management

For the management of complex diabetes in adults, Telehealth has the potential to positively transform the quality and cost-effectiveness. Modest benefits in HbA1c lowering and other clinical outcomes which better sustained over time than the usual care were observed.

Telemedicine platforms are both feasible and effective for the delivery of health care in diabetes, though there are many caveats that need to be modified to the institution, clinician, and patient population for virtual care to make an

institutional impact. The services offered by telemedicine in complex diabetes management are as follows:

1. Virtual visits
2. Remote biometric data monitoring (eg, glucose, data downloaded from insulin pumps)
3. Secure electronic messaging between clinician and patient
4. Coaching: telephonic/texting versus game-based
5. Telemonitoring program

Telemedicine serves as an alternative lower cost service for stable patients so that costly care can be reserved for new diagnoses, disease exacerbations, and hands-on device education. Thus, overall costs can be lowered without sacrificing, and potentially increasing, quality of care.

Telehealth strategies have shown to be effective, and outcomes of large-scale implementation would lead the way toward global strategies to combat the diabetes pandemic.¹⁹

Role of Telemedicine in Pregnancy Associated With Diabetes

Use of telemedicine in the clinical management of diabetes in pregnancy facilitates greater involvement of other professionals, such as nurses and dietitians, whose support can help save time and resources in the follow-up of these patients.²⁰

In a systematic review of 47 clinical studies by DeNicola et al,²¹ telehealth interventions were associated with improvements in obstetric outcomes, breastfeeding, early access to medical abortion services, and schedule optimization for high-risk obstetrics.

Meta-analysis of 32 RCTs (5108 patients) showed that telemedicine group had significant improvements in controlling HbA1c (MD = -0.70, $P < .01$), fasting blood glucose (FBG; MD = -0.52, $P < .01$), and two-hour postprandial blood glucose (2hBG; MD = -1.03, $P = .01$) compared with the corresponding parameters in the standard care group. In the telemedicine group, lower incidences of cesarean section (relative risk [RR] = 0.82, $P = .02$), neonatal hypoglycemia (RR = 0.67, $P < .01$), premature rupture of membranes (RR = 0.61, $P < .01$), macrosomia (RR = 0.49, $P < .01$), pregnancy-induced hypertension or preeclampsia (RR = 0.48, $P < .01$), preterm birth (RR = 0.27, $P < .01$), neonatal asphyxia (RR = 0.17, $P < .01$), and polyhydramnios (RR = 0.16, $P < .01$) were found. Compared with standard care, telemedicine interventions can decrease the glycemic levels of patients with GDM more effectively and reduce the risk of maternal and neonatal/fetal complications.²²

Telemedicine use in the support of pregnant women with diabetes would have an impact on the classical maternal-fetal outcomes, perception of the effectiveness of care “diabetes self-efficacy.”

Role of Telemedicine in Diabetic Retinopathy (DR)

Current screening strategies for detecting DR have poor compliance, but technological development can enhance access to ophthalmic care. Telemedicine is a promising strategy for improving access to care and care delivery in image-oriented fields like ophthalmology, where photographs/images that are captured by trained technicians are often required for diagnostic decisions. Tele-ophthalmology programs have facilitated the identification of DR cases by utilizing digital retinal imaging. Several studies have shown that the sensitivity (62.5%-98.2%) and specificity (76.6%-98.7%) of tele-ophthalmology in diagnosing DR are comparable with those of the traditional clinical examinations.²³

Access and Cost-Effectiveness of Tele-Ophthalmology

Nathoo et al identified 27.2% of patients with DR (788 eyes) using tele-ophthalmology, and over a two-year interval, telemedicine contributed in saving approximately 450 round trips, equating to approximately 1900 hours and 180 000 km of driving, showing that tele-ophthalmology can be efficiently used for DR screening. Although these figures indicate the reduced travel time and cost for a rural population, it does not consider the cost saved from time away from work or lost wages during eye consultations.²⁴ A study for the rural population India highlighted that the cost of QALYs for this application of telemedicine was cost-effective when compared with no screening at all.²⁵

Patients' Perceptions on Tele-Ophthalmology

Acceptability of tele-ophthalmology as advance screening tool from patients is one of the most important parameters of its efficiency. Patients appear to perceive tele-ophthalmology as a highly acceptable approach for their DR screening. A study by Boucher et al reported that majority of patients (90.8%) found it as a very acceptable method for monitoring if an ophthalmologist was not available. Furthermore, 82% (239 patients) declared their preference for this type of screening over the traditional approach, as they considered it faster, easier, more accessible, and convenient.²⁶

Although early recognition and treatment of DR is of proven value in reversing or preventing loss of vision, the infrastructure to detect cases that require treatment is not yet universally available. The familiarity of patients and primary care providers with tele-ophthalmology needs to be focused. Tele-ophthalmology programs need to be well organized to provide quality health care services.²³

The difference between ophthalmoscopy and tele-ophthalmology for DR screening is given in Table 2.³

Table 2. The Difference Between Ophthalmoscopy and Tele-Ophthalmology for Diabetic Retinopathy.

Ophthalmoscopy	Tele-ophthalmology
Requires trained ophthalmologist or retina specialist for fundus examination	Requires trained technicians, only the grading requires the trained retina specialist
Dilatation of the pupil is mandatory	Dilatation of the pupil is optional or targeted mydriasis
Less expensive	Higher initial investment for a tele-ophthalmology setup
Cost to patient is higher	Cost to a patient is less
It is less convenient in rural areas as more travel, more time-consuming	It is more convenient and hence required less travel, less time spent

American Diabetes Association (ADA 2022) Recommendations for Telemedicine

Telemedicine is a growing field that can increase access to care for patients with diabetes. In T2DM patients, compared with usual care or in addition to usual care, various telemedicine modalities can be effective at reducing HbA1c. Telemedicine is efficacious particularly for rural populations or those with limited physical access to health care for glyce-mic control as measured by A1c.²⁷

Telemedicine for DM in COVID-19 Pandemic

Disasters and pandemics bring unique challenges to providing health care. Although telemedicine will not solve them all, it is well suited for medical practitioners to evaluate and manage patients. Without exposing staff to viruses/infections in the times of such outbreaks, telemedicine visits can be conducted. It will also provide rapid access to HCP who might not be available immediately in person. Thus, health systems that invested in telemedicine ensure that COVID-19 patients' kind of issues receive the care they need. And diabetes is one of the major risk factors for increased mortality due to COVID-19.¹

Major countries are under a lockdown or preparing to limit the spread of COVID-19. Consequences of this lockdown for the diabetes patients could be absent or less exercise, changes in diet (eg, increased snacking, consumption of foods rich in calories), and decreases availability of anti-hyperglycemic agents and/or insulin. Also, lockdown had restricted the routine visits to the physician. All these factors can lead to uncontrolled glycemia or worsen comorbid diseases such as hypertension.

In this unprecedented situation, telemedicine can prove to be useful for the management of patients with chronic diseases, such as diabetes.¹

Telemedicine in T1DM

The role of telemedicine in the care of people with T1DM has expanded intensely during the coronavirus pandemic and

is anticipated to remain a major care delivery modality going forward. Predieri et al evaluated the effects of lockdown on glycemic control in 62 children and adolescents with T1DM followed through telemedicine. Glucose standard deviation ($P < .0001$) and coefficient of variation ($P = .001$) improved across the study. Median time in range increased from 60.5% to 63.5% ($P = .008$), time above range decreased from 37.3% to 34.1% ($P = .048$), and time below range decreased from 1.85% to 1.45% ($P = .001$). These data suggest that the use of real-time continuous glucose monitoring (CGM), the continuous parental management, and the telemedicine can display beneficial effects on T1DM care.²⁸ However, a meta-analysis of 38 studies involving 2582 participants failed to support telemedicine use for glycemic control and other clinically relevant outcome among patients with T1DM.²⁹ Telemedicine for routine T1DM care has shown equivalence to standard in-person care, with respect to glycemic control, while also increasing access, convenience, and satisfaction. A spectrum of digital connected care services is emerging to support people with T1DM.³⁰

Limitations of Telemedicine in Diabetes Management

Although telemedicine has a wide range of potential advantages, it also has some disadvantages or barriers.^{2,4} The most frequently cited barrier to the implementation of telemedicine solutions globally is the perception that the cost of telemedicine is too high. Other limitations are as follows:

- For developing countries, high costs, underdeveloped infrastructure, and lack of technical expertise;
- Organizational and bureaucratic difficulties due to lack of personal contact;
- Legal issues surrounding patient privacy and confidentiality, competing for health system priorities, and lack of demand;
- Potential breakdown in the relationship between health care provider and patient;
- Various potential technical and structural problems could hamper the adoption of telemedicine programs;
- Lack of connectivity between diabetes telemedicine systems and hospital electronic medical records;

- Inadequate data encryption and security systems to fully ensure patient privacy.

Summary

Diabetes mellitus leads to complications due to which patients need much more examinations, procedures, and clinical visits. Telemedicine improves self-management processes and clinical outcomes of care in DM patients. It is a valuable, cost-effective, and reliable device for screening diabetes patients for various complications, and it provides easy access to people in rural areas. With these technologies, clinicians can reach out to remote and underserved communities and serve patients at their doorstep. Although telemedicine has several potential advantages, it also has some disadvantages or barriers. The biggest barrier is the perception that the costs of setting up a telemedicine unit are too high.

It also provides the opportunity to manage the patients with diabetes during the lockdown period in COVID-19 epidemic, except for few cases, where face-to-face consultation and/or HOS is necessary. All these can lead to reduced health care costs and improved patient outcomes.

Abbreviations

ADA, American Diabetes Association; DM, diabetes mellitus; DR, diabetic retinopathy; DTMS, Diabetes Tele Management System; GDM, gestational diabetes mellitus; HCP, health care professional; QALY, quality-adjusted life years; RCT, randomized controlled trial; SMBG, self-monitored blood glucose; SMBP, self-monitored blood pressure; T1DM, type 1 diabetes mellitus; T2DM, type 2 diabetes mellitus.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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