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EDITORIAL

Using Telemedicine to Improve Outcomes in Diabetes—An Emerging Technology

David C. Klonoff, M.D., FACP

Introduction

The definition of telemedicine is the use of telecommunications to support health care. Telemedicine includes timely transmission and remote interpretation of patient data for follow-up and preventative interventions. The main purpose of this approach is to facilitate a productive interaction between the patient and the health care provider in order to achieve improved treatment results and lower treatment costs.

To understand the current and potential future advantages and disadvantages of implementing telemedical care, it is helpful to consider the answers to the following seven questions: (1) what is telemedicine, (2) how is telemedicine applied to diabetes, (3) what are the goals for using telemedicine, (4) what are the benefits of using telemedicine, (5) are the goals of telemedicine achieved for diabetes, (6) what are barriers to adoption of telemedicine, and (7) what are promising research opportunities in diabetes telemedicine?

What Is Telemedicine?

The five components of a sound telemedicine system include (1) a process for accurate data collection in digital format, (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.

Telemedicine interventions can be communicated from handheld hardware devices to a remote Web server. Hardware for transmission may include (1) cell phones,[1] (2) handheld personal digital assistant devices or diaries,[2] and (3) portable/laptop computers or desk computers.[3] 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) email 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 into the patient's computer, cell phone, or other handheld device.

How Is Telemedicine Applied to Diabetes?

Telemedicine is an automated support tool for patients with diabetes to facilitate better decisions by patients and health care providers. Systems have been developed to organize six types of uploaded objective and subjective data of interest to managing diabetes, including (1) patient-collected physiological data, such as blood glucose levels, continuous glucose levels, and blood pressure; (2) laboratory data, such as hemoglobin A1c (A1C) or lipid levels; (3) behavioral information, such as dietary intake and exercise patterns; (4) medication dosages, allergies, and other history; (5) subjective symptoms of hypoglycemia or other complaints; (6) pertinent event data, such as emergency room visits, hospitalizations,

Author Affiliation: Mills-Peninsula Health Services, San Mateo, California

Abbreviation: (A1C) hemoglobin A1c

Corresponding Author: David C. Klonoff, M.D., FACP, Mills-Peninsula Health Services, 100 South San Mateo Drive, Room 5147, San Mateo, CA 94401; email address dklonoff@yahoo.com

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scheduled ophthalmology visits, vaccines, and missed clinic appointments; and (7) images of retinal photos, wounds, or other structures. The pattern of information can be analyzed with decision support software.[4] In this way, a midlevel practitioner or a physician can contact the patient either on a scheduled regular response basis if the situation is safe or on an automatic immediate as-needed basis in the event of a high-risk dangerous event.[5] Images of retinal examinations[6] or foot wounds[7] can be transmitted from a generalist's office to a specialist consultant at a remote central location. In some cases, foot images for remote transmission can even be collected at home by patients themselves. These images can be evaluated either in real time by a physician taking the measurement or soon afterward by a specialist consultant at a remote central location.

Telemedicine programs can impact various aspects of patient care, including informational, clinical, behavioral, structural, and economic.[8] The informational impact is a better quality of information than handwritten records, which may be incomplete or inadvertently forgotten at home on appointment days. The clinical impact is a more frequent communication of information and instructions, which can lead to improved outcomes with lower A1C levels or fewer adverse sequelae. The behavioral impact is more frequent therapy adjustments and reminders, leading to greater patient education and empowerment. The structural impact is usually time-saving for patients who might need to come in to the physician's office for fewer visits; however, the physician workload of reviewing messages and updated data on a regular basis may actually increase. The economic impact of these programs is likely complex, but it is poorly understood at this time.

What Are the Goals for Using Telemedicine?

There are four main goals for using telemedicine to collect, transmit, analyze, discuss, and automatically respond to medical data. These reasons all relate to promoting greater effectiveness in the interaction between the patient and the health care provider team. Telemedicine can facilitate the achievement of individualized treatment goals by (1) training patients to manage their own disease; (2) introducing population-based tools for health care, such as individually tailored education modules and registries; (3) providing access to electronic decision support tools with oversight from physicians; and (4) delivering timely information and directions based on individual data and population data.[9]

What Are The Benefits of Using Telemedicine?

A telemedicine program can be judged as successful if it successfully meets four criteria by being (1) sound, (2) effective, (3) cost-effective, and (4) practical. Current telemedical systems meet at least three out of four criteria.[10]

A sound telemedicine technology facilitates accurate collection of data, accurate input of data, verification of data accuracy, and a process to correct incorrect data. A sound technology will include time stamping of inputted data to avoid back filling, forward filling, or other data manipulation. Current telemedical systems for diabetes achieve this criterion.

An effective technology allows for the determination of process outcome measures, clinical outcome measures, and patient satisfaction. First, the effectiveness of automated telemedicine systems can be measured to assess the adoption of process outcomes, such as timely foot screenings, retinal evaluations, vaccine administrations, and measurement of laboratory tests. These tests include A1C, glucose, lipids for all patients with diabetes, and other laboratory analytes for selected diabetes patients, including serum creatinine levels in users of metformin, liver tests in users of statins, serum potassium in hypertensive patients on selected blood pressure medications, and serum fructosamine in some patients with hemoglobinopathies. Second, the effectiveness of telemedicine programs can be assessed on the basis of improvements in objective clinical outcomes, such as A1C levels, number of hypoglycemic events, glycemic variability according to a predefined formula, or emergency room visits for diabetes-related events. Finally, patient satisfaction can also be used to measure the effectiveness of a telemedicine program. User experience can be quantified by using surveys to measure patient satisfaction, classifying patient feedback in response to provider instructions, and determining the amount of system use by patients.[11] Based on a small amount of data, current telemedical systems for diabetes possibly achieve this criterion.

A cost-effective telemedicine technology, compared to base therapy, will provide benefits for a cost that is either less expensive than current care (also known as a cost-saving intervention) or a cost-per-benefit ratio, which is within a range that society is already willing to pay for other widely used services. This amount is typically in the range of a cost of up to $50,000 per each quality adjusted life year gained.[12] Because it has not

been established whether current telemedical systems for diabetes achieve this criterion, they are not clearly cost-effective.

A practical telemedicine program will overcome technical and structural problems that have hindered the adoption of many new medical programs. Such problems have included (1) a lack of connectivity between stand-alone diabetes telemedicine systems and hospital electronic medical record systems, (2) inadequate decision support software, and (3) inadequate data encryption and security systems to fully ensure patient privacy. Current telemedical systems for diabetes partially achieve this criterion and can be considered somewhat practical.

Are the Goals of Telemedicine Achieved for Diabetes?

Based on the four criteria for a successful telemedicine program presented earlier, telemedicine has been demonstrated to be sound, possibly effective, and somewhat practical, but has not been demonstrated to be cost-effective. (1) The soundness of systems is clear. (2) These systems are possibly effective. Research on telemedicine programs that has been published has typically described short-term projects of up to 12 months. Although most studies of telemedicine programs for type 2 diabetes mellitus have demonstrated improved A1C outcomes,[13] such programs in type 1 diabetes mellitus have not consistently demonstrated improved A1C levels.[14] The largest telemedicine study ever conducted was the Informatics for Diabetes Education and Telemedicine project.[15] This study compared the outcomes of a combined Web and streaming video telemedicine system against base therapy without a telemedicine system in 1665 Medicare patients. Telemedicine subjects experienced an improvement in glycemic control, blood pressure levels, and total and low-density lipoprotein cholesterol levels at 1 year of follow-up. The long-term costs and benefits of telemedicine programs are unknown.[14] (3) Cost-effectiveness data are very sparse, however, because there has been very little work in the way of realistic economic modeling or empiric data analysis in the field of diabetes telemedicine.[16] Patients and providers will need to demonstrate continued ongoing compliance and favorable medical and economic results before these programs will be funded on a widespread basis for long-term care. (4) Telemedicine systems are hindered by technical and structural problems that are being corrected gradually and will likely be solved in the near future.

What Are Barriers to the Adoption of Telemedicine?

Considerable barriers currently limit the penetration of telemedical care in the United States. Both health care providers and patients must overcome these barriers to make telemedicine become a routine practice in the United States.[14]

Health care provider barriers are both technical and systemic. For many health care providers, technical barriers, such as a fear of computers, poor access to computers, or a lack of training in computers, will deter the adoption of telemedicine. Privacy concerns based on reports of numerous recent security breaches in the banking industry[17] and hospital industry[18] and a potential lack of access to information during power failures or computer server malfunctions are additional concerns. Furthermore, a telemedicine system must be able to accommodate multiple brands of glucose meters.

The greatest barriers to adoption of telemedicine are systemic—the main problems are inadequate or nonexistent reimbursement and licensing/malpractice concerns. Most health plans do not cover telemedicine encounters, which are intended to result in fewer patient office visits and fewer hospitalizations. A fee-for-service provider delivering telemedicine care will be spending uncompensated time performing this care, which could result in fewer office and hospital visits and reduced revenue. Therefore, unless time spent on telemedicine care is compensated, it will clearly never catch on in the fee-for-service world. In a capitated environment, such as government-run health plans, a health maintenance organization, or an integrated health delivery system, there can be overall savings by investing in telemedicine care to achieve better outcomes with fewer outpatient visits and fewer hospitalizations. Before telemedicine can be practiced, it is necessary to invest in developing an electronic medical record and in receiving training for this type of service, which can be a further disincentive to using this approach. In addition to these financial concerns, many state laws covering liability, malpractice, state licensing, and antitrust have produced a precarious environment for telemedicine practitioners.[19] Regarding licensure and liability of health care providers who provide telemedical treatment for patients in another state, it is unclear whether physicians delivering such care may legally practice medicine beyond their state boundaries. In a malpractice suit, telemedicine practitioners might be forced to defend themselves against legal actions in the

state where they hold a license, as well as in the state where an alleged patient injury occurred. In the state of Georgia, the Georgia Partnership for TeleHealth was developed by John Oxendine, the State Commissioner of Fire Safety and Insurance, in consultation with the state medical board and the state insurance industry.[20] This project has made the practice of telemedicine there legal and a covered service by malpractice insurance carriers.

What Are Promising Research Opportunities in Diabetes Telemedicine?

There is great interest in developing telemedicine care for diabetes in the United States. From a scientific standpoint, the evidence of its benefits is limited. There is a strong suggestion that this approach will be useful for improving outcomes and lowering costs, but there is insufficient high-quality data to convince many payers or patients to pay for this treatment method. Effectiveness studies of telemedicine to date suffer from a combination of one or more of the following design flaws: small sample size, lack of controls, poor study design, or lack of demonstration of a long-term benefit.[14] Many telemedicine products are now being developed—some for diabetes alone and others for multiple diseases simultaneously. With generalization to include multiple disease states come greater potential opportunities for patient enrollment, but also less specificity of each product for managing diabetes. Specific performance outcomes of multiple products and investigational systems will be needed to fully understand the landscape of what all these products can or cannot accomplish. Behavioral modification research is needed to assure that the instructions provided in telemedicine-generated responses will actually be carried out. There has been very little published economic analysis of telemedicine interventions for diabetes. This type of information is needed to influence medical policymakers who currently may be denying coverage for this type of evolving therapy. Telemedicine interventions will likely improve in their effectiveness as electronic medical records and decision support software become more ubiquitous and both clinicians and patients develop familiarity with their benefits and drawbacks.

Conclusions

Telemedicine is particularly well suited to treating diabetes, as compared to other diseases, because diabetes requires interpretation and predetermined responses to many types of data that can be measured in the home by the patient. As technology for communication improves, as better data management and decision support software become available, and as payers and regulatory bodies become comfortable with legal and liability issues inherent to this approach to home care, then it is expected that diabetes telemedicine will become increasingly adopted. Telemedicine promises to become a novel 21st-century tool for diabetes health care providers to communicate with patients to improve the quality and lower the costs of health care.

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