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eHEALTH INITIATIVE
Real Solutions. Better Health.

An Issue Brief on eHealth Tools and Diabetes Care for Socially Disadvantaged Populations

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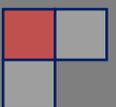
Executive Summary

Introduction

Successfully treating diabetes requires a number of coordinated care processes and resources involving both the provider and the patient. There is a heavy reliance on self-management and education as patients routinely measure their blood glucose levels at home and follow protocols initiated by their provider and a care team that includes dietary suggestions, recommended exercise regimens and medication. Clinical settings that serve socially disadvantaged populations often face a number of challenges in creating effective programs to serve and assist their patients, including:

- They have scarce resources to effectively treat all of their patients within their catchment area;
- Are often the only center of care within a large geographic area;
- Are not connected to a large health system, which limits the amount of specialty care that can be provided;
- Individuals who are socially disadvantaged often have a lack of education about diabetes;
- Lack of transportation to a primary care facility; and
- Difficulties with language; cultural beliefs; and financial barriers.

In diabetes care, the use of health IT has been associated with improvements in the measurement of diabetes, including blood glucose levels, blood pressure and lipids as well as in the frequency of eye and foot exams. Many of these technologies are patient-centric, enabling a partnership among practitioners, patients and their families to ensure that procedures and decisions respect patients' needs and preferences. These patient-based technologies, henceforth known as eHealth tools, can also help redefine care delivery in settings that have limited resources and personnel.

The eHealth Initiative, a non-profit organization whose mission is to research and identify the ways in which health IT can be used to improve the quality, safety and efficiency of healthcare, received a grant from the California HealthCare Foundation in April, 2012 to study and review eHealth Tools that can improve diabetes care and control among socially disadvantaged populations. This issue brief is the first in a series of three and describes four domains of technologies identified for diabetes care: **telemedicine, mobile health, patient web portals** and **social media**.

Telemedicine

Telemedicine involves the use of information and communications technology to provide health care services to individuals who are not in close proximity to their provider. The term does not refer to a single technology, but rather a group of technologies that is part of a wider process of care. While a number of health information technologies can be utilized in both private and public medical settings, the use of telemedicine is particularly advantageous for socially disadvantaged populations. A number of telemedicine case studies were cited within this study that utilized a number of technical approaches, such as videoconferencing, digital retinal cameras, secure messaging, and remote monitoring. Each of these would either transmit patient data directly to a provider in real-time, or would store the data and then forward it to a provider upon request. Examples include:

- **Informatics for Diabetes Education and Telemedicine Study (IDEATel)**, which used over 1,600 patients within New York State in a randomized controlled trial in which they were provided with a web camera, a home glucose meter, and access to their own data and a website with educational materials on diabetes.
- **Diabetes TeleCare** program in rural North Carolina used a digital log for 200 patients in the course of a year so they could record information daily on blood glucose levels, diet, and physical activity. Patients were also remotely screened for retinopathy with a digital retinal camera in which the images were sent remotely to ophthalmologists for review.
- **Veterans Administration Care Coordination Home Telemedicine (CCHT)** A group of over 400 veterans used a secure device to answer questions about their diabetes symptoms and health status on a daily basis for a 24 month period as part of the Veterans Administration Care Coordination Home Telemedicine (CCHT). The data was sent to a series of care coordinators who determined whether the patient should receive a follow-up phone call or an appointment should be made with their physician.

Each of these pilot programs demonstrated sustained reductions in blood glucose levels, lipids and blood pressure as well as reductions in emergency room visits and hospital readmissions. The research revealed that telemedicine can increase the accessibility of health services to those who are not in close proximity to a health care provider; among rural populations and those with limited ability to obtain primary care services in person routinely or easily.

Mobile Health

The use of mobile health devices (mHealth) and applications for chronic disease care have been one of the most significant health IT developments of the past five years. Existing and emerging mHealth technologies, such as smartphone applications; devices with email and text messaging (SMS) functionality; pagers and the Internet help facilitate patient self-management of diabetes. These eHealth tools can

practically and effectively monitor a patient's status and clinical outcomes, while simultaneously increasing patient adherence to treatments. Examples include:

- The **WellDoc Diabetes Manager System** mobile health application provides weekly automated clinical coaching driven by real-time patient data, such as blood glucose values, carbohydrate intake, medications, and weight. In a randomized cluster controlled trial, 150 patients used this system in conjunction with a glucose monitor over a period of 12 months and showed significant reductions in blood glucose levels.
- **DiaBetNet** uses a wireless personal digital assistant (PDA) with diabetes management software and an integrated motivational game to assist youths between eight and 18 years in managing their Type II diabetes. Over 70 patients participated in a six month pilot study and demonstrated improvements in their overall knowledge of diabetes and continual maintenance of their blood glucose levels.
- The **iglucose Mobile Health Solution** collects and transmits stored data from a number of compatible electronic blood glucose meters. The data is sent to a diabetes management portal via wireless cellular technology, where glucose readings can be shared with family members, primary care providers, or other specialists. This tool utilizes a variety of reports to inform patients about their health status, and uses a number of methods to communicate with the patient including online access, email, fax or SMS text.

In addition to those comprehensive systems, there are also a number of specific applications that are available for direct download onto a smartphone. The number of smartphone applications for diabetes has significantly increased by almost 400 percent over the past three years, from 60 applications available for the iPhone, to over 260 that are available over a number of mobile platforms. Examples include:

- **Glucose Buddy**, which allows patients to enter information about their diet, exercise regimen and medications. Users can access a variety of graphs and reports to trend their diabetes and health status, and access an interactive forum for diabetes education and support.
- **iBGStar Diabetes Manager Application & Glucose Meter**, which includes a device that is plugged into the smartphone to view, store and track blood glucose levels. Additionally, the application matches blood sugars to a meal that an individual has just finished; stores nutritional information about the meal; and communicates that information to a provider.

Mobile health applications, which have significantly risen in availability over the past year, are the fastest growing sector of the patient-centered tools industry. Given the increase in smartphone adoption within the first and second quarters of 2012, it seems likely that patient-centric technologies will utilize more mobile capabilities.

Patient Web Portals

Patient web portals (PWPs), which integrate electronic medical records and patient health records, have grown in both significance and popularity over the last five years. These web-enabled systems have the potential to communicate significant amounts of information to a patient as well as increase the efficiency and productivity of care.

- HealthCare System developed a comprehensive PWP called **Patient Gateway** that allows direct patient access to an EHR through a secure Internet connection. A randomized controlled trial of 244 patients was conducted over a one-year period in which patients could log on and review their medications and diabetes care measures and communicate with their primary care provider via secure messaging. The results of this study showed changes in the medication regimens for the intervention group that could potentially lead to better diabetes care, and a trend toward lower blood glucose levels.
- Group Health Cooperative created a PWP called **MyGroupHealth** which facilitates secure messaging between a patient and provider with data such as lab results and medication information. Patients who utilized this PWP were shown to have better glycemic control of their diabetes.
- **Kaiser Permanente HealthConnect** is a large, comprehensive health information system that utilizes a PWP to facilitate communication between a patient and provider using secure messaging. In addition, patients can view their lab results and medications online, as well as portions of their health record. A large percentage of the secure emails sent to providers required a clinical assessment or decision, while another significant proportion required a clinical action.

Patient web portals have gained tremendous popularity over the past few years, with a number of major health organizations creating and implementing portals for their patient communities. These portals show great promise in facilitating communication between patients and providers, as well as a means of accessing educational materials to assist all populations in the management and care of their diabetes.

Social Media

Social media encompasses a wide range of online forums, including blogs, collaborative websites (wikis), social networking sites, photo and video sharing, chat rooms and virtual worlds. Patients are using these channels to gather information about their condition to communicate more effectively with their provider; identify other individuals with Type II diabetes to share clinical information and receive support; and to identify sources of education regarding their disease. Examples include:

- **TuDiabetes.Com** is one example of an online community, which currently has over 15,000 members sharing their experiences with diabetes through blogs, forums, events and news. The themes on the site are centered on healthy living, best practices in self-management, nutrition and dietary advice, and emotional support. Research has demonstrated that online social support programs targeting diabetes have been shown to decrease the prevalence of adverse symptoms associated with diabetes, improve health behaviors and reduce utilization of health care resources.
- **dLife** is a social networking site developed and managed by LifeMedia, Inc. with over 25,000 members, and offers information on Type II diabetes symptoms, healthy diet tips and exercise suggestions, medications for diabetes control, and an online forum for individuals to share their personal experiences. This site uses blogs, videos and an electronic newsletter to communicate within their community that is user-generated and overseen by site administrators.

Despite widespread use, there is a need to study and evaluate the effectiveness of social media on diabetes self-management. The large number of specific social networking communities, blogs, wikis and other platforms have demonstrated the utility of this technology to help patients form support groups, provide educational resources, and share knowledge and best practices in the care and management of diabetes.

Conclusions

The advances in a number of these eHealth Tools, particularly in the areas of telemedicine, mHealth, patient web portals and social media, show tremendous promise in helping socially disadvantaged populations manage their Type II diabetes. The review of over 100 peer-reviewed articles for this study led to the following conclusions:

• The rate at which mHealth is advancing could significantly impact diabetes care. Mobile health applications, which have significantly risen in availability over the past year, are the fastest growing sector of the patient-centered tools industry. Given the increase in smartphone adoption within the first and second quarters of 2012, it seems likely that patient-centric technologies will utilize more mobile capabilities.

• mHealth tools are viable tools for socially disadvantaged populations. Research shows that the disadvantaged populations have increased access to mobile health, and so mHealth would be an effective tool by providing outreach and access to care regardless of an individual's socioeconomic status, race, ethnicity, or geographical location. mHealth can provide vital tools to increase healthcare access; improve care delivery systems; assist individuals in engaging in culturally competent outreach and education with technology that is easy to use, affordable and scalable, and is already adopted by patients of all ages and socioeconomic status. Effective mHealth can empower patients with diabetes by providing information and education about medications and risk factors; connect patients to communities and resources; and provide patient advocacy through engagement.

• Social media is currently underutilized by healthcare providers. Despite the widespread use—we are not sure what it means and how it might impact patients—there is a need to study and evaluate the effectiveness of social media on diabetes self-management. The large number of specific social networking communities, blogs, wikis and other platforms have demonstrated the utility of this technology to help patients form support groups, provide educational resources, and share knowledge and best practices in the care and management of their diabetes. However, we did not identify any studies that have evaluated the effectiveness of social media on Type II diabetes care, nor its overall use among socially disadvantaged populations.

• Patient web portals are helping to educate patients about their diabetes. They have gained tremendous popularity over the past few years, with a number of major health organizations creating and implementing portals for their patient communities. These portals show great promise in facilitating communication between patients and providers, as well as a means of accessing educational materials to assist all populations in the management and care of their diabetes.

• It is not clear what patients "want" or "like." Very few assumptions have been tested with patient populations outside of a controlled experiment. While many of the studies identified in this brief discuss the number and type of patients that utilized eHealth tools, there was little data on patient perceptions of the usability of these technologies. Some research has outlined a few major themes that should be included in the design of any eHealth tool, and a number of the ones included within this brief met most of the criteria. However, it is unclear as to whether patients who participated in a number of these studies found the tools usable and satisfactory for their needs. Studies also did not reveal whether the tool was adapted for use by those with low health literacy, those for whom English was not their primary language, and those with limited technical knowledge.

• Consensus-based standards are needed to accelerate the growth of tools for disadvantaged populations. A number of these eHealth tools use standards that were initially designed for other fields, such as videoconferencing or Internet web pages. However, the use of these standards helps these technologies exchange data on an internal level, so that the appropriate information is received at the point-of-care. On an external level, there is no consensus on standards for these eHealth tools to exchange data with disparate systems. This is a problem that has been inherent within the field of health IT for some time. Although a number of these eHealth Tools use common, well-recognized encryption standards for security and represent a low risk to the unauthorized disclosure of personal health information, there is little known about the specific protocols used. None of the studies researched indicated the types of protection that were not offered to patients participating in the pilot studies, nor were any specific security protocols referenced.

An Issue Brief on the Use of eHealth Tools for Diabetes Care Among Socially Disadvantaged Populations

Introduction

The effective management of chronic illness requires a close partnership between the patient and the provider. Patients with chronic disease are generally responsible for their daily care and are often the best source when describing the severity of their symptoms and the efficacy of any treatment. As a result, they must become active participants in their treatment as well as being diligent about the self-management of their disease. However, compliance with self-management regimens is often poor, usually due to the inability of patients to follow through with instructions, such as "monitor and track your blood pressure," "reduce your stress levels, "and "monitor and track your blood sugar." This problem of compliance, combined with the need to create a consistent and bi-directional communication between a patient and a provider, underscores the need for the use of appropriate health information technologies (health IT) to manage chronic disease.

The eHealth Initiative, a non-profit organization whose mission is to research and identify the ways in which health IT can be used to improve the quality, safety and efficiency of healthcare, received a grant from the California HealthCare Foundation in April, 2012 to study and review technologies that can improve diabetes care and control among socially disadvantaged populations. This issue brief is the first in a series of three. The brief describes four domains of technologies identified for diabetes care: telemedicine, mobile health, patient web portals and social media. Each identified technology was assessed for the following:

- evidence that the technology has a direct impact on diabetes care and control;
- availability and accessibility of the technology to socially disadvantaged communities;
- impact of the technology on risk factors that are inherent to socially disadvantaged populations;
- usability of the technology for patients;
- cost-effectiveness of the technology for physicians;
- ability of the technology to exchange data within a large health information system; and
- privacy and security frameworks of each technology to protect personally identifiable health information.

The rise of diabetes within the United States over the past decade has become so significant that it has been termed an epidemic. According to data from the from the Centers for Disease Control and Prevention (CDC) 2011 National Diabetes Fact Sheet, over 25.8 million children and adults have diabetes (8.3 percent of the population).[1] Of those, approximately 18.8 million people have been diagnosed with the disease, while over 7 million people remain undiagnosed[2]. Furthermore, data on fasting glucose and hemoglobin A1C (HbgA1c) levels from the National Health and Nutrition Examination Survey (NHANES) indicates that 35 percent of the population, or approximately 79 million Americans, are estimated to have blood glucose levels high enough to be considered at risk of developing diabetes.[3]

The rate of diabetes among racial and ethnically diverse populations is especially significant. According to data from the 2009 Indian Health Service (IHS) National Payment Information Reporting System (NPRIS), there are numerous disparities in both the rate and the risk of diabetes among minority populations.[4]

- 16.1% of American Indians and Alaskan Natives have diagnosed diabetes.
- 8.4% of Asian Americans, 11.8% of Hispanics, and 12.6% of non-Hispanic blacks have diagnosed diabetes, as compared to 7.1% for non-Hispanic whites.
- 18% higher risk of diabetes among Asian Americans, 66% higher among Hispanics, and 77% higher among non-Hispanic blacks than non-Hispanic white adults.
- The rate of new cases of Type II diabetes among youth ages 20 years or less was higher for non-Hispanic blacks and American Indians as compared to non-Hispanic whites.

Type II diabetes, or non-insulin-dependent diabetes mellitus, is the most common form of the disease and disproportionately affects socially disadvantaged populations. These populations can be defined as those who lack access to primary and specialty care because they are socioeconomically disadvantaged or live in rural areas.[5] These groups are at a higher risk of Type II diabetes because of late diagnosis, inadequate control of diabetes risk factors (including obesity and sedentary lifestyle), poor self-management of the disease, and the development of diabetes-associated complications.[6]

The study will conclude in December of this year with a comprehensive final report to be issued in January 2013.

Background

Affecting over 8 percent of the United States population, diabetes costs the nation almost $100 billion annually and can cause severe complications in individuals, including cardiovascular disease, neuropathy and retinopathy.[7] The risk of morbidity from diabetes is higher among patients of a lower socioeconomic status, as these groups are disproportionally affected by Type II diabetes.[8] Each of the primary risk factors, including obesity, poor self-management and a sedentary lifestyle, interact multiplicatively in the development of the disease and therefore need to be managed comprehensively. In fact, a number of published studies cited throughout the brief indicate that interventions aimed at changing an at-risk person's lifestyle can reduce

the overall incidence rate. The Diabetes Prevention Program, which consisted of a structured diet and increased physical activity, demonstrated a 58% reduction in the incidence of Type 2 diabetes for participants.[9]

Treating diabetes requires a number of coordinated care processes and resources involving both the provider and the patient. Successful management of the disease relies on educating the patient about their condition and providing them the tools to practice self-management. Glucose levels must be measured at home by the patient and treated with a combination of diet, exercise and medication. Additionally, patients must undergo routine foot and eye examination as well as screenings for other risk factors, including hypertension and hyperlipidemia. As part of the treatment process, patients and providers need to communicate frequently about the patient's status and care plan. Diabetes care uniquely blends patient and provider responsibilities, as much of the care takes place outside of the physician's office.

Chin et al noted that within the safety-net settings, such as community health centers that typically serve socially disadvantaged populations, there are a number of additional difficulties in creating effective programs to serve the needs of diabetic patients. First, safety-net settings often have scarce resources to dedicate to diabetes care. Second, a significant number of these settings represent the only centers of patient care within a geographic area. Third, these settings are often independent of integrated delivery systems in which comprehensive care plans can be more easily implemented. Finally, patients who seek care in these settings are often impoverished and have low health literacy.[10] Given these challenges, safety-net settings that attempt to design programs to deal with the clinical and managerial problems associated with diabetic patients need to utilize innovative approaches.

Evidence-based interventions can reduce both the risk and complications of diabetes through medication management, lifestyle coaching, better diet and exercise, self-monitoring and appropriate use of health services. However, these interventions often fail to reach socially disadvantaged populations for a number of reasons, including lack of education about diabetes, lack of transportation to a primary care facility, difficulties with language, cultural beliefs, and financial barriers.[11] A number of studies have underscored the potential for health information technology (health IT) to address some of these barriers and provide support to patients; enhance changes within healthcare delivery; and provide clinicians with access to expertise and timely, useful data about individual patients and populations. In diabetes care, the use of health IT has been associated with improvements in the measurement of diabetes, including HbA1C levels, blood pressure and lipids as well as in the frequency of eye and foot exams.

The use of health IT can also support interventions and programs focusing on disease management and wellness. Specifically, health IT has been used to help providers develop and share patient-specific care plans, enhance communication, strengthen the patient-provider relationship and provide access to evidence-based guidelines of care. Many of these technologies are patient-centric, enabling a partnership among practitioners, patients and their families to ensure that procedures and decisions respect patients' needs and preferences.[12] These patient-based technologies, henceforth known as eHealth tools, can also help redefine care delivery in settings that have limited resources and personnel; provide clinicians with

necessary information either remotely or directly to assist them in following evidence-based guidelines for care; and may exchange data with larger health information systems to provide information about a patient to multiple providers that may share responsibility for the patient's care. eHealth tools assist in bridging both clinical and nonclinical settings and can encompass different communication channels, such as telemedicine, mobile health, social media and patient web portals.[13]

Telemedicine is an automated support tool for patients diagnosed with diabetes to facilitate better decisions by both patients and healthcare providers. These systems can be used in a number of ways to collect and store both objective and subjective data that is sent to providers to facilitate better management of the disease. This can include physiological data, such as blood glucose levels and blood pressure; laboratory data, such as hemoglobin A1C (HbgA1C) and other lipid levels; behavioral information, such as dietary intake and exercise patters; medication dosages and allergies; symptoms of hyperglycemia and other conditions associated with diabetes; and event data, such as emergency room visits. This information is analyzed through the use of decision support software, or through the consult of a physician viewing the data and an appropriate response and care plan is then operationalized. These types of systems can improve the quality of information sent to providers; improve the frequency and quality of communication from patients to providers; increase patient education and empowerment; reduce the travel time and expense to see a provider in-person; and create cost efficiencies due to more accurate treatments and necessary adjustments to care plan.

Mobile communication devices, in conjunction with the Internet, present opportunities to enhance disease prevention and management by extending health interventions beyond the reach of traditional care, which is also known as mHealth. These technologies represent an evolution of telemedicine from the desktop to wearable technologies, which may improve the accessibility of treatment for diabetes as well as the ability of patients to actively engage their providers. Additionally, the innovations and functionality of mHealth, such as text messaging, smartphone applications and wireless sensor technology, can improve the speed, accuracy and convenience of diagnostic tests; improve medication adherence and test result delivery; improve interactive, two-way communication; and provide a simple methods for data collection, remote diagnosis, emergency tracking and access to health records.

Patient web portals (PWPs) pull information from a number of existing clinical systems, providing patient and provider with access to a comprehensive view of the patient's medical history wherever they can use the internet. PWPs offer the exciting possibility of truly patient-centered care through robust mechanisms for patient participation in the management of chronic disease. PWPs advance the ability of patients to access and contribute pertinent information relevant to their health, such as diagnoses, immunization and insurance records, medications, allergies, and laboratory results. Health providers and patients can communicate with each other via the patient web portal, which enables meaningful participation by the patient as an equal partner in their care plan and its implementation. Depending on the exact configuration, PWPs may allow for secure access to records so that appointments, health reminders and alerts, prescriptions, referrals, payments, and insurance

eligibility and claims can be smoothly updated and/or adjusted by both the health provider and the patient. Recent systematic reviews of PWP-delivered disease management interventions found that PWPs consistently increased satisfaction with care, improved access to health information, enhanced patient-provider communication, and resulted in better overall disease management and patient outcomes.

Finally, searching for health information is the third most popular use of Internet technology as it is estimated that in the United States, health information is sought online by 81 percent of Internet users and 66 percent of all adults. The vast reach of the Internet helps individuals perform in-depth information searches; assists consumers with treatment decisions; and prepares them to actively participate in their care. Research has demonstrated that online social support programs targeting chronic illnesses have been shown to decrease symptoms, improve health behaviors and reduce the utilization of healthcare resources. Additionally, the communication within these online programs is more effective when it reaches individuals on an emotional and rational level, or relates to their social or life contexts. Online social media, such as Facebook, Twitter, YouTube and specialty sites for diabetes patients, have these communication elements within their design.

Results

Assessing the Technology within the Four Domains of eHealth Tools for Effectiveness with Socially Disadvantaged Diabetic Patients

Telemedicine

Telemedicine involves the use of information and communications technology to provide healthcare services to individuals who are not in close proximity to their provider. The term does not refer to a single technology, but rather a group of technologies that is part of wider processes of care.[14] While a number of health information technologies can be utilized in both private and public medical settings, the use of telemedicine is particularly advantageous for socially disadvantaged populations. For example, telemedicine can increase the accessibility of health services to those who are not in close proximity to a healthcare provider; among rural populations and those with limited ability to obtain primary care services in person routinely or easily.

Home-based telemedicine applications employ a number of distinct technical approaches for use in the treatment and care of patients. The first is synchronous videoconferencing in which a patient can directly interact with a provider, nurse or diabetes educator to receive information on their condition, in addition to ongoing monitoring and motivations. Remote monitoring technologies can capture and store specific measurements, such as blood glucose levels, blood pressure and other vital signs that can be transmitted to a provider (store-and-forward). Additionally, patients can use mobile applications on their wireless devices to capture information

about diet, physical activity level and vital signs, and electronically facilitate dialogue with their care team.

A significant number of studies have examined the use of home-based telemedicine in the self-management and control of Type II diabetes. Given the diversity of the studies in terms of design, target, patient population and healthcare settings, the calculation of an overall effect of telemedicine on diabetes care was not feasible. However, there were several applications of telemedicine that demonstrated a significant effect on diabetes risk factors strongly associated with socially disadvantaged populations, as shown in Table 1.

Table 1: Telemedicine Applications to Diabetes Self-Management

Application Studied	Effect on Risk Factors
Videoconferencing; use of a home glucose meter; access to patient's clinical data; access to a web page for education materials	Sustained reduction in blood glucose (HgbA1C); LDL cholesterol; systolic and diastolic blood pressure
Two-way educational teleconferencing; retinal imaging with a nonmydriatic retinal camera sent to a community health center	Increase in the number of eye exams; reduced blood glucose and cholesterol level; improved self-management behaviors
Use of a digital retinal camera (EyePACS) to record and transmit retinal images to providers	Increase in the number of diabetes patients who have diabetic retinopathy; evaluation rates for diabetics rose to 20 percent, nearly double the previous rate of 10 to 12 percent
Use of electronic secure messaging to communicate with care providers	Improved glycemic control; greater optimization of treatment regimens; increase in primary care visits
Wireless home blood pressure monitor and telemedicine device	Sustained improvement for systolic blood pressure after 12 months

Case Studies

Three select case studies from the past five years that demonstrate the impact of telemedicine and its potential clinical effectiveness in diabetes management among socially disadvantaged populations are described below:

The Informatics for Diabetes Education and Telemedicine Study (IDEATel) used a randomized trial design to compare telemedicine-based case management with usual care in older, ethnically diverse, Medicare beneficiaries with Type II diabetes residing in medically underserved areas of New York State. The sample consisted of 1,665 subjects residing in New York State which were recruited and randomized between December 2000 and October 2002. Inclusion criteria were age 55 or older, being a current Medicare beneficiary, having diabetes and being on

treatment with diet, an oral hypoglycemic agent, or insulin, residence in a federally designated, medically underserved areas and fluency in either English or Spanish. Participants in the intervention group were provided with a home telemedicine platform that included a web camera, a home glucose meter, and access to their own data and a website with educational materials on diabetes. After five years, sustained reductions were observed in HgbA1C, LDL cholesterol, and systolic/diastolic blood pressure for patients using telemedicine compared to those receiving usual care, as shown in Table 2 below.[15]

Table 2: Clinical Outcomes for the IDEATel Project (Randomized Controlled Trial)

Outcome	Usual Care	Telemedicine
HgbA1C (%)	7.38	7.09
LDL Cholesterol (mg/dl)	94.97	91.13
Systolic Blood Pressure (mm Hg)	140.15	135.83
Diastolic Blood Pressure (mm Hg)	68.29	65.66

Diabetes TeleCare is a disease management program in rural South Carolina that provides remote education and eye screenings to socially disadvantaged individuals via telemedicine technology. The goal of the program is to help patients adhere to the American Diabetes Association guidelines related to physician assessments, medication adherence, blood glucose monitoring, and diet and exercise. Over a 12 month period, 200 patients were asked to visit their local community health center, where they interacted with a nurse/certified diabetes educator (CDE) and dietician at the University of South Carolina using two-way teleconferencing. During the first encounter, the CDE and patient established personal goals and patients were offered a 20 minute educational session and digital log to subsequently record their blood glucose levels, diet, and physical activity. Self-monitoring activities were performed daily by patients and entered into the log until they met their individual goals, at which point the interventions began to decrease. The results of the log were communicated with the CDE, dietician, and a physician. Additionally, participants were remotely screened for retinopathy using a retinal digital camera. Results were discussed with the patient using real-time videoconferencing and an appointment with an ophthalmologist was made if necessary. Although this program has yet to receive extensive evaluation, results from the first year showed that 77 percent of the patients received eye exams, as opposed to only 23 percent of patients that received usual care.[16] The patients for this study were recruited from three community health centers in northeast South Carolina and were located 100 miles from the self-management team and primary care physicians at the University of South Carolina. Each participant was over 35 years of age; diagnosed with high blood glucose and blood pressure; and overweight with a body mass index (BMI) of

over 35. In Table 3, the clinical outcomes of the participants as compared to their baseline data are shown.

Table 3: Clinical Outcomes for Diabetes TeleCare Pilot Study (Randomized Controlled Trial)

Outcome	Baseline Data (Avg)	Results (Avg after 12 months)
HgbA1C	9.3	8.2
LDL Cholesterol (mg/dl)	108.6	89.7
BMI (kg/m)	37.1	35.8
Systolic Blood Pressure (mmHg)	135.3	127.6
Diastolic Blood Pressure (mmHg)	76.2	70.2

The **Veterans Administration (VA) Care Coordination Home Telemedicine (CCHT)** program was designed to reduce the use of avoidable and costly healthcare services such as hospitalizations. A pilot program was implemented at four medical centers within an integrated service network that covered most of Florida, Puerto Rico and southern Georgia. The intent was to assess healthcare services utilization by an ethnically diverse group of veterans diagnosed with Type II diabetes.[17] Participants used a messaging device to answer questions about their diabetes symptoms and health status on a daily basis. This data was sent to a series of care coordinators who determined whether the patient should receive a follow-up phone call or an appointment should be made with their physician. Additional tasks performed by the care coordinators included: placing new orders for medications, helping patients manage their medications, scheduling new appointments, reminding patients of their appointments, and assisting patients having difficulties with the device.

The study population included 400 veterans diagnosed with Type II diabetes who were at high risk for multiple inpatient and outpatient visits, including those to an emergency department (ED). Veterans were eligible if they had two or more (ED) visits within a twelve month period before enrollment. They also needed access to a telephone line and had to be non-institutionalized prior to enrollment. Using a retrospective, concurrent matched cohort design, the results after 24 months showed significant decreases in diabetes-related hospitalizations as well as ED and outpatient visits, as shown in Table 4.

Table 4: Service Related Outcomes for Patient in the VA CCHT Study (Matched Cohort Design)

| Outcome	Baseline Data	Results (After 24 months)
>1 Hospitalizations	35.3	26.9

Outcome	Baseline Data	Results (After 24 months)
>1 ED Visits	23.7	15.8
>1 Outpatient Visits[1]	8.3	4.8

Based on the studies and information gathered for this report, there is significant interest in utilizing telemedicine for diabetes among socially disadvantaged populations. The results from the pilot tests cited above indicate this approach is useful for improving clinical outcomes, reducing hospital and emergency department admissions, and lowering costs. This type of eHealth tool is well-suited for treating diabetes, as it requires interpretation and predetermined responses to many types of data that can be measured in the home by the patient. Over time, the technology for communication will improve, as well as that for data management and decision support, which promises to make telemedicine a useful eHealth tool to improve the quality of care and lower costs for those with Type II diabetes.

**Mobile Health Devices and Applications**

The use of mobile health devices (mHealth) and applications for chronic disease care has been one of the most significant health IT developments of the past five years. According to data published in a *Nielsen Report* analyzing smartphone penetration by ethnicity within the United States in the first quarter of 2012, each ethnic population had a larger increase in smartphone adoption as compared to non-Hispanic whites, as shown in Figure 1:

Figure 1: Percentage of Adoption (Q1 2012)

Hispanic	57.3
White	44.7
Black/African American	54.4
Asian/Pacific Islander	67.3
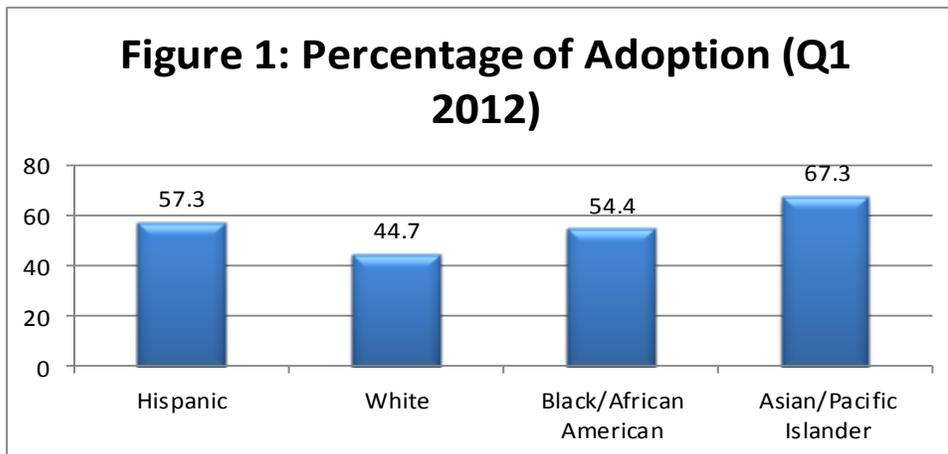
Source: Nielsen

Furthermore, the Nielsen research also indicates that the adoption of smartphones is highest among individuals ages 18-45, with potential increases occurring over time, even among poorer and elderly populations, as shown in Figure 2:

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[1] Outpatient visits refer to a diabetes specialty clinic.
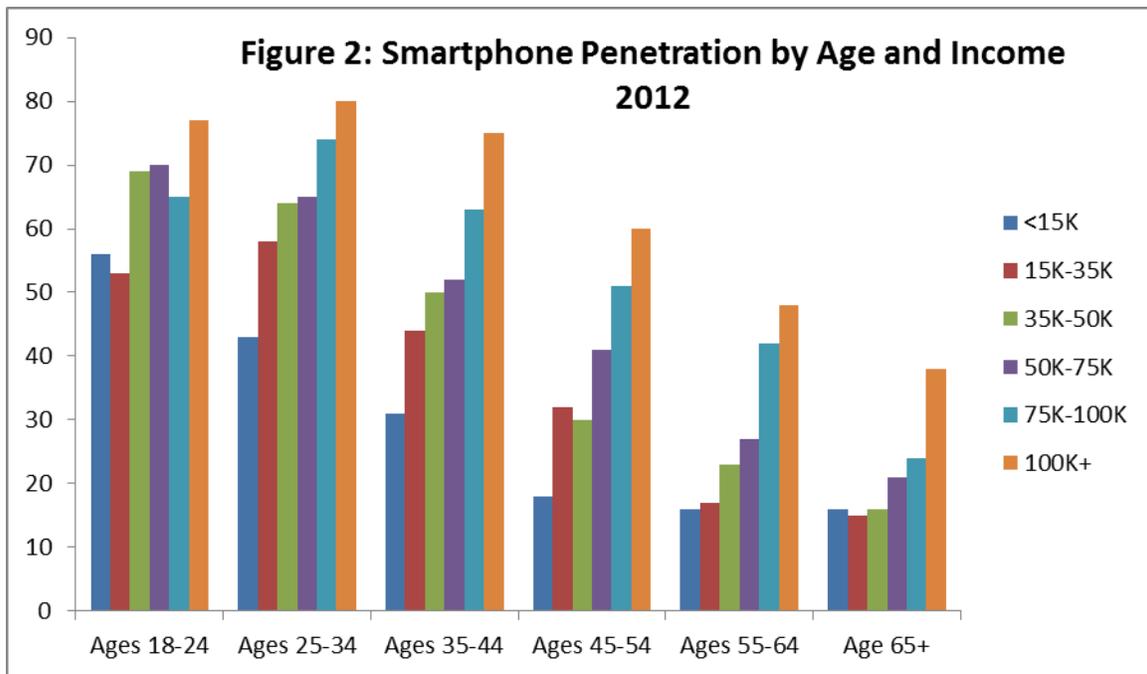
Source: Nielsen

Likewise, the number of mHealth applications available for smartphones is accelerating. As of 2012, there are over 40,000 health-related applications and this number is expected to double as the number of smartphone users increases and the sophistication of the technology improves. Additionally, the number of mHealth application users – defined as those who downloaded an mHealth application at least once – will reach 247 million by the end of 2012, a significant increase from the 124 million users identified in 2011.[18]

Existing and emerging mHealth technologies, such as smartphone applications; devices with email and text messaging (SMS) functionality; pagers and the Internet can help facilitate patient self-management of diabetes. These eHealth tools can practically and effectively monitor a patient's status and clinical outcomes, while simultaneously increasing patient adherence to treatments.[19] Some of the studies citied below that examined the use of these technologies have indicated significant decreases in HbA1C and LDL levels; improvements in diet and physical activity; and improved health-related outcomes for diabetic patients. The use of mHealth applications and devices may encourage patients to adhere to their monitoring regimens by encouraging self-monitoring efforts with reminders and alerts, and serving as simple repositories for information generated by the patient, which can then be shared with the patient's care team. A summary of the types of mHealth applications and their associated functionality is shown in Table 5 below.

Table 5: Overview of Mobile Health Functionalities and the Results of Pilot Studies

Functionality	Study Method	Intervention	Results
Smartphone application; text (SMS) messaging; real-time transfer of information	Randomized Controlled Trial	Patients entered self-care data; real-time educational, behavioral and motivational messages were sent to patients on a regular basis.	Positive changes in HbA1C of 1.2% Positive changes in systolic blood pressure from -6 to +10 Positive changes in LDL Cholesterol of -29 to 0
Two-way pagers	Randomized Controlled Trial	After patients sent blood glucose and medication data, they received information regarding medication adherence, glucose testing reminders and exercise reinforcement messages.	79% of the participants in this study enjoyed using the pager and felt their care was improved at the end of the study.
Wireless, portable diabetes management system	Randomized Controlled Trial	Youth with Type II diabetes entered data regarding blood glucose levels and carbohydrate intake, and filled out a diabetes knowledge survey that was sent to a primary care provider.	Lower median carbohydrate intake Higher rate of transmitted HgbA1C levels Improved knowledge scores of diabetes
Cell phones; text messaging; email	Pre-Post Test	Patients entered their current vital signs through their cell phone. Exercise plans, reminders and tailored advice were sent back.	Increased intention to exercise Reduction in body mass index (BMI) Reduction in systolic/diastolic blood pressure

Results from studies of the use of mobile health devices and applications in diabetes care strongly suggest mHealth applications can help patients reduce HbA1C levels and improve glucose values; reduce LDL cholesterol; reduce systolic and diastolic

blood pressure; and reduce sedentary behavior by encouraging a healthy, active lifestyle across diet and physical activity in patients diagnosed with Type II diabetes. Several programs also have demonstrated improvements in glycemic control, self-efficacy, and adherence to care plans among older adults. Most mHealth interventions identified in this study require patients to input their health information online, including initial blood glucose values; current medication lists; types and dosages of insulin (if needed); weight and height values; and other information necessary for diabetes management. A provider, nurse or diabetes educator would examine and evaluate the information, and send the patient recommendations and reminders via SMS on a weekly basis (e.g., "lack of exercise may be causing your blood glucose to rise;" "please reduce your insulin by two units"). Intervention periods for these studies typically lasted from three to twelve months. Additional detail on the mHealth applications referenced above to improve diabetes care includes:

WellDoc Diabetes Manager System is a mobile health application that provides weekly automated clinical coaching through behavioral algorithms driven by real-time patient data, such as blood glucose values, carbohydrate intake, medications, and weight. WellDoc also features a medication adherence program and allows for the transfer of real-time blood glucose data from patient to provider. A cluster-randomized clinical trial was conducted over one year in 2010 to evaluate the use of WellDoc in conjunction with a One Touch Ultra 2 blood glucose meter. Over 150 patients were divided into four clusters, with one cluster (n=23) using only the WellDoc system with the blood glucose meter. The average decrease in HbA1C of 1.6 percent for patients in this intervention group was higher than the 0.7 percent change observed in the control group (which used no technology).[20]

DiaBetNet, developed by the MIT Media Lab, uses a wireless personal digital assistant (PDA) with diabetes management software and an integrated motivational game to assist youths between 8 and 18 years in managing their Type II diabetes. Patients enter their vital signs for transmission to a physician, and are encouraged to play the interactive game to educate themselves about blood glucose levels, blood pressure, diet and exercise. Over 70 patients improved their overall knowledge of diabetes and maintenance of HgbA1C levels, and lowered their overall carbohydrate intake.[21]

There are a number of other mobile health devices and applications that have been developed over the past several years, but have not been scientifically evaluated for their overall effectiveness in managing Type II diabetes. Many of these are electronic glucometers that capture data on a patient's blood glucose level and transfer it to a provider through a centralized server or through an Internet cloud. None of these technologies have been independently evaluated, however, this functionality combined with other features likely plays a key role in helping patients manage many of the risk factors associated with Type II diabetes. Examples include:

PositiveID Corporation has created the **iglucose mobile health solution**, which collects and transmits stored data from a number of compatible electronic blood glucose meters. The data is sent to a diabetes management portal via wireless cellular technology, where glucose readings can be shared with family members,

primary care providers, or other specialists. This tool utilizes a variety of reports to inform patients about their health status, and uses a number of methods to communicate with the patient including online access, email, fax or SMS text.[22]

Telcare BGM is another wireless-capable blood glucose meter that captures patient data on HgbA1C levels and sends it directly to a centralized server. Data is then sent to a cloud-based web application where health information can be viewed by patients, family members and health providers on a dashboard that is available through a computer, tablet or smartphone application. The dashboard features functionality that alerts the patient when their glucose levels are trending too high or low, and suggests appropriate corrective actions.[23]

As part of a new initiative, the American Diabetes Association, the Centers for Disease Control and Prevention (CDC), the Health Resources and Services Administration (HRSA), two Beacon Communities and Voxia have created the **Text4Diabetes campaign**. The campaign utilizes SMS messaging to encourage individuals to engage with and manage their health, help them assess their diabetes risk levels, and better connect them with diabetes care and wellness educational materials. The program uses text message questions to assess an individual's risk for diabetes and determine which resources are most appropriate for the user.[24] Resources may include an online social forum; a check-up at a local pharmacy, or contact information for local health providers.

Another mHealth application, **the Diabetes QOL,** allows patients to transfer their weekly self-managed blood glucose levels to their provider. In a trial, the application interacted directly with a glucometer, allowing patients to seamlessly send the information via SMS on their smartphone. Every three months, the patient was asked to take the Diabetes Quality of Life Survey. Responses to the survey, along with the patient's glycemic values, were sent to health care providers. Patients received weekly SMS treatment advice based on their glucose values and follow-up calls were made based on the results of the survey. Using a randomized controlled trial design, evaluation of the application indicated a decrease in glucose levels of 0.14 percent among the intervention group as opposed to an increase of 0.12 percent within the control group.   The evaluation also demonstrated a statistically significant reduction in the number of hypoglycemic episodes and improvements in the overall quality of life of the patient.[25]

Smartphone Applications

Each of the examples provided above discusses the use of mHealth as part of a larger telemedicine system for diabetes. In addition to those comprehensive systems, there are also a number of specific applications that are available for direct download onto a smartphone. The number of smartphone applications for diabetes has significantly increased by almost 400 percent over the past three years, from 60 applications available for the iPhone, to over 260 that are available over a number of mobile platforms.[26]   These applications can be divided into the following categories: insulin levels, communication, diet, physical activity, weight, and blood pressure. In Table 6, the percentage of applications, by category, through several smartphone devices are shown.

Table 6: Number and Types of Applications Available by Smartphone Device

Application	Insulin	Communication	Diet	Physical Activity	Weight	Blood Pressure
Apple iPhone	35	36	26	17	19	13
Google Android	19	17	15	10	16	16
BlackBerry	5	6	3	2	5	4

Three of the more popular smartphone applications based on a review by CNET Magazine include[27]:

Glucose Buddy, which was created by TuDiabetes.Com (an online community for diabetics), allows patients to enter information about their diet, exercise regimen and medications. Users can access a variety of graphs and reports to trend their diabetes and health status, and access an interactive forum for diabetes education and support.

Vree is an application that enables users to self-manage their diabetes by providing an interface to enter data on blood glucose, diet, exercise and medication. The application also contains a large food database that provides nutritional information to help manage diet, access to articles and advice on diabetes management, and the ability to email a provider with the information recorded by the application.

iBGStar Diabetes Manager App & Glucose Meter includes a device that is plugged into the smartphone to view, store and track blood glucose levels. Additionally, the application matches blood sugars to a meal that an individual has just finished; stores nutritional information about the meal; and communicates that information to a provider.

Patient Web Portals

Patient web portals (PWPs), which integrate electronic medical records and patient health records, have grown in both significance and popularity over the last five years. Part of this is attributable to the ubiquitous nature of the Internet, as well as the growth in interest from both consumers and patients.[28] PWPs can provide secure access to personal health information for an individual, as long as they have an Internet connection. Ralston et al stated that PWPs often offer additional functionality such as the ability to request and create a medical appointment, request medication refills, send and receive messages from a provider, and receive alerts or reminders regarding health status. These web-enabled systems have the potential to communicate significant amounts of information to a patient as well as increase the efficiency and productivity of care.[29]

A systematic review of the literature regarding PWPs was conducted by the Vanderbilt University Medical Center in December of 2010. Osborn and colleagues reviewed over 26 articles and found a number of benefits for patients that used PWPs to self-manage their diabetes. Results from the studies included enhanced patient-provider communication, an increase in overall satisfaction with care, expanded access to health information, and improvements in disease management and patient outcomes.[30] Because these results are based on the aggregated results of the evaluations reviewed for the study, it was difficult to ascertain which specific functions of PWPs benefitted patients the most.

Partners HealthCare System, a multi-hospital health care network comprising of several thousand physicians caring for over one million individual patients, developed a comprehensive PWP called **Patient Gateway** that allows direct patient access to an EHR through a secure Internet connection. Functionalities of Patient Gateway include the translation of a patient's current clinical data into an educational format, provision of patient-tailored decision support based on glucose, cholesterol, blood pressure, and weight values that are sent to the physician; and facilitation of a Diabetes Care Plan, created by the patient and sent directly to a physician.

Partners HealthCare conducted an evaluation of Patient Gateway using a randomized controlled trial design involving 11 clinics and 244 patients over a period of one year. Individuals in the intervention group received an online diabetes journal two weeks prior to a physician visit and were provided access to Patient Gateway through which they could review their medications and diabetes care measures and communicate with their primary care provider via secure messaging. Individuals in the control group were provided access to Patient Gateway only. Results of this study showed changes in the medication regimens for the intervention group that could potentially lead to better diabetes care, and a trend toward lower blood glucose levels. While not conclusive, the initial results of this study indicate positive results from the use of PWPs to effectively manage the risk factors and symptoms associated with Type II diabetes.[31]

Three other care organizations have developed PWPs for their patient population, including:

The Group Health Cooperative Integrated Delivery System created a PWP called **MyGroupHealth** which facilitates secure messaging between patient and provider. Messages can contain test results and other medical information related to a patient's diabetic condition. Patients who used more secure messaging had better glycemic control, though this effect could also have been partially attributable to the provider recommending medication changes, an improved overall continuity of care, or more self-care behavior by patients.[32]

Kaiser Permanente HealthConnect is a large, comprehensive health information system that utilizes a PWP to facilitate communication between a patient and provider using secure messaging. In addition, patients can view their lab results and medications online, as well as portions of their health record. A large percentage of the secure emails sent to providers required a clinical assessment or decision, while another significant proportion required a clinical action.

My HealtheVet, provided by the US Department of Veteran Affairs, is a secure PWP that provides access to information, resources and tools to veterans for use in the management of their health. Patients can view their medical information directly through the PWP and enter data, such as blood glucose levels, blood pressure, weight and other information related to their health status. Cho et al conducted a cross-sectional mailed survey in 2010 of 201 veterans with Type II diabetes to assess the use of My HealtheVet in five VA tertiary clinics. The results of the survey indicated that over half of the respondents would use the PWP to access information about their diabetes and over 41 percent of veterans would be interested in using the PWP to help monitor and track their blood glucose reading.[33]

Social Media

The eHealth tools and strategies used to both prevent and manage Type II diabetes have changed over the past several years with the emergence of social media. This is defined as "a variety of sources of online information that are created, initiated, circulated and used by customers' intent on educating each other about products, brands, services, personalities and issues." Social media encompasses a wide range of online forums, including blogs, collaborative websites (wikis) social networking sites, photo and video sharing, chat rooms and virtual worlds. In the last decade, there has been a propensity to delivery Internet-based messages through these media. They have become a major factor in influencing various aspects of consumer behavior including awareness, information acquisition, opinions and attitudes. When gathering information about medical conditions, patients are increasingly looking to the Internet for data. A recent survey indicated that patients search the Internet more frequently than they communicate with their doctors about health care questions. They also seek to meet and interact with a community of patients with similar problems, both to share clinical information and to provide and receive support. With the evolution of dynamic and interactive websites, as opposed to static, content-driven ones, patients now have an opportunity to benefit from a social network to learn about their illness and to gain support from others with similar experiences.

To date, the potential influence of social media on diabetes management is largely unexplored, despite its extraordinary rise in popularity and use over the last decade. A 2010 survey underscored the importance of social aspects and experience-sharing among individuals diagnosed with diabetes, concluding that there was a strong need to tailor social interactions regarding an individual's diabetes to support, educate and provide patients with access to resources.[34]

Research has also demonstrated that online social support programs targeting diabetes have been shown to decrease the prevalence of adverse symptoms associated with diabetes; improve health behaviors and reduce utilization of health care resources. Through the use of the Internet, social media programs can serve as interactive mediums for providing health information and enhancing social support. Additional research suggests that health communication is most effective when it reaches people on an emotional and rational level, relates to that person's life, combines mass media and interpersonal communication, is tailored to the individual,

and is interactive. Online social media tools have many of these communication elements incorporated into their designs, and various forms of social media, such as virtual communities, blogs, podcasts, and wikis have been used to create large educational and support groups for individuals for diabetes.[35]

In 2010, Green et al conducted a qualitative evaluation of the content of communication in communities developed within Facebook for those patients diagnosed with diabetes. They identified the 15 largest Facebook groups that focused on diabetes management and, within each group, downloaded the 15 most recent "wall posts" and the 15 most recent discussion topics from the ten largest groups. Through this data, 480 unique users were identified within a series of 690 topics generated from both the posts and the discussion topics. Patient and family members used Facebook to share personal clinical information, to request disease-specific guidance and feedback and to receive emotional support. Approximately two-thirds of the posts included unsolicited sharing of diabetes management strategies, and over 29 percent of posts featured an effort to provide emotional support to others as part of a community.[36]

Weitzman et al conducted an observation study of the quality of diabetes-oriented social networking sites in 2012. Eleven sites were included that were identified through Google using "diabetes" as a primary search term and "social networking," "virtual community," and "community" as secondary terms. In addition to the keyword match, inclusion criteria were: site falls within top 20 identified through Google; site is in English; adults can access the site; members can develop a unique personal profile that persists over time; and members can interact with members directly. The sites were evaluated across a number of indicators, including: alignment of content with diabetes science and clinical practice recommendations; safety practices for auditing content, supporting transparency and moderation; accessibility of privacy policies and the communication and control of privacy risks; and centralized sharing of member data and member control over sharing.
The results indicated that the quality of these identified sites was variable, with over 50 percent aligned with diabetes science/clinical practice recommendations. There were gaps in medical disclaimer users and specification of relevant blood glucose levels. Safety was mixed as there was misinformation about a diabetes 'cure' on four moderated sites; and on those sites with advertising, ads for unfounded 'cures' was present on three. There were virtually no procedures to secure data storage and transmission, with only three sites supporting member controls over personal information.[37]

We found no conclusive evidence about the effect of social media on diabetes care or any studies evaluating how these mediums can be leveraged for socially disadvantaged populations. However, Frost and Massagli have indicated that minority populations, specifically non-Hispanic blacks and Native Americans, are more likely to create an online profile on a social networking site, are more willing to use the Internet to research information about their health, and are more likely to discuss health information online in chat rooms, discussion groups or online support group, as compared to non-Hispanic whites.[38] These findings suggest that there is untapped potential for using social media to improve care for underserved diabetic populations.

While communities around health and diabetes care have become increasingly popular on social media sites, such as Facebook, Twitter and YouTube, other sites have built large, virtual communities specifically around diabetes management. Some examples include:

TuDiabetes.Com is an online community run by the Diabetes Hands Foundation, which currently has over 15,000 members sharing their experiences with diabetes through blogs, forums, events and news. The themes on the sites are centered on healthy living, best practices in self-management, nutrition and dietary advice, and emotional support.

dLife is a social networking site developed and managed by LifeMedia, Inc. with over 25,000 members and offers information on Type II diabetes symptoms, healthy diet tips and exercise suggestions, medications for diabetes control, and an online forum for individuals to share their personal experiences. This site uses blogs, videos and an electronic newsletter to communicate within their community that is user-generated and overseen by site administrators.

About.Com – Type II Diabetes blog is written by Elizabeth Woolley and contains information on risk factors for diabetes, nutrition information, tips for exercise, Type II diabetes symptoms, prediabetes, treatment regimen, methods for controlling diabetes and potential complications.

Diabetes Daily Wiki is a diabetes encyclopedia that contains relevant information on symptoms and risk factors, lifestyle, exercise routines, food and nutrition, and complications. It is written and maintained by community members of the Diabetes Daily community, an active web-community that serves as a support mechanism with those diagnosed with either Type I or Type II diabetes.

Assessments

Apart from identifying the various types of technologies currently available for diabetes care; the issues of usability, cost benefit and effectiveness, interoperability and privacy/security were also assessed against these groups of technologies. These issues are significant in providing context in the factors associated with the proper use of these eHealth tools; the initial cost and expected benefit in using these tools for diabetes self-management; how they exchange data with large health information systems, such as electronic health records; and how individual patient data is kept secure and access is only granted through individual consent.

Usability

The usability of patient-centric eHealth tools is essential in effectively managing diabetes and promoting wellness. The usability of these tools can be understood and assessed according to four major factors: user-friendliness, user design, user satisfaction and user confidence. The first two primarily deal with the type of technology and the design of the interface. The last two concern user perception

and are most relevant to this brief. The term user satisfaction, defined by how well actual care received meets a patient's expectations, merits particular attention when assessing usability because it is a critical component of both quality of care and patient outcomes. For example, studies have evaluated patient satisfaction with regards to telemedicine in a wide variety of areas, such as primary care, emergency care, pediatrics and radiology.

A study conducted by East Carolina University used data from 495 teleconsultations and found that over 98 percent of the patients were satisfied with their telemedicine experience. The study concluded that the high satisfaction rate was at least partially attributable to the removal of barriers and deterrents that can occur within a traditional healthcare delivery system, such as the distance traveled and time required for an appointment, or the lack of patient involvement in the examination and discussion of results.[39]

Satisfaction with telemedicine among rural patients, who are socially disadvantaged, tends to be significantly higher than among those receiving traditional care. Brown-Connolly created and deployed a standardized satisfaction questionnaire in 18 rural California counties. Using a five-point scale, data was collected from 793 patients receiving consultation in a number of specialties.[40] The overall score for mean satisfaction with telehealth was 4.5 out of 5, indicating widespread satisfaction with the use of telehealth services. Additional survey questions also assessed each respondent's willingness to continue to use telemedicine, finding that patients believe they obtained the correct and necessary information from their provider, their questions were adequately addressed by their provider, and they would continue to use telehealth on an ongoing basis. Brown-Connolly noted that the use of telehealth reduced travel distance for patients meeting their provider by an average of 90 miles.

User acceptance, on the other hand, can be evaluated against two main constructs: ease of use (user-friendliness) and confidence with the technology. A 2012 ethnographic study identified four common usability design themes among mHealth technologies for diabetes care that successful applications for diabetes care would share. The study used data from interviews and focus groups with diabetic patients and their family members.[41] Researchers combined the information from the interviews with knowledge of user-centered design approaches employed by other consumer-oriented products to identify the following four themes that are central to the effective use of mHealth applications for diabetes care:

Theme #1: Fast, Discrete Transactions.
A substantial number of the telemedicine and mobile applications assessed for this 2012 study take blood glucose readings directly from a glucometer or through user input. The information is transferred either directly to a central server or to an Internet cloud. The data is collected and transferred wirelessly though Bluetooth technology within a matter of seconds. Additional weight, nutrition and exercise information are transmitted directly to a central web server upon input, where they can be viewed by the patient and/or family member within moments after the data is entered.

Theme #2: Data Collecting To Facilitate Decision Making
Many mobile applications used for diabetes management utilize visual charts and graphs to illustrate a patient's health information, including daily glycemic levels, calorie consumption, weight, blood pressure and physical activity. Further, many of these applications include decision-support prompts and alerts to notify a user when their levels fall or rise dangerously. These prompts also can inform an individual know when they have consumed more calories than needed, when their carbohydrate intake is too high, or if they need to increase their activity level for the day.

Theme #3: Behavior Modification
A number of pilot studies have demonstrated the utility of eHealth Tools in capturing and reporting glycemic levels and other health information. In many of these studies, patients were even able to achieve better control of their blood glucose, blood pressure, and weight in controlled environments, suggesting the potential for tools like telemedicine and mobile applications to affect behavior change. Unfortunately, we could find little research indicating that these behavioral effects are sustainable in the long term, as many of the articles we reviewed did not include follow-up studies using the same cohort of patients. Thus, it is difficult to ascertain whether eHealth tools have a long-term impact on diabetes control or on mitigating the risk factors associated with Type II diabetes.

Theme #4: Information Sharing
Mobile applications, such as Vree or iBGStar, integrate with either a web-based application, such as a patient web portal, or with a personal health record. User data from these applications can be stored and shared with family members, informal caregivers or providers based on the preferences of the user. Osborn et al reviewed a number of usability studies about PWPs to determine if patients were open to the idea of using technology to assist in the self-management of diabetes, the most salient features of the PWP, and the potential barriers to sustainable use. They found that a majority of patients from all age groups are not averse to using technology for disease management.[42] However, the study did not investigate the impacts of socioeconomic status and race, making it difficult to assess acceptance of PWPs by socially disadvantaged populations.

Popular PWP features identified by the study include the ability to electronically communicate with providers and tools to track progress in both weight and diet. Interestingly, none of the studies referenced by Osborn indicated that access to educational resources on diabetes management and monitoring; routine foot and eye exams; or best practices in self-management were selected by respondents as useful features. Therefore, while patients may be using PWPs to communicate with their providers, they are not necessarily taking advantage of the numerous resources available to assist in self-managing their diabetes and tracking outcome-related measures (such as lipid profiles).[43] Common barriers to PWP use include lost passwords and lack of knowledge about features of the portal, such as diet or blood glucose trackers. A major concern identified by Osborn was the perception that a PWP would replace the interpersonal communication between a patient and a provider, which a majority of individuals valued.

Cost Benefit and Effectiveness of eHealth Tools

Healthcare providers invest in health information technology, from large-scale information systems used by multiple hospitals to mobile applications used by individual patients, in part on the expectation that health IT will help improve efficiency and decrease costs. After all, when patients better manage their conditions, they will less frequently require healthcare services, especially those that are most expensive, such as emergency room visits and hospital readmissions. For socially disadvantaged populations in particular, the cost burden associated with Type II diabetes is significant, and strains the healthcare system at both the community and national levels. However, because of a lack of evidence on the economic impact of eHealth tools, measuring the cost benefits and savings is difficult. Although a number of the studies described in this brief have demonstrated the efficacy of utilizing eHealth tools to manage the risk factors associated with Type II diabetes, none of them sought to measure the cost-effectiveness of the technologies being studied. This is largely due to an inability to extrapolate findings from a localized study into a national context.

In 2008, a study conducted by the University of Texas Medical Branch (UTMB) in Galveston evaluated a cost analysis of telemedicine conducted by the Center for Information Technology Leadership (CITL). CITL sought to project the potential cost savings of telemedicine after initial investments in infrastructure were recouped. Although the savings model CITL used was not specific to diabetes, it assumed a combination of "store-and-forward" technologies that involved the transmission and interpretation of medical data with "real-time" video consultations. They also examined the value of both direct consultations between a provider and a patient, as well as a three-way consultation in which a specialist was directly involved, reasoning that the number of in-person visits and redundant or overlapping tests would be reduced if patients participated in these three-way consultations.[44] The CITL study recognized $3.61 billion in savings as a result of physician-to-physician consultations, primarily due to a 45 percent reduction in unnecessary tests.

With respect to Type II diabetes specifically, we found sparse data on cost-effectiveness for any type of eHealth tool due to a lack of realistic economic models and empirical data regarding the potential financial benefits of using eHealth tools to improve diabetes outcomes. A significant majority of the studies included in this brief examined the use of various technologies over a short period of time, usually a 12-18 month timeframe. In order to appropriately model costs, both patients and providers will need to demonstrate continued ongoing compliance as well as favorable medical and economic results.

Interoperability

Effectively using eHealth tools to help patients manage their diabetes often requires the secure exchange of clinical data through multiple message formats and from different information systems.[45] Therefore, a semantically sound and technically feasible set of standards are needed to correctly transmit and interpret this data.

Although the fields of telemedicine and mHealth have made tremendous strides in utilizing standards to connect with larger health information system, there is no defined set of either messaging or vocabulary standards that are universally drawn upon by existing health IT platforms.

Interoperability for eHealth tools can be viewed on an internal and external level, both of which are necessary for the sustained success of these technologies. Internal interoperability refers to the interaction of components on an operational level, such as common physical interface standards or the American National Standards Institute (ANSI) series of standards for videoconferencing. This type of interoperability ensures that point-of-care encounters succeed, often necessitating effective communication despite differences in time, location, type of equipment and level of technical expertise.[46] External interoperability focuses on effective networking and interaction between health information applications and health information systems. External interoperability is driven by the health information standards which seek to link disparate systems, including EHRs, laboratory, pharmacy, image archival, and decision support systems. The ability to collect and exchange data across each of these systems is critical to achieving an uninterrupted and integrated continuum of care for the patient. Some of the standards used to facilitate external interoperability include those promulgated by Health Level Seven (HL7) and the Digital Imaging and Communications in Medicine (DICOM), as well as those published under the United States Health Insurance Portability and Accountability Act (HIPAA).

Together, external and internal interoperability standards create a framework that is essential for enabling providers in distant locations or practicing different specialties to capture, exchange, and understand data. Though telemedicine and mobile health applications have improved the availability of specialty care and patient education resources in an effort to encourage use among socially disadvantaged populations, many of these more disparate systems are still incompatible with these tools. As with the rest of the health IT industry, patient-centric tools (and the systems with which they seek to connect) are plagued by proprietary specifications that inhibit data exchange.

Fortunately, standards developed for interrelated fields have been leveraged by eHealth tools, such as the ANSI standards for videoconferencing. Coder-decoder protocols (CODECS) within the ANSI standard have led to wide-scale videoconferencing interoperability that is agnostic in terms of the hardware used by each individual telemedicine platform.[47] Likewise, Hypertext Markup Language (HTML), which is commonly used by web browsers, is a widely accepted standard for telemedicine, mHealth applications, and web-based technologies. HTML provides a standard for the delivery of content as well as database and program access independent of the operating system platform. Finally, the use of the DICOM and Picture Archiving and Communication Systems (PACS) for digital imagery and archiving has been essential to developing store-and-forward and remote monitoring telemedicine systems. For populations living in rural or disparate areas, the ability to utilize a common standard for access and communication shows great promise in these technologies.

However, the ability for eHealth tools to exchange data with larger healthcare information systems is all too often still a work in progress, as the industry has yet to define and agree upon clinical messaging and vocabulary standards to be used across different technologies. Controlled terminologies would enhance the ability of mobile applications to communicate effectively with EHRs and other components of a hospital information system (HIS), while facilitating the exchange between a patient web portal and an EHR, regardless of location and vendor.

Privacy and Security

The field of eHealth tools has grown substantially as patients begin to use devices and applications to record their blood glucose levels, daily activities, diet and vital signs. In most instances, clinical data is collected from these patients through the device or application, either through manual data entry or remotely via sensor. It is imperative that patients can control data collection and distribution to protect their information and to be able to grant access to individuals if and when the need arises. For example, the ideal management of Type II diabetes requires a care team, which generally consists of a provider, a nurse or certified diabetes educator, and a dietician. If a patient develops complications from diabetes, such as retinopathy, then specialists must also be consulted and incorporated into the care team, and consequently require access to that patient's clinical data. While there is a need to exchange and share this data with the appropriate providers and caregivers to ensure accurate and high quality care, there is also a significant need to respect patient privacy. In this respect, a patient must have control over the disclosure of the data with the understanding that different situations may require different responses.

Security is a key concern for those that are designing the eHealth tools and the patients who are using them. A number of studies of the use of videophone technology for real-time videoconferencing have investigated tools that employ a common (H.324) transmission standard. The H.324 standard enables low-quality interactive video connectivity over an analog telephone line, also known as plain old telephone service (POTS).[48] Because the current HIPAA regulations exclude POTS-based technologies, videophone technologies pose a low security risk to the unauthorized access or disclosure of personal health information. In such systems, the only threat of access is if an individual obtains a court order to wiretap the telephone line, or the user cannot verbally verify the individual in the remote location where services are being provided.

Store-and-forward types of telemedicine or mobile health rely on the transmission of medical images, video clips, medical records and medical data through the use of a standard Internet Protocol (IP). Information shared over the public Internet often remains accessible to individuals through the use of commercially available equipment. Therefore, to secure health information, many of the eHealth tools use public-key encryption to safeguard the information over Wi-Fi Protected Access (WPA), an IEEE standard that is commonly used in locations where wireless Internet is available.[49] Many systems that use the Internet as an access point, including patient web portals, require encrypted authentication with a user name and

password. Additionally, in some cases, role-based access is given to the patient and members of the care team to determine who can access and use which data. Studies we reviewed offered limited detail on privacy protocols and security measures employed by the various tools. More research is needed on the types of encryption protocols used by mHealth devices in particular, as well as the message authentication measures used to ensure data integrity when information is exchanged from one entity to another.

Methodology

We began this study with a comprehensive literature review utilizing the following databases: the Medical Literature Analysis and Retrieval System Online (Medline); PubMed; and the Cumulative Index to Nursing and Allied Health Literature (CINAHL). A search was also conducted through Google Scholar. Relevant references from extracted articles were identified to increase the literature search yield. Search terms comprised of "diabetes & medically underserved," "diabetes & telemedicine," "diabetes & mobile health, "social media & diabetes," and "patient web portals & diabetes."

Only original studies which evaluated the use of eHealth tools (mobile health applications, telemedicine, social media and patient web portals) for diabetes management in medical practice and were published after 2005 were reviewed. These included studies using randomized controlled trials or observational (non-randomized controlled trials, pre-post studies, and post-intervention studies) or qualitative methods. Studies evaluating the use of health IT for other chronic diseases, review papers which described other studies, and opinion pieces were excluded. In addition, studies evaluating the use of electronic health records or chronic disease registries were excluded as the focus of this project is on patient-centric tools and not on components of health IT that are primarily used by physicians.

Titles and abstracts of selected articles were independently reviewed by two authors and, if found eligible, the full article was then obtained for additional review. When there was disagreement between the two authors about the eligibility of an article, the third author adjudicated the conflict. A total of 514 articles were identified using the above search strategies, with 107 satisfying the inclusion/exclusion criteria. For this report, the studies identified and abstracted were classified based on methodology used, as shown in Table 7:

Table 7: Number and Types of Studies Identified

Study Methodology	Number of Studies
Randomized Controlled Trial	68
Quasi-Experimental Design	4
Pre-Post Test Design	12

Study Methodology	Number of Studies
Post-Intervention Studies	3
Case Studies	5
Systematic Reviews	15

Each of the articles was abstracted through a disciplined process to identify the technologies being studied; the results of the utilization of those technologies on diabetic patient outcomes; the relationship between those outcomes and risk factors associated with socially disadvantaged populations; and specific characteristics of each technology, including:

- overall usability of the technology;
- cost of the technology as well as its potential return-on-investment and cost effectiveness;
- data transmission standards to determine its interoperability with larger health information systems; and
- protocols developed within the technology through which personally identifiable information is protected.

Additionally, a non-traditional literature review was conducted through Google to identify specific products that employ the features and functionalities of the eHealth tools identified in the literature review. Information about the development and proliferation of these tools, in addition to projections about their use in the future, were abstracted from online news sources, such as Healthcare Data Management and others.

Key informant interviews were conducted to fill in the identified gaps within the literature. The informants were chosen based on the recommendation of a Technical Advisory Group formed for this project, in addition to specific individuals who were selected based on a review of their articles. A semi-structured interview protocol was designed for this purpose.

Study Limitations

A limitation to this study is the inability to identify research that demonstrates the utility and effectiveness of these eHealth tools on the non-clinical factors associated with Type II diabetes. Particularly amongst socially disadvantaged populations, the need for comprehensive lifestyle changes associated with diet and increased physical activity are paramount in effective management of the disease. However, the vast majority of the applications found in the research that underwent pilot studies focused specifically on clinical outcomes, with an emphasis on blood glucose, lipids and blood pressure. Many of the mHealth applications that provided data screens for input on diet and exercise were not evaluated to determine their effectiveness within socially disadvantaged populations. Given the amount of evidence indicating that

lifestyle changes are essential for control of Type II diabetes and that poor nutrition and a sedentary lifestyle are causal risk factors for the study population, additional research is needed to determine the effectiveness of these applications. Additionally, the demographic characteristics of socially disadvantaged populations indicate a wide array of cultures and ethnicities. Each group has its own distinct culture, beliefs and language when communicating with providers. A significant limitation within the studies found for this brief was the lack of a robust and comprehensive framework to assess usability. While some research indicated the functionality needed for the acceptance and use of patient-centered applications; very little demonstrated how various cultures could use these applications successfully.

Conclusions

- **The rate at which mHealth is advancing could significantly impact diabetes care.** There have been significant advances in the fields of telemedicine, mobile health, social media and patient-web portals that assist in the management and care of individuals with Type II diabetes. Mobile health applications, which have significantly risen in availability over the past year, are the fastest growing sector of the patient-centered tools industry. Given the increase in smartphone adoption within the first and second quarters of 2012, it seems likely that patient-centric technologies will utilize more mobile capabilities.
- **mHealth tools are viable tools for socially disadvantaged populations.** Research shows that the disadvantaged populations have increased access to mobile health, and so mHealth would be an effective tool by providing outreach and access to care regardless of an individual's socioeconomic status, race, ethnicity, or geographical location. mHealth can provide vital tools to increase health care access; improve care delivery systems; assist individuals in engaging in culturally competent outreach and education with technology that is easy to use, affordable and scalable, and is already adopted by patients of all ages and socioeconomic status. Effective mHealth can empower patients with diabetes by providing information and education about medications and risk factors; connect patients to communities and resources; and provide patient advocacy through engagement.
- **Social media is currently underutilized by care providers.** Despite the widespread use—we are not sure what it means and how it might impact patients – there is a need to study and evaluate the effectiveness of social media on diabetes self-management. The large number of specific social networking communities, blogs, wikis and other platforms have demonstrated the utility of this technology to help patients form support groups, provide educational resources, share knowledge and best practices in the care and management of the diabetes. However, we did not identify any studies that have evaluated the effectiveness of social media on Type II diabetes care, nor its overall use among socially disadvantaged populations.
- **Patient web portals are helping to educate patients about their diabetes.** Patient web portals have gained tremendous popularity over the past few years, with a number of major health organizations creating and implementing portals for their patient communities. These portals show great promise in facilitating communication between patients and providers, as well as a means of accessing

educational materials to assist all populations in the management and care of their diabetes.

- **It is not clear what patients "want" or "like."** Very few assumptions have been tested with patient populations outside of a controlled experiment. While many of the studies identified in this brief discuss the number and type of patients that utilized eHealth tools, there was little data on patient perceptions of the usability of these technologies. Some research has outlined a few major themes that should be included in the design of any eHealth tool, and a number of the ones included within this brief met most of the criteria. However, it is unclear as to whether patients who participated in a number of these studies found the tools usable and satisfactory for their needs. Studies also did not reveal whether the tool was adapted for use by those with low health literacy, those for whom English was not their primary language, and those with limited technical knowledge.

- **Consensus-based standards are needed to accelerate the growth of tools for disadvantaged populations.** A number of these eHealth tools use standards that were initially designed for other fields, such as videoconferencing or Internet web pages. However, the use of these standards helps these technologies interoperate on an internal level, so that the appropriate information is received at the point-of-care. On an external level, there is no consensus on standards for these eHealth tools to interoperate with disparate systems. This is a problem that has been inherent within the field of health IT for some time. Although a number of these eHealth tools use common, well-recognized encryption standards for security and represent a low risk to the unauthorized disclosure of personal health information, there is little known about the specific protocols used. None of the studies researched indicated the types of protection that were offered to patients participating in the pilot studies, nor were any specific security protocols referenced.

The transition to managing chronic disease requires changes within healthcare organizations and the delivery of care. Primary among those changes is the recognition that the patient is at the center of the care effort and is the one responsible for carrying out and monitoring the necessary actions to manage their diabetes correctly and adequately. With diabetes disproportionately affecting socially disadvantaged populations, there is a fundamental need to provide these individuals with the appropriate tools to empower them to manage their health; create continuous and consistent communication with their provider; and provide resources for them to educate themselves about diabetes and potential care strategies. Critical to this strategy is the use of eHealth tools which can provide Web-based health education; promotion of and support for self-management in community or home-based settings; and adherence to evidence-based clinical procedures and medications. From the information gathered for this brief, it is probable that the technologies used for telemedicine, mobile health applications, patient-web portals and social media can promote partnerships between the patient and providers; facilitate better patient self-management; improve compliance with care protocols and medication management; and reduce the hospital readmission rate for those with diabetes.

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