ORIGINAL ARTICLE

The Utah Remote Monitoring Project: Improving Health Care One Patient at a Time

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Abstract

Background: The expanding role of technology to augment diabetes care and management highlights the need for clinicians to learn about these new tools. As these tools continue to evolve and enhance improved outcomes, it is imperative that clinicians consider the role of telemonitoring, or remote monitoring, in patient care. This article describes a successful telemonitoring project in Utah.

Subjects and Methods: This was a nonrandomized prospective observational preintervention–postintervention study, using a convenience sample. Patients with uncontrolled diabetes and/or hypertension from four rural and two urban primary care clinics and one urban stroke center participated in a telemonitoring program. The primary clinical outcome measures were changes in hemoglobin A1C (A1C) and blood pressure. Other outcomes included fasting lipids, weight, patient engagement, diabetes knowledge, hypertension knowledge, medication adherence, and patient perceptions of the usefulness of the telemonitoring program.

Results: Mean A1C decreased from 9.73% at baseline to 7.81% at the end of the program ($P < 0.0001$). Systolic blood pressure also declined significantly, from 130.7 mm Hg at baseline to 122.9 mm Hg at the end ($P = 0.0001$). Low-density lipoprotein content decreased significantly, from 103.9 mg/dL at baseline to 93.7 mg/dL at the end ($P = 0.0263$). Other clinical parameters improved nonsignificantly. Knowledge of diabetes and hypertension increased significantly ($P < 0.001$ for both). Patient engagement and medication adherence also improved, but not significantly. Per questionnaires at study end, patients felt the telemonitoring program was useful.

Conclusions: Telemonitoring improved clinical outcomes and may be a useful tool to help enhance disease management and care of patients with diabetes and/or hypertension.

Introduction

DIABETES CARE AND MANAGEMENT modalities have evolved and are increasingly using technological approaches. An interdisciplinary team approach is used to provide care, and the key team member is the patient. A unique advancement to clinically assess and educate patients to appropriately use diabetes self-care management strategies is telemedicine, defined as use of medical information ex-

changed by electronic communications across different sites.¹ One approach is remote patient monitoring, where a patient at a distant site measures and transmits clinical data to a healthcare provider, using an electronic interface. Telemonitoring encounters may be synchronous or “live”² or asynchronous. Asynchronous or “store and forward” sessions use patient measurements of blood pressure (BP), glucose, and weight that are recorded and viewed by a healthcare provider at a different site by telephone or the Internet.³

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A plethora of telemonitoring projects have been published, and most have included nurses as care coordinators.⁴⁻⁷ This project in Utah involved a multidisciplinary team that included a pharmacist who is a certified diabetes educator (CDE) and Board-certified in advanced diabetes management, as well as non-CDE healthcare educators. This is notable because pharmacists are becoming an integral part of healthcare delivery models.⁸

A commonly quoted statistic is that the number of persons with diabetes in the United States is 25.8 million,⁹ and annual diabetes costs are \$245 billion.¹⁰ Increased costs may be due to failure to comply with prescribed treatments.¹¹ One report indicated that increased medication adherence could save \$5 billion annually and result in fewer emergency department visits and hospitalizations.¹² Hypertension (HTN) is a leading cause of worldwide mortality, contributing to over 9.2 million yearly deaths—primarily due to strokes and coronary heart disease.¹³ HTN affects 30% of adults in the United States, and the annual costs exceed \$50 billion.^{14,15} Two-thirds of American adults have HTN, or they use antihypertensives.⁹ Medication nonadherence costs associated with diabetes, HTN, and hyperlipidemia are estimated to be \$105.8 billion.¹⁶ Because of skyrocketing costs, telemonitoring strategies are being studied to improve clinical outcomes and treatment adherence.

The objective of this study was to use approved telemonitoring devices to expand and improve chronic disease management of patients with diabetes (with or without HTN) or with HTN only and to measure clinical parameters. The Office for the Advancement of Telehealth project was a collaborative effort between the Utah Telehealth Network and the Association for Utah Community Health. The telemonitoring project involved asynchronous measurements transmitted from the patient to a remote care coordinator (RCC) pharmacist CDE. One rural clinic used a healthcare educator as the RCC.

Subjects and Methods

Study design and setting

This was a nonrandomized prospective observational preintervention–postintervention study involving a convenience sample of patients with diabetes and/or HTN. Diabetes patients from four rural and two urban primary care clinics participated in the study. Patients with only HTN from an urban stroke center also participated and were enrolled by a study coordinator. This project used a pharmacist as the RCC for most sites. Several participants were underserved individuals receiving medical care at federally qualified Community Health Centers. This study was approved by the University of Utah Health Sciences Center Institutional Review Board.

Description of the telemonitoring program

One of two telemonitoring delivery methods was used. One was the Authentidate™ Electronic House Call™ (Authentidate Holding Corp., Berkeley Heights, NJ), a Food and Drug Administration 510 (k)–cleared remote monitoring device. This unit has a touch screen with a built-in BP monitor to measure and record systolic and diastolic BP (SBP and DBP, respectively) as well as heart rate. Patients used

their own glucose meters to measure blood glucose (BG) and were provided with a Taylor® electronic digital scale (Taylor Precision Products, Inc. Oak Brook, IL) to measure their weight. Patients manually entered BG and weight readings when prompted. The device was programmed to sound an alarm at a prespecified patient-preferred time to prompt the patient to initiate a telemonitoring session. If preferred, the patient could opt to start the session at his or her convenience. Patients were asked to enter data twice daily Monday–Thursday and once daily on Fridays. The device was programmed by the RCC to ask how they were feeling that day and whether or not they had taken their medications and then receive a prompt to measure BP and then enter BG (if they had diabetes) and weight measurements. After entering BP, BG, and weight, the patient received a series of education messages programmed by the RCC in English or Spanish. The programmed diabetes or HTN education messages consisted of an 8-week curriculum and were focused on teaching patients about their disease and associated comorbidities. Other messages reminded patients of target values (hemoglobin A1C [A1C], BP, preprandial and postprandial BG, and lipids), medications, healthy nutrition, physical activity, stress reduction, risk reduction, and ancillary care. There was one set of standard messages that applied to all patients with type 2 diabetes and one set of standard messages that applied to all hypertensive patients. The 8-week message curriculum was repeated three times so that the patients received 24 weeks of education.

The second telemonitoring delivery method was use of an interactive voice response (IVR) system, available from the same vendor as the Authentidate Electronic House Call. Patients were provided with an Omron® series 7 BP monitor (Omron Healthcare, Lake Forest, IL) and electronic digital scales, but they used their own BG meter. Patients received a call from the telemonitoring IVR service at a prespecified time or called at their own convenience, but they were asked to do the sessions once daily Monday–Friday. After appropriate identification, the patient was greeted in English or Spanish and asked how he or she was feeling and if he or she had taken prescribed medications. They were then prompted to enter BP, BG, and weight readings and then received a series of disease-management education messages. The messages were also part of the 8-week curriculum that was repeated three times to deliver 24 weeks of education. The Electronic House Call unit was immediately available in Spanish or English to the patients at the different primary care clinics. The IVR technology was initially available only in English and was used by the stroke center patients. The IVR system became available in both Spanish and English the last 9 months of the trial and was used by clinics other than the stroke center.

Session times were conducted daily Monday–Friday and were individually scheduled according to the patient's preference to make sure this did not conflict with his or her work. The RCCs programmed alerts based on low or high BP, heart rate, BG, and weight measurements (based on provider preference) and received an e-mail alert if a patient had an out-of-range value. This then prompted the RCCs to contact the patient directly and clarify whether any further action was necessary. The RCCs were in regular telephonic contact with patients to ask whether they had any questions and to provide further lifestyle information, if requested, or to help prevent

future out-of-range values. Thus case management was provided by the RCC pharmacist CDE at three Community Health Centers (one rural, two urban), the healthcare educator at one rural clinic, or the study coordinator at the stroke center.

Medical providers were contacted either via a note in the electronic medical record (or immediately if there was a concern, in person or by telephone) if there was an out-of-range value (decided by individual providers or clinics as a value that was high or low). If a medical provider wished to provide further instructions, he or she contacted the RCC to contact the patient. By evaluating monitoring data several times daily, the RCC was also able to determine if patients were not doing the telemonitoring sessions. In this case the RCC also called the patient to determine if the patient had been doing the sessions or whether there was an equipment transmission technical problem that could be resolved. The RCCs generated graphical reports of BP and BG usually every 2–4 weeks, based on provider preference, and entered these into the clinic electronic medical record.

Patient selection

Inclusion criteria. From a convenience sample of adult patients with type 2 diabetes and/or HTN over 18 years old and an A1C >7% and/or BP >140/90 mm Hg, subjects were selected by their medical provider or the RCCs and asked if they would like to participate in the study. Major reasons cited for refusal were time constraints or simply that they did not wish to participate. Limited funding allowed only for a certain number of Electronic House Call and IVR devices. Patients with diabetes and controlled or uncontrolled HTN (BP >140/90 mm Hg) participated, as did patients with HTN only. Inclusion criteria were willingness to participate and follow instructions, have basic cognitive skills and fluency in English or Spanish, be able to learn to use equipment or have a caregiver who was in regular contact who could use the equipment for them, have a phone, cell phone, or Internet access, and have sufficient electrical service to operate the system. Patients had to have a current or new diagnosis of diabetes (with or without HTN) or HTN only. If patients agreed to participate, they were consented and enrolled and taught how to use the telemonitoring device. They were then followed up prospectively for a period of approximately 6 months—unless the provider wished for the patient to continue the telemonitoring sessions for a longer period of time or until the patient was able to return to clinic to have discharge labs and assessments performed. Patients came from both urban and rural sites and were similar in demographics. The main difference was only the site. One unique patient group comprised participants from the stroke center because they had only HTN and no diabetes.

Exclusion criteria. Nursing home or extended care facility residents were excluded, as well as those who would be unable to return for follow-up visits over the next 6 months, who were uncooperative or combative, or who were non-adherent to the monitoring protocol. Nonadherent patients were defined as those who stopped doing the telemonitoring after a few days and when contacted by the RCC (because the sessions were not being done) indicated they did not wish to continue. Patients with serious underlying conditions such as malignant HTN, heart failure, cardiomyopathy, or other se-

rious comorbidities were excluded. Patients under 18 years of age or those who were pregnant or became pregnant during the study were also excluded.

Data collection

The main clinical parameters were A1C and BP (if applicable) and were measured at baseline and at the end of the observation period. The target A1C for diabetes patients was <7%, and the goal BP for all patients was <130/80 mm Hg. Other measures included fasting lipids, including low-density lipoprotein (LDL) (with a target goal of <100 mg/dL), and body mass index. Validated questionnaires that measured patient activation,¹⁷ diabetes knowledge,¹⁸ HTN knowledge,¹⁹ and medication adherence²⁰ were administered at baseline and at the end. At the end, patients were also queried about utility of the telemonitoring process, satisfaction with telemonitoring, and whether participation in the telemonitoring program had changed any of their health-related behaviors such as taking medications or exercise.

Outcomes

The primary outcome was to measure change in A1C and/or BP from baseline to discharge. Other outcomes were changes in clinical parameters such as LDL (for hyperlipidemia) and body mass index. Changes in medication adherence, self-efficacy (using the Patient Activation Measure), and patient knowledge of diabetes as well as HTN (if applicable) were also measured. Lifestyle changes (including exercise), and process measures such as number of telemonitoring sessions and alerts were also tracked.

Explanatory factors

Patients make many decisions that impact their overall disease states. Different tools may be used to measure whether patients are adequately caring for their chronic illnesses. These include scales that evaluate patient activation, knowledge of their disease state, and medication adherence. The Patient Activation Measure is a validated scale that assesses patients' abilities to take care of a chronic disease state such as diabetes.¹⁷ This 13-item scale evaluates the patient's skill, self-reported knowledge, and confidence in managing his or her chronic disease. The Diabetes Knowledge Test is a 14-item questionnaire of patients' understanding of their diabetes¹⁸ that evaluates how much a patient knows about certain factors such as target clinical values such as A1C, knowledge about different nutrients, how to deal with low or high glucose levels, and identification of certain complications. The Hypertension Knowledge Test asks 10 questions evaluating target BP, factors that may improve it, and complications of high BP.¹⁹ Medication adherence is one important aspect of any chronic disease because consistent and appropriate medication use is a key factor affecting whether a disease state may be controlled. A validated eight-question medication adherence self-reported questionnaire²⁰ was used to assess each patient's adherence at baseline and at the end of the study.

Statistical analysis

The objective of analyses was not to evaluate whether telemonitoring is an effective technology—that is well known.^{4–7} Rather, the goal was to measure potential impacts

of access to telemonitoring care on certain patient outcomes. Data from the study were analyzed by comparison of baseline with discharge measurements in individuals who completed the study. Paired *t* tests were used for comparison of continuous measures, and the Wilcoxon sign-rank test was used for ordinal measures. This approach biases estimates of the effect of the intervention relative to the “gold standard” intent-to-treat design. However, if dropouts occur early in the course of the study, then simple pre–post measurements provide a practical measure of the expected impact of patients completing the program.

Statistical power was secondary in this project because enrollment was based on the goal of providing services to the maximum number of people, within funding constraints. However, the study had ample power to detect differences, given previous reports of effects of telehealth on A1C⁴ and BP control.²¹

Results

A convenience sample of 125 persons consented to participation, and individuals were enrolled in the study between September 1, 2011 and March 31, 2013 (Fig. 1). Two patients were excluded: one with diabetes and HTN, due to unexpected pregnancy, because this was an exclusion criterion, and another with HTN, due to a language barrier and thus inability to comprehend the programmed education messages. The latter patient was an IVR patient from the stroke

center who spoke only Spanish, and not English. At the time the patient was enrolled, the IVR system was not available in Spanish. Although the patient was able to enter BP readings, this person could not comprehend the education messages. Thus the investigators made a decision that the patient’s data should not be included because we could not assess the full telemonitoring impact.

There were 14 early dropouts due to nonadherence with telemonitoring: six with type 2 diabetes and HTN and eight with HTN only. Long-term management services via telemonitoring were provided to 109 individuals: 95 with type 2 diabetes (with or without HTN) and 14 with HTN only (Fig. 1). Specifically, 83 individuals had type 2 diabetes and HTN, 12 individuals had type 2 diabetes without HTN, and 14 patients had HTN without type 2 diabetes. Of the 14 patients tracking only BP, 11 were from the stroke center (an urban) clinic, and the other three were from rural clinics. There were 61 patients from urban clinics: 50 were doing telemonitoring for diabetes, and 53 were doing so for HTN. Of these, eight were monitored only for diabetes, 42 were monitored for both diabetes and HTN, and 11 patients from the stroke center were monitored only for BP. There were 48 patients from rural clinics: 45 were telemonitoring for diabetes, and 43 were doing so for HTN. Of these, four were monitored only for diabetes, 41 for both diabetes and hypertension, and three for BP only.

Demographics for the 109 individuals who completed the telemonitoring program and primary language spoken are

FIG. 1. Patient enrollment and follow-up. A1C, hemoglobin A1C; BP, blood pressure; DM, diabetes mellitus; HTN, hypertension.

TABLE 1. DEMOGRAPHICS FOR PATIENTS COMPLETING THE PROGRAM

Characteristic	Value
Age (years) (mean)	50.6
Gender [<i>n</i> (%)]	
Female	64 (58.7)
Male	45 (41.3)
Primary language [<i>n</i> (%)]	
Spanish	72 (66.1)
English	37 (33.9)

listed in Table 1. There were more females than males in the study, and the majority of patients spoke Spanish as their primary language. In total, 85 persons used the Authentidate ExpressMD Electronic House Call monitor, and 24 used the IVR system throughout the project. Five persons used IVR at the end because of the vendor transitioning to a new system. Although the intended enrollment time was 6 months, patients were allowed to continue in the telemonitoring project, per provider preference. The average duration of time for patients in the telemonitoring program was 7 months. There were a total of 24,481 telemonitoring sessions and 1,712 alerts for out-of-range values (high or low and determined by individual medical provider or clinic). The compliance rate with performing telemonitoring sessions was 80.8%.

Table 2 reports baseline and end A1C and BP values as well as concentrations of LDL and other lipids. As shown in Table 2, patients completing the study had markedly lower A1C values (almost 2 points lower). At the end, 30 of 95 persons with diabetes (31.6%) were at the goal A1C of <7%. Results from clinic sites were very similar because 32% (16 of 50 patients) of urban patients and 31.1% (14 of 45) of rural patients achieved a goal A1C of <7% by the end of the study.

Although only 97 patients were specifically monitoring BP, 105 clinic measurements were taken at entry and discharge. Clinic BP values improved, and patients had markedly lower SBP values (Table 2). The mean SBP of 130.7 mm Hg was reduced by almost 8 mm Hg to 122.9 mm Hg ($P=0.0001$ by paired *t* test). Mean DBP declined from 78.3 mm Hg at baseline to 76.2 mm Hg ($P=0.0903$ by paired *t* test), but not significantly. The percentage of patients from all sites at goal SBP of <130 mm Hg was 52.4% (55 of 105) at baseline and 65.7% (69 of 105) at the end. Percentage of patients from all sites at goal DBP of <80 mm Hg was 58.1% (61 of 105) at baseline and increased to 61.9% (65 of 105) at the end.

There were 58 participants from urban sites; their percentage at goal SBP was 46.6% (27 of 58) at baseline, and it increased to 67.2% (39 of 58) at the end. The percentage of urban patients at goal DBP was 62.1% (36 of 58) at baseline and 65.5% (38 of 58) at the end. There were 47 participants from rural sites. The percentage of rural patients at goal for SBP was 59.6% (28 of 47) at baseline and 63.8% (30 of 47) at the end. The respective percentages for DBP were 53.2% (25 of 47) and 57.4% (27 of 47).

It is important to note that only 97 of the 109 patients were actually monitoring BP via telemonitoring: 53 urban and 44 rural site patients. Matched pre- and postintervention values were available for 96 persons. For those participants, mean SBP at baseline was 132.5 mm Hg, and at the end it was 124.1 mm Hg ($P=0.0001$ by paired *t* test). Mean DBP at baseline was 78.7 mm Hg and decreased slightly to 76.7 mm Hg at the end ($P=0.1044$ by paired *t* test). The total percentage of patients specifically monitoring BP with the goal SBP of <130 mm Hg was 47.9% (46 of 96) at baseline, and this increased at the end to 62.5% (60 of 96). Patients at goal DBP of <80 mm Hg increased from 55.2% (53 of 96) at baseline to 60.4% (58 of 96) at the end.

For urban patients specifically monitoring BP, the number of patients at goal BP increased from baseline to end point. The percentages of patients at goal SBP for baseline and end point were 41.5% (22 of 53) and 64.2% (34 of 53), respectively. The percentages at goal DBP for baseline and end point were 58.5% (31 of 53) and 62.3% (33 of 53), respectively.

For rural patients specifically monitoring BP, the number of patients at goal BP also increased from baseline to end point. The percentages of patients at goal SBP for baseline and end point were 55.8% (24 of 43) and 60.5% (26 of 43), respectively. The percentages of patients at goal DBP for baseline and end point were 51.2% (22 of 43) and 58.1% (25 of 43), respectively.

Another statistically significant finding was improvement in LDL (Table 2). Results were available for 60 individuals with baseline and end measurements to allow calculation of a pre-post mean value. Mean LDL was 103.9 mg/dL at baseline and was significantly lower at 93.7 mg/dL at the end ($P=0.0263$ by paired *t* test). At baseline, 53.3% (32 of 60) were at the goal of <100 mg/dL, and 66.7% (40 of 60) were at goal at the end. LDL values were measured for 32 urban and 28 rural site patients. In urban patients, 56.3% (18 of 32) were at goal LDL at baseline, and 75% (24 of 32) were at goal at the end. For rural patients, 50% (14 of 28) were at goal LDL at baseline, and at the end 57.1% (16 of 28) were at goal.

TABLE 2. HEMOGLOBIN A1C, BLOOD PRESSURE, AND LOW-DENSITY LIPOPROTEIN VALUES

Condition	Baseline	End	95% CI	P value
Type 2 DM A1C (%) (<i>n</i> =95)	9.73	7.81	−2.38 to −1.45	<0.0001
BP (mm Hg) (<i>n</i> =105)				
Systolic	130.7	122.9	−11.69 to −3.92	0.0001
Diastolic	78.3	76.2	−4.42 to 0.32	0.0903
LDL (mg/dL) (<i>n</i> =60)	103.9	93.7	−19.09 to −1.24	0.0263
Triglycerides (<i>n</i> =77)	217.2	193.2	−53.1 to 5.10	0.104
Weight (<i>n</i> =105)	199.1	200.0	−0.668 to 2.62	0.24

A1C, hemoglobin A1C; BP, blood pressure; CI, confidence interval; DM, diabetes mellitus; LDL, low-density lipoprotein.

TABLE 3. PATIENT ACTIVATION, DIABETES AND HYPERTENSION KNOWLEDGE, AND DIABETES AND HYPERTENSION MEDICATION ADHERENCE

Patient factor	Score (mean)		95% CI for change	P value
	Preintervention	Postintervention		
Patient Activation Score (n=91)	42.5	43.6	−0.68 to 2.29	0.07
Knowledge				
Diabetes (n=90)	9.2	10.9	1.19 to 2.18	<0.001
Hypertension (n=68)	7.9	8.8	0.55 to 1.3	<0.001
Medication adherence				
Diabetes (n=72)	6.2	6.5	−0.05 to 0.77	0.089
Hypertension (n=55)	6.3	6.7	−0.02 to 0.74	0.054

CI, confidence interval.

The intervention produced nonsignificant improvements in measures of triglycerides but had no effect on patients' weight. Telemonitoring access did not increase or decrease the number of clinic visits. In the 6 months prior to entry, patients reported an average of 2.3 visits. At the end of the study, they also reported 2.3 visits over the past 6 months (the duration of the study). However, the number of reported emergency department visits decreased from 0.346 per patient to 0.189 per patient ($P=0.039$ by Wilcoxon sign-rank test). Too few hospitalizations were reported in the preceding 6 months before study entry to be able to evaluate potential effects on reducing rates, but there was no evidence of increased hospitalizations.

Potential mechanisms of the benefits of telemonitoring on diabetes and HTN on patient activation, knowledge of their disorders, and self-reported adherence to medications were explored through validated questionnaires. Results are shown in Table 3. Patient activation score improved but was not significant. There were statistically significant increases in both diabetes and HTN knowledge from baseline scores ($P<0.001$ for both). Medication adherence for both diabetes and HTN improved but was not significant ($P=0.09$ and $P=0.054$, respectively).

Table 4 reports the results of a self-reported discharge questionnaire that queried patients about their beliefs regarding use of the telemonitoring system. Most (78.5%) thought telemonitoring improved their adherence and was beneficial for their disease state (94.4%). Almost all subjects were satisfied with their telemonitoring experience. (97.2%).

TABLE 4. PATIENTS' BELIEFS ABOUT THE IMPACT OF TELEMONITORING

Question	Responses (n)	Percentage agree or strongly agree
Telemonitoring improved my medication adherence.	107	78.5%
Telemonitoring was useful to monitor my disease state.	107	94.4%
I was satisfied with my telemonitoring experience.	107	97.2%
Telemonitoring increased exercise.	106	34.0%

A substantial number of persons believed use of the telemonitoring system increased the amount they exercised (34%).

Discussion

Telemonitoring by patients from various clinics in Utah resulted in an improvement in diabetes and SBP control. The most significant finding in this study was the decrease in A1C from baseline to discharge for the diabetes patients by almost 2 percentage points. There was a corresponding improvement in knowledge of diabetes. Large numbers of persons were taking insulin, and perhaps optimized use may have helped improve results. At baseline, 59 of 95 (62.1%) persons with diabetes were on insulin, compared with 60 at the end (63.2%). For urban patients, 35 of 50 (70%) were on insulin at baseline, compared with 34 of 50 (68%) at the end; one urban patient was able to successfully discontinue insulin. For rural patients, 24 of 45 (53.3%) were on insulin at baseline, compared with 26 of 45 (57.8%) at the end.

BP values improved overall from baseline to end point and were significant for SBP in clinic measurements for 105 participants and also in the 97 patients who were specifically engaged in monitoring their BP using different devices. Improvements were found at both urban and rural sites. Improvement in knowledge of HTN may be the underlying explanation for these results.

Mean LDL values improved significantly from the start to the end of the study. At baseline, 3-hydroxy-3-methylglutaryl-coenzyme A reductase inhibitors (statins) were used by 63 of 109 (57.8%) persons. At the end, slightly fewer individuals were on statins: 60 of 109 (55%). This may have been due to improved self-care efforts, adherence issues, or reporting error, but nevertheless LDL improved. There were more urban than rural patients on statins at baseline and at the end. Initially, 40 of 61 (65.6%) urban patients and 23 of 48 (47.9%) rural patients were on statins at baseline. At the end, 37 of 61 (60.7%) urban patients and the same number of rural patients as at baseline (47.9%) were on statins.

Medication adherence and patient activation improved, but results were not statistically significant. The number of reported ED visits also decreased by about 50% during the study period relative to the 6 months before enrollment, from more than one in three reporting a visit to only one in five to six persons during the study period. This is based on self-reported data because the investigators did not have

Institutional Review Board approval to seek outside records to confirm the numbers and is thus a weakness of the study. However, this finding may be clinically relevant.

Study strengths

There are several strengths of this study. First, this was a real-world study conducted in mostly primary care clinics. Another strength was having a bilingual pharmacist CDE to program messages in Spanish because 66% of patients primarily spoke Spanish. Another was the compliance rate of 80.5% with the telemonitoring sessions and the mean duration of time that patients stayed in the telemonitoring program—7 months. A unique patient population in this project was 11 persons from a stroke center (a non-primary-care clinic), where clinicians were vested in monitoring BP because patients had already experienced a stroke. The RCC pharmacist directly communicated with the study coordinator in the stroke center. The study coordinator received reports generated by the RCC every 2 weeks and verified with the RCC when BP readings were outside the target range.

Because many of the patients were underserved, a theoretical strength of this study was that they had an opportunity to learn more about technology and thus may be more willing to engage in similar programs in the future. Many patients agreed that the telemonitoring program had helped them take their medications on time. There were over 24,000 telemonitoring sessions. Overall, providers stated they welcomed the information to evaluate their patients and felt this information was very helpful in providing care rather than seeing patients on average only every 2–4 months. Some providers commented that they liked to evaluate the reports, especially prior to the patient's next clinic appointment. Another strength was learning how to deal with alerts for out-of-range values. The RCCs responded to approximately 1,700 alerts to clarify what was occurring with the patient, provide further education if needed, and report information to the patients' provider. Although not specifically quantified, some alerts were due to inappropriate BP measurements—such as taking BP measurements immediately after exercising or rushing to the telemonitoring unit because the “alarm” was sounding. This required patient education to insure that they knew how and when to appropriately measure BP. Again, although not specifically quantified, other alerts were high or low glucose values and prompted a call to the patient to clarify whether the number entered was correct, or whether he or she had skipped the medication or was ill (such as with a cold or flu) or whether he or she had a dietary indiscretion. Again, although not specifically quantified, other alerts were due to misentries. Thus, it was a study strength for alerts to prompt further clarification, education, and case management. At first all alert information was provided to the providers, which resulted in “data shock” and prompted providers to ask the RCCs to mainly just enter 2-week reports in the electronic medical record. Other factors may have contributed to positive outcomes: the combination of case management and telemonitoring. This occurred in the 77 study patients for whom the pharmacist had a collaborative practice agreement with providers, in one rural clinic overseeing 10 patients who had a formal health educator, and in the 11 stroke center patients who had close monitoring by a study coordinator.

Study limitations

There were also varied study limitations. A limitation in study design is that it is a relatively small observational group lacking a control group. Also, patients had to enter their own BG values and weights into the system rather than having the measurements being downloaded directly into the system, and this is a study weakness. One limitation is that there might be self-selection bias because patients who chose to participate are those who might be more adherent with necessary treatments. Although the outcomes were generally positive, this may not correlate with long-term effects and outcomes. Study results would have been greatly strengthened if follow-up A1C and BP values were reported 6 months after the intervention was completed to determine if improvements were sustained, but this was outside the scope of the study, and the investigators did not have Institutional Review Board approval to continue the study.

Because of the 14 dropouts, our results may overestimate the benefit seen compared with an “intention to treat trial.” However, the results do reflect what might be seen in clinical practice. Patients who dropped out tended to do so early, suggesting the results are a fair measure of program effects. Our results are generalizable to telemonitoring programs that include pharmacists who are authorized to make dose adjustments as part of the study program because most patients in this study were treated using this approach. However, although pharmacist-involved telemonitoring programs are emerging,^{22–25} this is not a generally available option for most telemonitoring programs.

It is interesting that the two patients who were excluded because of study criteria were quite engaged in the process. There was a higher dropout rate in the clinics where the pharmacist did not have collaborative practice; for those patients case management was not a component of the telemonitoring program. Also, complete discharge laboratory results and questionnaires were not available for some patients, as can be seen in the varying results for LDL. A limitation for one clinic nonpharmacist health educator was the number of steps needed to contact the provider to make changes in the patient's management. Another limitation was the inability to evaluate cost savings associated with the program—at best perhaps cost savings by having reduced the number of reported emergency department visits was found. However, it is a study limitation that this information was obtained by self-report.

Conclusions

Overall, both patients and providers found the telemonitoring program to be beneficial. Seventy-nine percent of patients agreed or strongly agreed they took their medications on time because of telemonitoring. The results showed positive clinical outcomes in A1C, SBP, and LDL as well as improved knowledge of diabetes and HTN and demonstrate another possible venue to provide diabetes and HTN chronic disease management and care. Part of the success is due not only to the technology, but also to more active case management. By 2017, telehealth services are expected to increase sixfold.²⁶ Thus, it is important for clinicians to stay informed about emerging technologies that may help bridge the gap between clinic visits and patient self-care modalities to improve their patients' disease status.

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