Pharmacist-provided diabetes management and education via a telemonitoring program

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Abstract

Objective: To assess clinical outcomes (glycosylated hemoglobin [A1C], blood pressure, and lipids) and other measurements (disease state knowledge, adherence, and self-efficacy) associated with the use of approved telemonitoring devices to expand and improve chronic disease management of patients with diabetes, with or without hypertension.

Setting: Four community health centers (CHCs) in Utah.

Practice description: Federally qualified safety net clinics that provide medical care to underserved patients.

Practice innovation: Pharmacist-led diabetes management using telemonitoring was compared with a group of patients receiving usual care (without telemonitoring).

Interventions: Daily blood glucose (BG) and blood pressure (BP) values were reviewed and the pharmacist provided phone follow-up to assess and manage out-of-range BG and BP values.

Evaluation: Changes in A1C, BP, and low-density lipoprotein (LDL) at approximately 6 months were compared between the telemonitoring group and the usual care group. Patient activation, diabetes/hypertension knowledge, and medication adherence were measured in the telemonitoring group.

Results: Of 150 patients, 75 received pharmacist-provided diabetes management and education via telemonitoring, and 75 received usual medical care. Change in A1C was significantly greater in the telemonitoring group compared with the usual care group (2.07% decrease vs. 0.66% decrease; P <0.001). Although BP and LDL levels also declined, differences between the two groups were not statistically significant. Patient activation measure, diabetes/hypertension knowledge, and medication adherence with antihypertensives (but not diabetes medications) improved in the telemonitoring group.

Conclusion: Pharmacist-provided diabetes management via telemonitoring resulted in a significant improvement in A1C in federally qualified CHCs in Utah compared with usual medical care. Telemonitoring may be considered a model for providing clinical pharmacy services to patients with diabetes.

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Diabetes management challenges both clinicians and patients. In the United States, 29 million individuals have diabetes, both diagnosed and undiagnosed,[1] and total yearly costs for diagnosed individuals are $245 billion.[2]

Patients are overwhelmed by the self-care demands of diabetes treatment.[3] One survey found that many individuals with diabetes lack a focused management plan and are confused about health care issues.[4] A frequently occurring problem in diabetes management is treatment nonadherence, which is costly[5] and highly prevalent. Improvements in this area could potentially save $5 billion annually, resulting in 700,000 fewer emergency department visits and 341,000 fewer hospitalizations.[6]

Studies demonstrating the benefit of pharmacists in diabetes care—and their expertise in medication management—highlight their importance as interdisciplinary team members.[7–11] Pharmacists operating under collaborative practice agreements may play an important role[10] in improving outcomes in patients with diabetes—particularly those pharmacists who are board-certified pharmacotherapy specialists, certified diabetes educators, or board certified in advanced diabetes management.[11] Smith et al.[12] strongly advocated for the inclusion of pharmacists in team-based health care delivery models and recommended increasing their role in primary care service delivery. As a commonly encountered disease state, diabetes and its monitoring and management could well fit into this primary care service delivery model, the authors concluded.

A potential tool for pharmacist-provided diabetes management is telemonitoring, a technology that advances chronic disease management by providing specific recommendations to patients following the transmission of their health data to medical providers at different locations.[13] Several studies have elucidated the success of nurses coordinating diabetes care via telemonitoring,[14–17] but studies highlighting pharmacist involvement in telemonitoring are only now being reported.[18,19] Other telemonitoring studies related to diabetes and hypertension are also now available.[20–23]

Key Points

Background:

- While several successful diabetes telemonitoring projects have been previously conducted, they were primarily nurse led.
- Of the diabetes telemonitoring projects previously conducted by pharmacists, a few have shown improvements in glycosylated hemoglobin (A1C) levels in poorly controlled individuals, including patients on insulin.
- Pharmacist-managed diabetes telemonitoring projects have also shown improved blood pressure control.

Findings:

- Pharmacists may help provide diabetes management via telemonitoring to underserved, primarily Spanish-speaking patients.
- Telemonitoring is a useful strategy for providing medication therapy management services to patients with diabetes who may also have hypertension and hyperlipidemia.
- Through telemonitoring, patients' knowledge of diabetes and hypertension improved, and they had increased confidence in managing their diabetes (improved self-efficacy).

Objective

The objective of this study was to assess clinical outcomes (glycosylated hemoglobin [A1C], blood pressure, and lipids) and other measurements (disease state knowledge, adherence, and self-efficacy) associated with the use of approved telemonitoring devices to expand and improve chronic disease management of patients with diabetes, with or without hypertension. This report is part of a larger study funded by the Office for the Advancement of Telehealth, Health Resources and Service Administration, U.S. Department of Health and Human Services.

Practice innovation

Pharmacists are involved in diabetes disease state management programs in various settings, and their use of technology tools to provide patient management is an emerging health care delivery system that is showing promise in improving diabetes outcomes. This prospective observational study of 150 patients with diabetes, with or without hypertension, was conducted between September 1, 2011, and September 30, 2013, and led by a pharmacist with specialized training in diabetes.

Outcomes were evaluated in a pre–post intervention of 75 patients managed via telemonitoring (intervention group) compared with a cohort of 75 patients who did not receive telemonitoring. Control group members were identified by retrospective chart review of a registry of patients with diabetes who were seen during the same time frame and who had two or more visits within a 6-month period to capture at least two A1C values.

Baseline values were captured on the index date office visit; follow-up values were those documented closest to 6 months after the index date. Because the average duration of telemonitoring for study clinic patients was 7.28 months, the A1C value observation time determined for comparison clinic patients was closest to 6 months after the index date, or 7.12 months.

The date equipment was installed and telemonitoring sessions began was defined as the intervention group study index date. Patients typically received telemonitoring for approximately 6 months, and clinical parameters and other measurements (questionnaires) within that time frame were tabulated.

The Association for Utah Community Health Centers and the Utah Telehealth Network collaborated on this project. "Remote care coordinator" (RCC) was the project title given to the patient monitor. The RCC was a clinical faculty pharmacist certified diabetes educator (CDE) at the University of Utah College of Pharmacy. The University of Utah Health Sciences Center Institutional Review Board (IRB) approved this study and the tabulation of information for both the intervention and comparison groups, with only clinical data captured for the comparison group.

We identified a convenience sample of patients aged 18 years or older with new or existing type 2 diabetes (with or without hypertension) and A1C levels greater than 7%. Inclusion criteria for the intervention group were willingness to participate and follow instructions, basic cognitive skills, fluency in Spanish or English, willingness to use telemonitoring equipment, and telephone or Internet access. Hypertension was defined as blood pressure greater than 140/90 mm Hg or controlled with drug therapy. The project included blood pressure (even if controlled) as one of the monitoring parameters, as 75% of persons with diabetes have or will develop hypertension. This also allowed for the education of patients about the importance of monitoring blood pressure and the impact of high and low measurements.

Exclusion criteria for both groups were residence in a nursing home or extended care facility, serious underlying conditions (malignant hypertension, heart failure, cardiomyopathy, or other serious comorbidities), or pregnancy at baseline or during the study. Patients provided consent, then were enrolled and trained to use the telemonitoring device by the pharmacist RCC. Participants were underserved, primarily Spanish-speaking individuals who received medical care at three federally qualified community health centers (CHCs). The pharmacist RCC provided education and care in Spanish or English and had a collaborative practice agreement with CHC medical providers.

The comparison group was identified through a retrospective chart review and included individuals who received usual care at a fourth CHC. Baseline A1C values were measured between September 2011 and March 2013, with a 6-month observation period subsequently observed between baseline and end A1C values. Other study parameters included measurements of blood pressure, body mass index (BMI), and low-density lipoprotein (LDL) cholesterol.

Interventions

One of the following telemonitoring delivery methods was used: Authentidate Electronic House Call ([EHC] Authentidate Holding Corp., Berkeley Heights, NJ), a U.S. Food and Drug Administration 510(k)–cleared remote monitoring device; or the Interactive Voice Response (IVR) system from the same vendor. Although technology is available to deliver care through a variety of modalities, the system we used allowed patients to telemonitor at home in an asynchronous manner, with the clinical data from a monitoring session immediately forwarded to a secure website for retrieval by a pharmacist.

The EHC unit has a touchscreen with a built-in peripheral blood pressure monitor (Figure 1). Patients used their own glucometers for blood glucose measurements, although the EHC system has the ability to peripherally connect a glucometer and record the values. The project did not have sufficient funding to provide blood glucose test strips for patients. Patients were provided with a Taylor electronic digital scale (Taylor Precision Products, Inc., Oak Brook, IL) to measure weight. Although the EHC system can also peripherally connect a digital scale and download the measurement, this feature was not used in our project. Thus, the EHC device recorded blood pressure, with patients manually entering blood glucose levels and weight when prompted. Patients could opt to be reminded by the device to start a session at a prespecified time or when convenient.

While EHC monitors were used for those patients first enrolled in the study, the IVR system, which interfaces with a patient's own phone, was introduced later in the program when enrolling new patients. The rationale was to include a system that was more realistic, less expensive, and possibly easier for patients to learn and use than the EHC device. Patients using the IVR system were supplied with an Omron Series 7 blood pressure monitor (Omron Healthcare, Lake Forest, IL) and electronic digital scales, but they were required to use their own glucometer. As with the EHC monitor, patients using the IVR system manually entered blood pressure, blood glucose, and weight measurements when prompted.

The details of the project are depicted in Figure 2. Only intervention patients received diabetes management and education from the pharmacist. Upon enrollment, patients received instructions on how to use the EHC monitor. The system started by "welcoming" patients and asking how they were feeling. Patients responded with either "good" or "bad" on the device's touchscreen. They then entered "yes" or "no" when asked if they had taken their medications that day. The device next prompted patients to measure their blood pressure and then to manually enter their blood glucose and weight measurements. The touchscreen

Figure 1. Electronic House Call device with peripheral blood pressure cuff
Source: Image courtesy of Authentidate Holding Corp., http://www.inscrybemd.com.

subsequently displayed a series of diabetes education messages programmed by the pharmacist in English or Spanish. The Authentidate system includes hundreds of brief preprogrammed messages that may be used to educate patients with a variety of disease states.

The pharmacist CDE's messages delivered diabetes education information based on self-care behaviors identified by the American Association of Diabetes Educators (https://www.diabeteseducator.org/patient-resources/aade7-self-care-behaviors). Education messages focused on an introduction to diabetes and the importance of controlling glucose; causes of hyperglycemia and hypoglycemia; healthy nutrition; physical activity; specifics of glucose monitoring, including target glucose values and how to deal with high or low values; stress management; health care maintenance; and risk reduction. The 8-week curriculum was repeated three times so that patients received 24 total weeks of education. Examples of the type of information delivered as part of the 8-week curriculum are listed in Table 1.

Patients using the IVR system received a phone call at a prespecified time or dialed in at their own convenience. After verifying their identification, patients were greeted in English or Spanish; asked the same questions as those using the EHC device; prompted to enter blood pressure, blood glucose, and weight readings; and provided with audio diabetes education messages. There was no coordination between patient data received and specific education messages. If patients had specific questions or the pharmacist noticed that certain values were out of range, the pharmacist would contact the patient by phone.

Telemonitoring sessions occurred 5 days a week, Monday through Friday, and lasted approximately 5 to 10 minutes. The session time was dependent on how quickly the patient read and followed the prompts on the EHC device screen or in the IVR system. To ensure success in completing the sessions and to address any questions, the pharmacist called participants frequently in the first days after starting the program. The number of times called depended on the patients' ability to successfully complete a session and whether or not they had any questions. Some patients required only one or two calls, while other patients required as many as five to seven calls. Patients also had the option to contact the pharmacist by phone during the first few days of enrollment if they required any clarification. In addition, the pharmacist provided the patients with a phone number where they could leave a message during the 6-month telemonitoring enrollment; the pharmacist would contact the patient the same day. Patients were also periodically contacted by phone to provide feedback or to address any questions about the telemonitoring, their medications, their diabetes or hypertension, or other concerns. However, there was no set schedule for phone follow-ups.

The pharmacist reviewed telemonitoring session data several times daily. For predetermined out-of-range values (high or low), the pharmacist contacted

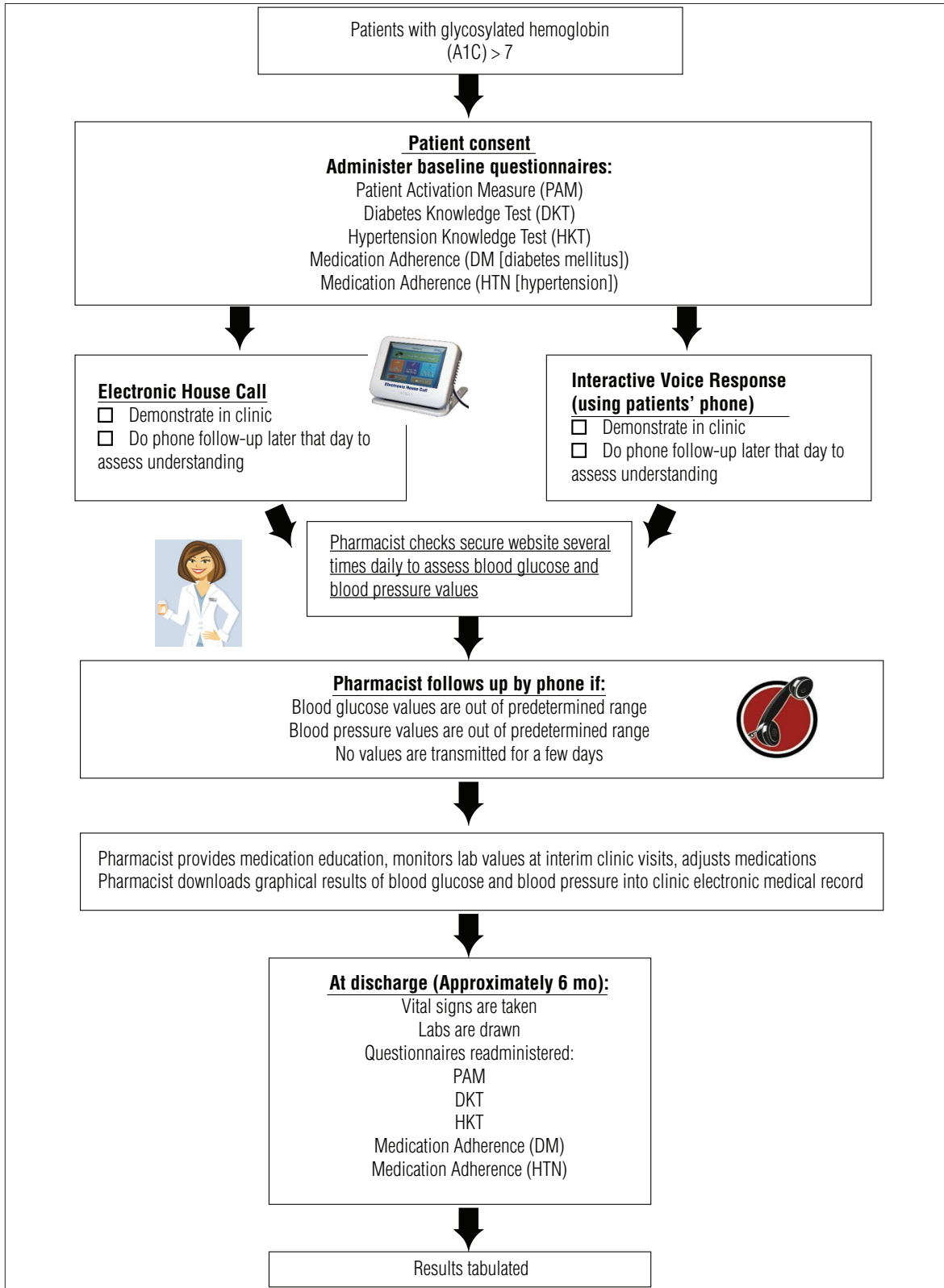

Figure 2. Telemonitoring project overview

Table 1. Selected diabetes self-management education messages

Week	Topic	Examples
1	Introduction	What diabetes is and why it should be controlled to avoid specific long-term complications Importance of reporting to the provider the adverse effects of medications or if medications are not lowering glucose
2	Causes of hyperglycemia or hypoglycemia	Causes of hyperglycemia: illness, stress, excess dietary intake, not taking medications Causes of hypoglycemia: missed or delayed meals, excessive exercise, taking too much medication Target goals of A1C, blood pressure, and LDL cholesterol
3	Healthy nutrition	Incorporating healthy foods such as vegetables and salads and avoiding excessive amounts of carbohydrates, fats, and sweetened beverages
4	Physical activity	Checking with your physician before starting an exercise plan Choosing enjoyable activities such as walking or dancing Using a pedometer to count steps
5	Monitoring tips	When to test blood glucose and how to obtain an appropriate sample Goals for fasting and postprandial blood glucose Importance of blood glucose monitoring to assess impact of food and medications
6	Managing hypoglycemia or hyperglycemia	How to manage hypoglycemia or what to do if glucose is too high Avoiding situations that may cause hyperglycemia or hypoglycemia
7	Dealing with stress	Avoiding food or alcohol to cope with stress Engaging in activities to lessen stress such as yoga, exercise, or reading
8	Health care maintenance and risk reduction	Immunizations, scheduled medical or dental visits, smoking cessation (if applicable)

Abbreviations used: A1C, glycosylated hemoglobin; LDL, low-density lipoprotein.

the patient directly to verify the accuracy of those values and instructed the patient to repeat the measurement or counseled on managing low or high blood glucose or blood pressure values. When missing entries were noted, the pharmacist directly contacted the patient to determine if there was a technical problem. Every 2 weeks, the pharmacist entered graphical reports of blood pressure and blood glucose into the clinic electronic medical record.

Evaluation

The primary outcome was the change in A1C levels measured at baseline and at conclusion of the monitoring period (using measurement taken closest to 6 months after the patient's index date for comparison patients). Changes in blood pressure, fasting lipids, and BMI, as well as the percentage of patients achieving goal A1C levels of less than 7%, were similarly measured. Validated questionnaires assessing patient activation,[24] knowledge of diabetes,[25] knowledge of hypertension,[26] and medication adherence[27] were administered to intervention patients at the beginning and the end of study participation.

Patient activation evaluates self-efficacy in caring for a chronic disease and measures skill, knowledge, and confidence in disease management. The diabetes knowledge test measures patients' understanding of diabetes management, while the hypertension knowledge survey evaluates patients' knowledge of target blood pressure, factors that may improve it, and possible complications. A validated medication adherence scale is a key factor in assessing medication-taking behavior. Changes in medications for diabetes, blood pressure, and lipids were noted in the intervention group. For intervention group patients, the number of telemonitoring sessions was also noted, with patients asked to rate their satisfaction with telemonitoring, perception of its benefit, and their perception of medication adherence using a Likert scale ranging from "strongly agree" to "strongly disagree."

Statistical analysis

The study had more than 90% power to detect an absolute change in A1C levels of 1.0% from baseline to discharge, or a 1.0% difference in A1C levels between intervention and control group patients. Baseline characteristics were summarized using descriptive statistics, and comparisons between intervention and control groups were evaluated using independent *t* tests and chi-square tests for continuous and categorical data, respectively. Pre–post outcome comparisons within groups were assessed using paired *t* tests, and differences between study groups were compared using independent *t* tests. Wilcoxon signed–rank test was used for ordinal measures. A multivariable linear regression model was used to identify the association between change in A1C levels from baseline to follow-up, controlling for baseline A1C, systolic and diastolic blood pressure, and LDL. All statistical analyses were conducted using SAS version 9.2 (SAS Institute, Inc., Cary, NC) at an alpha of 0.05. No adjustment was made for multiple comparisons.

Results

A total of 150 patients were evaluated—75 each in the intervention and comparison groups. One patient in the intervention group was excluded because of unexpected pregnancy. Patient demographics are listed in Table 2. Patients were middle aged (intervention group mean age, 48.3 y; comparison group mean age, 50.6 y), mostly female, and Spanish speaking. Baseline clinical characteristics were also similar between groups, with mean baseline A1C values of 9.87% for the intervention group and 9.44% for the comparison group. The groups were generally similar except for higher systolic blood pressure in the comparison cohort. Of the 75 intervention group patients, 62 used the EHC monitor and 13 used the IVR system. Patient age, gender, baseline A1C levels, and baseline blood pressure did not differ with monitoring device used.

The intervention group had a mean decrease in A1C levels of 2.07% (P <0.001) from baseline to end of the study, a change that was significantly greater than the 0.66% reduction (P = 0.006) observed in the comparison group (P <0.001 for difference between groups) (Table 3). For 17 newly diagnosed patients in the intervention group, A1C levels decreased from a baseline of 10.2% to 6.3% at study end. No patients with newly diagnosed diabetes were in the comparison group.

There was no difference in A1C reduction in the intervention group between patients monitored by EHC (−2.08%) versus IVR (−2.02%; P = 0.532). A total of 34.7% of study patients achieved the American Diabetes Association (ADA) goal A1C level of less than 7% (n = 26), compared with 14.7% (n = 11) in the control group (P = 0.004). The multivariable linear regression analysis showed that patients in the intervention group had a significantly greater reduction in A1C levels than control patients (−0.87% 95% confidence interval [CI] −1.49 to −0.269), controlling for potential confounders.

Also in the intervention group, systolic and diastolic blood pressure decreased significantly by 8.02 mm Hg (P <.001) and 2.77 mm Hg (P = 0.045), respectively (Table 3). Systolic and diastolic blood pressure values did not decrease significantly in the comparison group. Although baseline LDL measurements decreased by 10 mg/dL by study end in the intervention group, the change was not significant (P = 0.051); however, the change in LDL was significant in the comparison group (decrease from 102.66 mg/dL to 93.86 mg/dL; P = 0.027). Except for A1C levels, other clinical parameters (blood pressure, LDL, BMI) did not differ between the intervention and comparison groups (Table 3).

Self-efficacy, diabetes, and hypertension knowledge all improved in the intervention group (P ≤0.01 for all) (Table 4). However, while adherence to hypertension medication improved significantly (P <.001), improvements in diabetes medication adherence did not reach statistical significance (P = 0.257).

Intervention group patients completed 17,238 telemonitoring sessions (79.7% compliance rate). At study end, 97.3% of intervention patients agreed or strongly agreed that telemonitoring was useful in overseeing their disease state. Similarly, 97.3% agreed or strongly agreed that they were satisfied with telemonitoring, and 89.4% agreed or strongly agreed that telemonitoring helped them take medications on time.

Because the pharmacist had a collaborative practice agreement to make medication changes for intervention patients, these changes were tracked. Overall, 163 medication changes were made for 67 individuals in the intervention group. A total of 118 changes were made to diabetes medications for 63 patients, with insulin therapy the most frequent change. A total of 74 changes were made to insulin regimens, primarily to intensify insulin treatment. Initially, 47 patients were on insulin, including 7 new insulin users, with the telemonitoring program initiated in those individuals to monitor their insulin doses.

Additional modifications included adding or changing doses of metformin, dipeptidyl peptidase IV

Table 2. Baseline patient demographics

	Intervention patients		Control patients		
Characteristic	**Mean ± SD**	**N**	**Mean ± SD**	**N**	***P***
Age	48.28 ± 10.62	75	50.57 ± 11.01	75	0.196
Female gender, n (%)	49 (65.3)	75	50 (66.7)	75	0.863
Primary language, n (%)					
Spanish	66 (88.0)	75	65 (86.7)	75	
English	9 (12.0)	75	10 (13.3)	75	0.806
Months evaluated	7.28 ± 2.13	75	7.16 ± 2.05	75	0.725
A1C (%)	9.87 ± 2.06	75	9.44 ± 1.72	75	0.164
Systolic blood pressure (mm Hg)	126.20 ± 17.25	72	132.04 ± 16.39	75	0.037
Diastolic blood pressure (mm Hg)	77.48 ± 9.44	72	79.53 ± 8.21	75	0.162
LDL cholesterol (mg/dL)	97.44 ± 36.47	67	103.14 ± 33.59	67	0.348
BMI (kg/m^2)	33.13 ± 6.79	75	33.29 ± 6.95	75	0.886

Abbreviations used: A1C, glycosylated hemoglobin; BMI, body mass index; LDL, low-density lipoprotein.

Table 3. Comparison of A1C, blood pressure, LDL cholesterol, and BMI values within and between study groups

	Intervention patients				Control patients				
Laboratory value	Baseline N (mean ± SD)	Study end N (mean ± SD)	Change (SD)	*P* (from baseline)	Baseline N (mean ± SD)	Study end N (mean ± SD)	Change (SD)	*P* (from baseline)	*P* (intervention vs. control)
A1C (%)	75 (9.87 ± 2.06)	75 (7.80 ± 1.64)	–2.07 (2.36)	<0.001	75 (9.44 ± 1.72)	75 (8.78 ± 1.86)	–0.66 (1.99)	0.006	<0.001
A1C < 7.0 (%), n (%)	0 (0)	26 (34.7)	–	–	0 (0)	11 (14.7)	–	–	<0.004
Systolic blood pressure (mm Hg)	72 (126.20 ± 17.25)	72 (118.18 ± 18.32)	–8.02 (19.74)	<0.001	75 (132.04 ± 16.39)	75 (127.90 ± 18.54)	–4.133 (18.30)	0.054	0.216
Diastolic blood pressure (mm Hg)	72 (77.48 ± 9.44)	72 (74.70 ± 10.65)	–2.77 (11.576)	0.045	75 (79.53 ± 8.21)	75 (78.37 ± 8.42)	–1.16 (9.46)	0.291	0.354
LDL cholesterol (mg/dL)	47 (103.63 ± 38.39)	47 (93.27 ± 31.38)	–10.36 (35.20)	0.051	59 (102.66 ± 33.91)	59 (93.86 ± 29.59)	–8.79 (29.66)	0.027	0.805
BMI (kg/m^2)	75 (33.13 ± 6.79)	75 (33.24 ± 6.82)	0.11 (1.55)	0.535	75 (33.29 ± 6.95)	75 (33.36 ± 6.88)	0.07 (1.13)	0.577	0.864

Abbreviations used: A1C, glycosylated hemoglobin; LDL, low-density lipoprotein; BMI, body mass index.

(DPP-IV) inhibitors, sulfonylureas, and other diabetes medications. A total of 45 changes were made to cardiovascular agents, including antihypertensives in 22 patients and lipid-lowering agents in 12 other patients. Changes to antihypertensives primarily involved adding or adjusting doses of angiotensin-converting enzyme (ACE) inhibitors, angiotensin receptor blockers (ARBs), or diuretics. Changes to antihyperlipidemics mostly involved adding or modifying 3-hydroxy-3-methylglutaryl-coenzyme A (HMG-CoA) reductase inhibitor (statin) doses. Medication changes were not tracked for the comparison group, as this was not approved by the IRB.

Discussion

Pharmacists bring unique skills and training to the monitoring, education, and management of patient care, and they are an integral part of diabetes management teams.[11] A systematic review by Wubben and Vivian supports the role of pharmacists in outpatient diabetes interventions.[7] The Diabetes Ten City Challenge, an initiative of the APhA Foundation, has also demonstrated that pharmacists may help reduce A1C levels in patients with diabetes, as well as have a positive impact on elevated LDL and systolic blood pressure levels in these individuals.[8]

Our study found that pharmacist-provided interventions facilitated by telemonitoring resulted in significant improvements in diabetes control among patients receiving care in a federally qualified CHC system. We believe that the education messages and medication changes received by patients in the study's intervention group may have helped lead to a reduction in their A1C levels.

Although patients' systolic and diastolic blood pressure levels declined significantly from baseline in both the intervention and comparison groups (P <0.001 and P = 0.045, respectively), the difference between groups was not significant. In addition, fewer changes were made to patients' antihypertensives than to their diabetes medications.

Decrease in LDL levels was also small, but many of the study participants were already close to the 2014 ADA goal of less than 100 mg/dL.[28] In the comparison group, LDL levels declined significantly from baseline. This may have been due to a larger number of measurements noted for this group, perhaps indicating that their lipids were more closely monitored. Although there was no significant difference between cohorts, the intervention group had a larger LDL decrease than the comparison group. The authors recognize that new ADA guidelines do not focus on a specific LDL goal, but LDL target values were in effect during the study. Current ADA guidelines identify LDL levels greater than 100 mg/dL as a cardiovascular risk factor.[29]

Factors that affect disease states were assessed in

Table 4. Patient activation, disease state knowledge, and medication adherence scores

Patient questionnaire	Preintervention score N (mean ± SD)	Postintervention score N (mean ± SD)	Change (SD)	*P* (from baseline)
Patient activation	70 (63.74 ± 23.3)	70 (71.03 ± 14.4)	7.29 (24.07)	0.013
Diabetes knowledge	74 (8.95 ± 2.17)	74 (10.82 ± 2.04)	1.86 (2.43)	<0.0001
Hypertension knowledge	42 (7.42 ± 1.78)	42 (8.80 ± 1.35)	1.38 (1.56)	<0.0001
Diabetes medication adherence	64 (6.28 ± 1.74)	64 (6.52 ± 1.59)	0.23 (1.64)	0.257
Hypertension medication adherence	40 (6.34 ± 1.72)	40 (6.79 ± 1.36)	0.45 (1.35)	0.041

the intervention group, with clinical improvement potentially attributable to improved self-efficacy and improved knowledge of diabetes and hypertension. Although patient-reported adherence to antihypertensive medications improved significantly, improvements in diabetes medication adherence were not statistically significant; nevertheless, clinical outcomes improved. Our study contributes to the growing body of evidence supporting the contributions of pharmacists to improving patient outcomes through the use of telemonitoring.

For example, a study by Klug et al. showed a mean A1C decrease of 1.3% from a baseline of 9.8% to 8.5% ($P = 0.002$).[20] McFarland et al. evaluated pharmacist telemonitoring of poorly controlled patients on insulin, with the mean A1C difference statistically significant at 6 months for both the telemonitoring and usual care groups (6.9% vs. 7.5%, respectively; $P = 0.0066$).[21] While the authors also reported a difference in the mean reduction of A1C levels from baseline to 6 months for the telemonitoring and usual care groups, the difference was not significant (2.1% vs. 1.6%, respectively; $P = 0.1987$). Other studies have shown a significant impact of pharmacist telemonitoring on hypertension in achieving a greater percentage of patients reaching their blood pressure goals.[22,23]

A unique aspect of our real-world study is that it was conducted in underserved, primarily Spanish-speaking patients and included a bilingual pharmacist with advanced practice credentials to program messages in Spanish and English and to provide care under a collaborative practice agreement. Another strength was the 79.7% telemonitoring compliance rate. The mean duration of time that patients stayed in the telemonitoring program was adequate to evaluate changes. We also observed that telemonitoring was an effective way to provide close monitoring and management of both newly diagnosed individuals and those initiating insulin use.

Another important finding was the willingness of this underserved patient population to integrate technology into self-care processes; their acceptance of technology was a critical success factor. Telemonitoring appears to be an acceptable strategy for reducing disparities in access to care and improving outcomes for the underserved. In addition to the high compliance rate, the study showed that most intervention patients agreed or strongly agreed that telemonitoring helped them monitor their disease and take medications on time.

The most important lessons learned were that telemonitoring increased patient self-efficacy—a critical aspect of managing chronic disease states—as well as knowledge of diabetes and hypertension. The benefit of social support provided to patients may have also helped change their behavior and is another lesson learned. An additional lesson, and a recommendation for how to implement this program in the future, is not to rely on only one pharmacist to perform the remote monitoring. It was time consuming to enroll, receive consent, and administer baseline and endpoint questionnaires. In the future, a team of pharmacy technicians could be tasked with these processes.

Limitations

A historical comparison group was added to help identify the effect of the intervention program from disease progression and general trends in treatment. However, retrospective comparison group data included only clinical values; we were unable to assess self-efficacy, disease state knowledge, and medication adherence among these patients. In addition, use of an observational design introduces the risk of confounding. However, patients in the intervention and comparison group were very similar in baseline disease control. Furthermore, the effect of the intervention program on change in A1C levels during the follow-up period remained clinically and statistically significant when controlling for potential confounding.

The study population primarily spoke Spanish, a factor that may reduce external validity. It may not be common to find a bilingual pharmacist CDE in a collaborative practice. Self-selection bias also may have occurred, as patients who chose to participate may be more adherent to treatment. Contacting patients was challenging in some cases when phones were temporarily disconnected because of patients' financial burdens. Furthermore, telemonitoring equipment sometimes required troubleshooting to ensure successful transmission, a complex process involving multiple steps to diagnose and resolve technical issues.

Measuring effects on morbidity and health resource use over an extended time period would be optimal, as would evaluation of the durability of the

effects of telemonitoring pharmacist interventions. The feasibility of using telemonitoring for more than 6 months would depend on funding and patient willingness to participate. Currently, most insurance providers do not reimburse pharmacists for cognitive services delivered via telemonitoring. Perhaps research that evaluates reimbursement for telemonitoring services would help determine whether or not changes are sustainable or if patients may tire of this novel therapeutic approach.

Conclusion

Pharmacists who participate in telemonitoring projects have the potential to improve outcomes not only by monitoring clinical parameters involved in patient care but also by providing disease-specific education and using telemonitoring as a platform for medication management. Compared with usual care, a pharmacist-driven telemonitoring program showed a significant improvement in patients' A1C levels. Telemonitoring was well accepted by patients, with most finding it useful. Opportunities for pharmacists to participate in similar programs are evolving, and the authors hope that this project may serve as a model for pharmacist-provided diabetes care. We conclude that pharmacist-provided telemonitoring would be an excellent approach to providing medication management for many other disease states.

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