Improving Diabetes Control Through Remote Glucose Monitoring in a Diabetes Self-Management Program for Employees of a Health System

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IN BRIEF This study investigates the combination of diabetes education, telehealth, a wireless enabled meter, and medication algorithms to improve care for a targeted population of employees with type 1 or type 2 diabetes. After more than 2 years of follow-up, mean A1C was reduced by 1.8%, and a reduction was observed in cost of care, along with an increase in visits with the managing physician provider. Thus, this study showed improved diabetes control using new technologies to provide remote monitoring and telehealth augmenting the outreach and education provided in a diabetes self-management program.

Diabetes self-management education (DSME) is recommended for all patients at diagnosis, annually or sooner if new complicating factors influence treatment, and at transitions of care (1). DSME is cost-effective, reduces hospital readmissions, and reduces A1C (1). Despite these guidelines, only 5–7% of patients receive DSME. Barriers include misunderstandings by providers and patients about the necessity of education, difficulty making referrals, lack of access to services, and patient psychosocial and behavioral factors (1).

People with diabetes consistently have greater health care costs that are ~2.3 times those of people without diabetes (2). Previous studies have shown than having an A1C >7.5% is predictive of higher health care costs (3). In 2014, Greenville Health System in Greenville, S.C., spent twice as much on employees who had an A1C >7.5% than on those with an A1C <7.5%. Visits to a primary care provider (PCP) every 3 months may be inadequate to meet the needs of patients with uncontrolled diabetes.

Since the enactment of the 2010 Patient Protection and Affordable Care Act, U.S. health care has been shifting toward value-based care, and research is needed to identify delivery innovations that improve access, cost, and quality (4,5). The Triple Aim approach, a conceptual framework developed by the Institute for Healthcare Improvement, focuses on improving the experience of care, improving the health of populations, and reducing unnecessary costs (4).

The goal of this DSME initiative was to improve the quality of care for a targeted population of employees of a large health care system who had either type 1 or type 2 diabetes. The study employed primary care referral to a care coordination program anchored by DSME, medication algorithms, and telehealth glucose monitoring. Effective care coordination has been cited as a key determinant in improved quality outcomes (4). Previous studies have shown reduction in A1C using telehealth DSME with various approaches to telehealth led by nurse care managers, nurse practitioners, and multidisciplinary teams (5–10).

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FEATURE ARTICLE

Studies of DSME as a team-based intervention found greater A1C reduction than studies of the solo provision of DSME (10).

Patients within the managed population had the clinical oversight of their PCP and a team that included care managers, certified diabetes educators (CDEs), a pharmacist who was board certified in advanced diabetes management (BC-ADM), and an endocrinologist if needed. The primary study objective was to achieve a 15% reduction in patients' mean baseline A1C. Secondary study objectives were to improve patients' understanding of diabetes and diabetes self-management, increase rates of adherence to diabetes monitoring and medication, decrease rates of hypoglycemia and hyperglycemia, and reduce overall costs of health care. The ultimate goal was to develop a primary care workflow model that was both replicable and self-sustaining.

Methods

The study group included 50 patients referred from the health system's primary care practices and endocrinology office. Inclusion criteria specified that patients had to be 18–75 years of age, insured by the health system, diagnosed with either type 1 or type 2 diabetes, and have an A1C ≥8% measured within 3 months of the project's initiation. This was a prospective study, using data derived from the electronic medical record (EMR) system and a paper patient survey to elicit information on patient understanding of diabetes and self-care. Baseline data collected before project implementation and post-intervention data were compared to determine any associations between the intervention and outcome measures related to practice management and clinical outcomes.

Patients were identified by care managers, the managing physician, and/or a CDE. Patients who met inclusion criteria also needed the approval of a referring physician to participate in the project. Referrals were completed by the managing physician via the EMR. Participants were given a free wireless-enabled glucose meter that linked to a secure portal for the health care professional, the patient, and a support person. Participants also had the incentive of free testing supplies during the study period. Existing plan incentives included 100% coverage for DSME individual or group classes with no copay and reduced cost of plan-specified medications for patients who were enrolled in a health coaching program.

At an initial appointment, a CDE assessed each participant's diabetes knowledge and education needs, provided meter education, and identified barriers to diabetes self-management. Barriers to diabetes education included financial, transportation, or other socioeconomic obstacles. Diabetes education topics included the disease process, nutrition education, basic carbohydrate counting, the benefits of exercise, monitoring guidelines and goals, medication education, health promotion and goal-setting, acute care guidelines, chronic complications review, and psychosocial strategies. Additional sessions were recommended based on patients' needs.

After enrollment, a CDE or BC-ADM pharmacist reviewed blood glucose data using the secure patient portal and contacted each patient by telephone, text, email, meter message, or in person at least every 2–4 weeks. Managing physicians were updated using the EMR system. Any blood glucose value <50 mg/dL or three to five consecutive readings >250 mg/dL (excluding control tests) generated a telephone call to the patient within 1 business day. Managing physicians were responsible for a face-to-face visit every 1–3 months and for refilling and prescribing new medications within the intervention algorithm. A multidisciplinary team, including PCPs, an endocrinologist, pharmacists, and CDEs developed the medication algorithm to guide treatment decisions in accordance with American Diabetes Association (ADA) guidelines.

Primary care visits, hospital admissions, and emergency department visits were tracked prospectively. A1C, hypoglycemic episodes, hyperglycemic episodes, and frequency of glucose monitoring were documented. Hypoglycemia was defined as a glucose value <70 mg/dL. Hyperglycemia was defined as a glucose value greater than ADA-recommended or individualized glycemic targets. Patients' level of understanding of diabetes education was measured using a patient survey at enrollment, 6 months, 12 months, and at study conclusion.

A paired *t* test was used to determine statistical significance. The null hypothesis was that baseline A1C and A1C at study end would be equal, and the alternative hypothesis was that baseline A1C would be greater than A1C at study end. The null hypothesis was rejected if an observed *P* value was <0.05.

An internal clinical decision support and financial analytic software package was used to pull internal costs of patients from participating facilities. Medical record numbers were used as the unique identifier. Study group patients had specific enrollment dates indexed for the purposes of analysis to the first day of patient enrollment. One-year prestudy enrollment included services as of patients' date of enrollment to 365 days after enrollment. Year 1 post-study enrollment included services from 1 day after enrollment to 365 days after enrollment. Year 2 post-study enrollment included services received from 366 to 730 days after enrollment.

Types of visits were determined in a hierarchical manner in order of inpatient, outpatient emergency department, and office visits (primary and specialty care). Inpatient visits were determined by the encounter-level patient type within the financial analytic software with an indicator of "I." Outpatient emergency department visits were determined by a charge-level revenue code. Office visits were determined by the attending physician's national practitioner identifier along with a facility code of the practice. A list of health system providers who qualify as primary or specialty care was determined based on providers' practicing specialty matching to the list of qualifying specialties. Determining whether a visit was directly related to diabetes was based on the primary *International Classification of Diseases*, 9th or 10th revision, diagnosis code of the visit.

TABLE 1. Baseline Characteristics

Demographics	*n*	%
Female	42	84
Type 2 diabetes	47	94
Race		
Caucasian	27	54
African American	22	44
Asian	1	2
Duration of diabetes at baseline, years		
<5	6	12
5–10	20	40
>10	24	48

Results

Fifty patients were enrolled in the study from 14 January to 30 October 2014. As shown in Table 1, 84% of the patients were female (n = 42), and 94% had type 2 diabetes (n = 47). Study data were collected until 30 September 2016. The average total days in the study were 828.7 (range 391–991). Eleven patients stopped using the wireless-enabled meter prior to the completion of the study. Reasons for discontinuing included changing to a new job outside of the health system and patient preference.

At baseline, the average A1C was 10.252 (SE 0.239, Figure 1) and average fasting glucose was 170.714 mg/dL (SE 5.424). Using the last recorded A1C in the EMR at study end, the average final A1C was 8.386 (SE 0.265, Figure 1). Patients achieved an 18% reduction in the average A1C over the study period (absolute reduction of 1.856, P <0.05 [Figures 1 and 2]). Most patients achieved an A1C decrease of 2%, and 56% of patients experienced a decrease of 2–4% (Figure 3). Twelve patients achieved an A1C ≤7% by study end. Self-monitoring of blood glucose (SMBG) varied by patient and points in time, but blood glucose was monitored on average 1.2 times/day. Using ADA goals, 45.5% of all glucose meter readings were within pre- and postprandial goals. Over the entire study period, patients averaged 9.32 (range 0–56) total hypoglycemic episodes or 0.34 hypoglycemic episodes per patient per month. These results

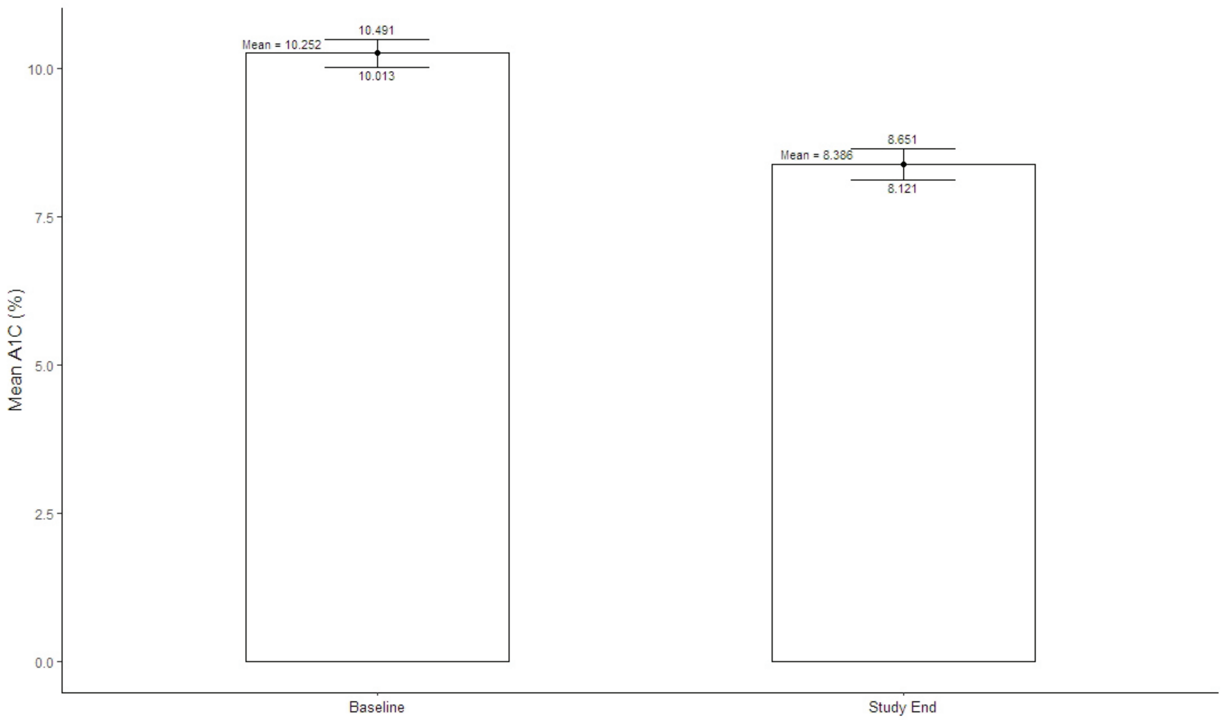

FIGURE 1. Comparison of mean A1C at baseline and study end (P <0.05, n = 50).

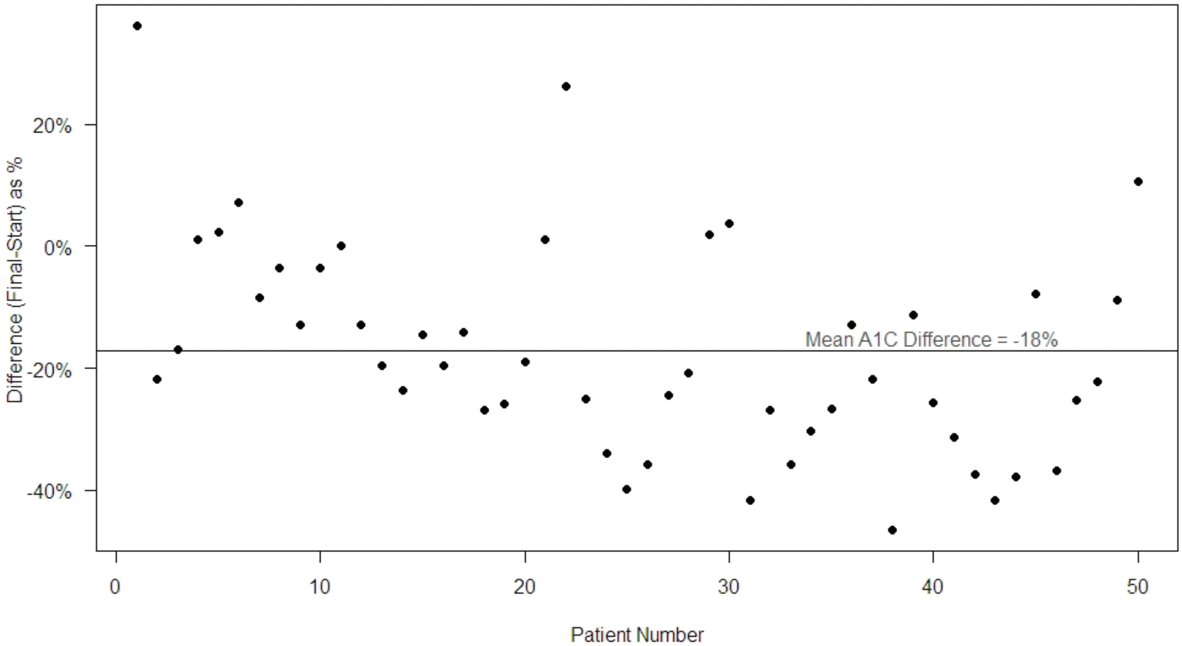

FIGURE 2. Histogram of A1C differences (n = 50).

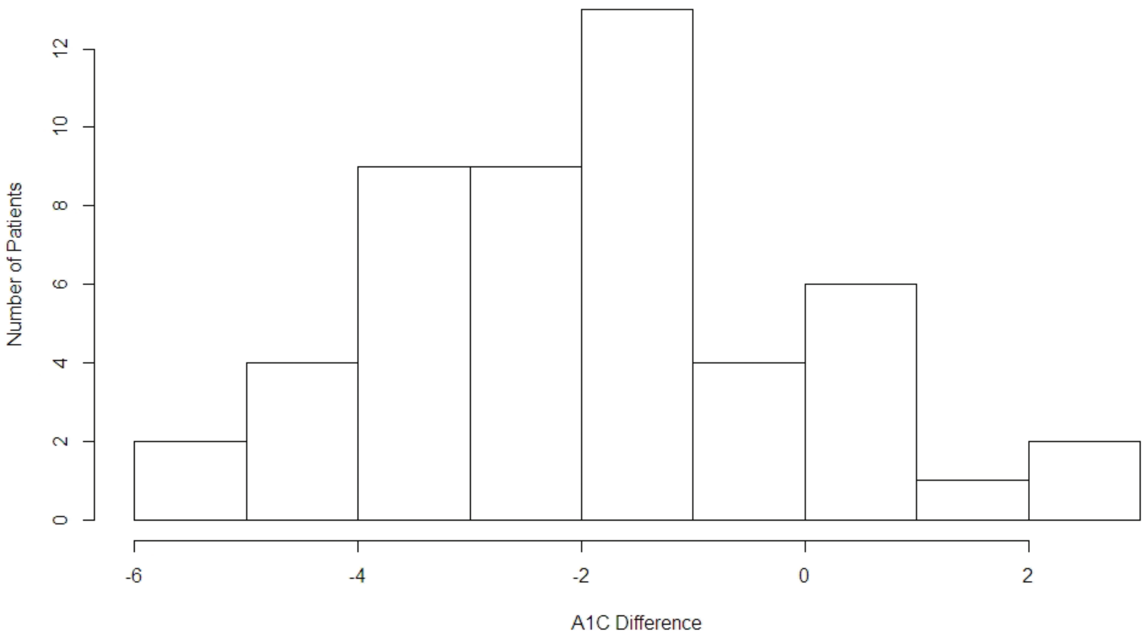

FIGURE 3. Patient A1C difference (final – baseline A1C) (n = 50).

indicated that adherence to SMBG did not improve longitudinally, but hypoglycemia rates were low despite medication titration.

Increases in outpatient PCP and endocrinology office visits were observed in study participants, along with a decrease in costs of care comparing the year before the study to year 1 and year 2 after study enrollment. No differences were found in hospital admissions or emergency department visits (data not shown). Inpatient costs decreased 4.3% from baseline to post-program year 1 and outpatient visit costs decreased 17.4% from baseline to post-program year 1 (data not shown). Total outpatient visits for diabetes increased from 55 in the year before enrollment to 73 visits in year 1 and 94 visits in year 2. The difference in PCP visits in year 1 compared to the year before enrollment was statistically signif-

TABLE 2. Self-R Questionnaire Results

	Baseline	6 Months	12 Months
Diabetes knowledge	35.1 Good	45.8 Very Good	49.2 Very Good
Diabetes self-management behaviors	22.9 Neutral	32 Fairly Sure	34.6 Absolutely Sure
Diabetes self-monitoring behaviors	3.1 Neutral	4.1 Most of the time	4.0 Most of the time

icant (*P* <0.05). This may indicate that patients were more engaged in their health care, yet visits were lower acuity, which reduced the cost of care.

Patients reported an improvement in their diabetes knowledge, self-management behaviors, and self-monitoring behaviors from baseline to 6 and 12 months (Table 2). Comparing baseline medications to study end, patients decreased the use of sulfonylureas, thiazolidinediones, and premixed insulin and increased use of dipeptidyl peptidase 4 inhibitors, sodium–glucose cotransporter 2 inhibitors, basal insulin, and bolus insulin (Figure 4). Diabetes medication copays did increase from fiscal year (FY) 2014 to FY 2015, but not from FY 2015 to FY 2016 (data not shown). The majority of patients used the health system's employee pharmacy, which generated medication reports. Medications filled at outside pharmacies were not captured.

Discussion

After an average of more than 2 years of follow-up, combining a wireless telehealth glucose meter with DSME and an algorithm for medication titration, participants in this study had an absolute reduction in A1C of 1.856.

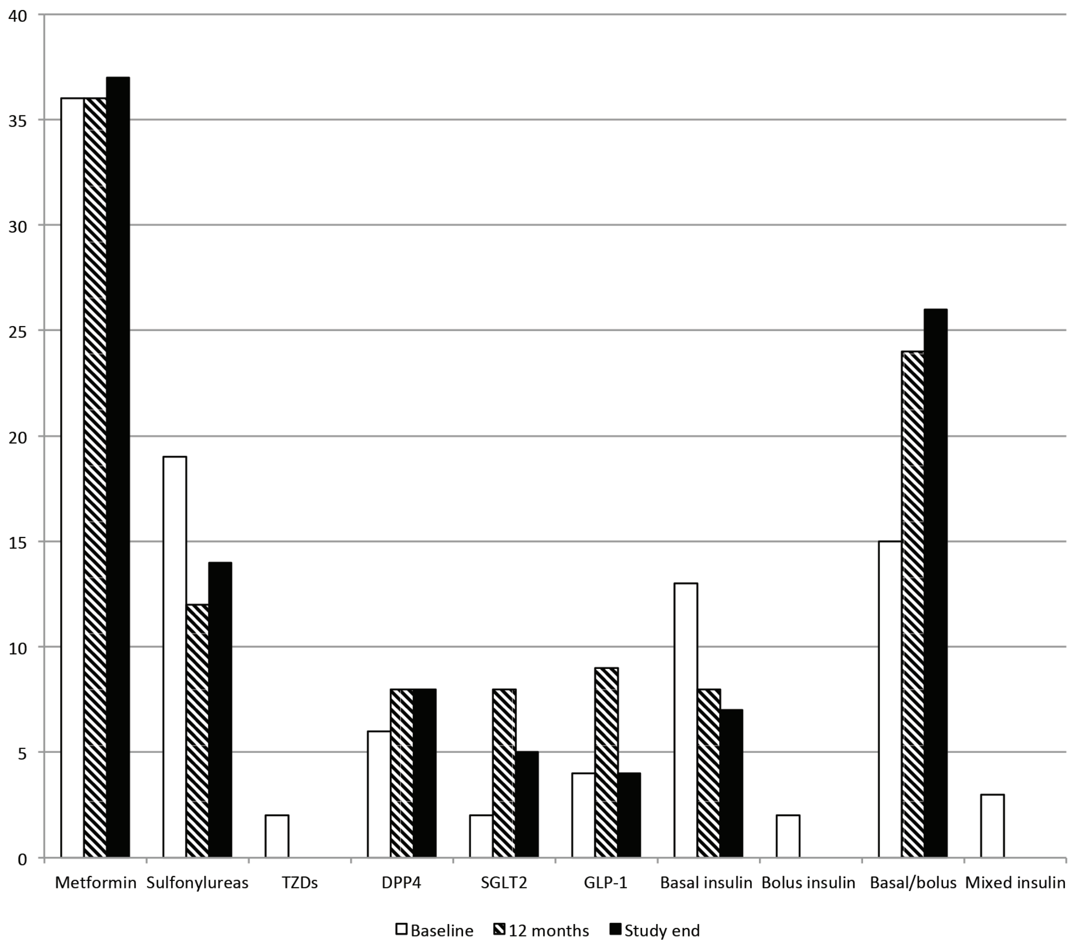

FIGURE 4. Medication classes. DPP-4, dipeptidyl peptidase 4 inhibitor; GLP-1, glucagon-like peptide 1 receptor agonist; SGLT2, sodium–glucose cotransporter 2 inhibitor; TZD, thiazolidinedione.

Previous literature has shown DSME to reduce A1C by as much as 1% in patients with diabetes (1). In our study, CDE nurses and a BC-ADM pharmacist proactively titrated insulin and coordinated the prescription of new medications with PCPs and endocrinologists, combatting clinical inertia.

Telehealth eliminates the barrier to diabetes education of transportation to receive health care services. Patients were provided with diabetes education based on their preference and needs through phone calls, text messages, email, individual appointments, or group classes. Employees in the study included clinical, administrative, nonclinical, and support staff. Some patients did not have access to an email account or text messaging, so the method of contact had to be flexible. A1C results from this multifaceted treatment approach are encouraging. Our results are in line with previously published reports, but further investigation is needed to see if the absolute change in A1C that we observed is truly better using this multifaceted approach.

This was a single-group, nonrandomized, observational study enrolling employees of a large health care system who had uncontrolled diabetes. Results from this study are encouraging with regard to using a wireless glucose meter to augment the efforts of DSME, which led to improved glucose control, more frequent visits to PCPs, and possibly cost reduction to the health care system. It is not clear whether these results can be extrapolated to other populations, but this certainly warrants further investigation.

Fitzner and Moss (12) describe best practices for telehealth delivery of DSME, including integrating multiple approaches, regularly scheduled monitoring, interactive communication, access to immediate intervention, tailoring of content to patients' needs, and facilitating access that is convenient to patients. All of these were incorporated into our study design. Diabetes educators contacted patients one to two times each month in addition to contacts triggered by severe hypoglycemic events and sustained hyperglycemia. As a result of this support, patients reported that their diabetes knowledge, self-management behaviors, and self-monitoring behaviors improved over the first 12 months of the study. Few patients returned the questionnaire at study conclusion, so the results could not be analyzed. Thus, we do not know whether these improvements persisted. However, patients' improved engagement in their health care was supported by an increase in PCP outpatient visits from baseline.

Current national guidelines recommend diabetes medications that reduce the risk of hypoglycemia and weight gain. Study participants reduced the use of sulfonylureas, thiazolidinediones, and premixed insulin. Both of these classes of oral medications can cause weight gain, and sulfonylureas are also associated with hypoglycemia; premixed insulin can cause hypoglycemia in patients who do not maintain a consistent meal schedule. Conversely, basal-bolus insulin regimens, which increased during this study, give patients more flexibility to adjust insulin to their eating preferences, and some patients learned to count carbohydrates and adjust their prandial insulin based on the carbohydrate content of their meals.

The Diabetes Control and Complications Trial and the U.K. Prospective Diabetes Study (UKPDS) both found an increase in severe hypoglycemia with intensive insulin management (13,14). Patients in our study reported lower rates of hypoglycemia than were found in the UKPDS (14) and in a large systemic review of patients on both oral agents and insulin (15). However, as an observational study, our project lacked a control group to compare rates to those of usual care. Furthermore, with an average SMBG of 1.2 times per day, there is a possibility that the rates are artificially low. This requires further study. Because of the increased cardiovascular risk with hypoglycemia, careful monitoring, medication titration, and self-care behaviors are important to limit the frequency and severity of hypoglycemia.

Patients were supplied with a free glucose meter and testing supplies throughout the study. The cost of testing supplies is frequently viewed as a barrier to diabetes self-management (16). Despite eliminating this barrier, adherence to SMBG in this study was suboptimal. Case managers were involved in the recruitment of patients but did not follow all patients longitudinally. Most of the care coordination was done by diabetes educators. Adherence to SMBG may have been improved by using care managers or health coaches for ongoing care management.

Enrollment of participants was slower than anticipated. Because of the strong relationships between patients and PCPs, patients who were not previously familiar with DSME wanted the assurance that their doctor recommended diabetes education in addition to the formal physician referral. Because the health system employs more women than men, it was not surprising that more women were enrolled in the study. However, the population included mostly Caucasians and African Americans, including no Hispanic patients and only one patient of Asian descent. Patients had to have a PCP within the system to facilitate communication between diabetes educators and providers using the EMR. Many Hispanic patients seek care outside of the health system due to the availability of translators at outside facilities.

The health system's ADA-accredited diabetes self-management program has a multidisciplinary team that includes dietitians, nurses, a BC-ADM pharmacist, and a social worker and provides services at six different sites. Although most diabetes educators have the CDE credential, a pharmacist who holds the BC-ADM credential is a unique addition to the program. The BC-ADM pharmacist provides evidence-based medication education to the team and health system providers and updates the algorithms. The pharmacist position is shared between inpatient pharmacy and the diabetes self-management program, allowing the pharmacist to bill for DSME through an ADA-accredited program and to work as an inpatient clinical pharmacy specialist. The joint position has been mutually beneficially for both departments as pharmacy services strives to expand into outpatient, billable sites.

As a result of this study, the health care system added the wireless-enabled meter and strips as a preferred brand for employees and dependents. Patients enrolled in the study were given the opportunity to continue with telehealth, but they were responsible for the cost of testing supplies after the project ended. The health plan continues to cover 100% of the cost of individual and group education in person. New patients have been referred and have enrolled in the ongoing program. Studies are ongoing in other pediatric and obstetric clinics in our health system. Because of the improvements in A1C, physicians and patients have shown interest in using the wireless-enabled meter for patients with other private and government insurance. Many insurance plans do not cover the specific meter, limiting the expansion of this service.

The diabetes education department continues to seek innovative methods to deliver telehealth, diabetes education, and support that are accessible to all patients and is considering other remote glucose monitoring options. In this study and a related pilot group, one CDE nurse provided telehealth services to ~90 patients as 0.5 of a full-time equivalent, or five 4-hour work days during business hours dedicated to remote monitoring. However, educators learned that telehealth cannot be scheduled for a particular day of the week. Patients may not be available at that day or time and may return calls, texts, or emails on other days of the week. As telehealth services are expanded, the need for an on-call educator has been identified.

Based on the success of this study, the health system will expand this model for remote monitoring, collaborating with PCPs, and using algorithms for medication titration. Internal health system data show that >11,000 patients in the upstate region of South Carolina have an A1C >9%. The health system has identified diabetes as a target disease state to improve care throughout the community. Remote monitoring services will be individualized to incorporate different devices, glucose meters, and mechanisms for sharing data given that other technologies besides the meter used in this study are available. Collaboration with PCPs is imperative for the success. Patients who do not have a PCP will be assisted in establishing care and could then enroll in the diabetes care model.

Reimbursement for remote monitoring is an issue. However, the health system will save money for its employee and dependent population and for at-risk Medicare and Medicaid patients. In the future, the health system will need reimbursement from other payers for these services and is currently exploring options. As technology advances, reimbursement for face-to-face care is no longer adequate and optimal for health care teams and patients.

Conclusion

By combining diabetes education provided by an effective, multidisciplinary team, including nurse and pharmacist educators, medication algorithms, and remote glucose monitoring, participants improved their knowledge of diabetes and self-care and experienced improved glycemic control. The early success of and lessons learned from this initiative can inform health delivery strategies focused on the use of telehealth and disease management workflow processes and support further investigation. Patient feedback indicated that physician engagement in DSME was important in long-term follow-up and that flexibility of educator contact is also relevant.

Questions remain, including how can DSME increase patient engagement to create sustainable improvement in diabetes clinical outcomes? This work may add to the literature suggesting that a flexible whole-person, patient-centered approach with remote monitoring and contact can improve self-care adherence. The magnitude of change before and after intervention encourages the implementation of similar DSME programs in other health plans.

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Prior Presentation

These findings were presented during the American Diabetes Association's 78th Scientific Sessions in Orlando, Fla., 22–26 June 2018 and at the American Association of Diabetes Educators Annual Conference, Baltimore, Md., 17–20 August 2018.

Duality of Interest

No potential conflicts of interest relevant to this article were reported.

Author Contributions

J.M.O. researched the data and wrote the manuscript. M.S. and N.S. researched the data and reviewed/edited the manuscript. B.N. and R.R.-S. contributed to discussion and reviewed/edited the manuscript. J.D. and M.L. researched the data. L.S.R. and A.B. reviewed/edited the manuscript. J.S.B. contributed to discussion and reviewed/edited the manuscript. J.M.O. is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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