Do Automated Calls with Nurse Follow-up Improve Self-Care and Glycemic Control among Vulnerable Patients with Diabetes?

John D. Piette, PhD, Morris Weinberger, PhD, Stephen J. McPhee, MD, Connie A. Mah, BA, Fredric B. Kraemer, MD, Lawrence M. Crapo, MD, PhD

PURPOSE: We sought to evaluate the effect of automated telephone assessment and self-care education calls with nurse follow-up on the management of diabetes.

SUBJECTS AND METHODS: We enrolled 280 English- or Spanish-speaking adults with diabetes who were using hypoglycemic medications and who were treated in a county health care system. Patients were randomly assigned to usual care or to receive an intervention that consisted of usual care plus biweekly automated assessment and self-care education calls with telephone follow-up by a nurse educator. Outcomes measured at 12 months included survey-reported self-care, perceived glycemic control, and symptoms, as well as glycosylated hemoglobin (Hb A_{1c}) and serum glucose levels.

RESULTS: We collected follow-up data for 89% of enrollees (248 patients). Compared with usual care patients, intervention patients reported more frequent glucose monitoring, foot inspection, and weight monitoring, and fewer problems with medication adherence (all $P \leq 0.03$). Follow-up Hb A_{1c} levels were 0.3% lower in the intervention group ($P = 0.1$), and about twice as many intervention patients had Hb A_{1c} levels within the normal range ($P = 0.04$). Serum glucose levels were 41 mg/dL lower among intervention patients than usual care patients ($P = 0.002$). Intervention patients also reported better glycemic control ($P = 0.005$) and fewer diabetic symptoms ($P < 0.0001$), including fewer symptoms of hyperglycemia and hypoglycemia.

CONCLUSIONS: Automated calls with telephone nurse follow-up may be an effective strategy for improving self-care behavior and glycemic control, and for decreasing symptoms among vulnerable patients with diabetes. **Am J Med. 2000;108: 20–27.** ©2000 by Excerpta Medica, Inc.

Regular assessments of blood glucose levels and effective self-care may improve glycemic control, thereby reducing the risk of complications from diabetes (1–4). Unfortunately, many patients fall short of targeted glucose levels because of problems obtaining treatment or inadequate self-care (5). In particular, low-income patients with diabetes use fewer outpatient services and have more hospitalizations than those with higher incomes (6), and patients who cannot speak English have difficulty achieving improvements in glycemic control that accompany effective provider-patient communication (7). Spanish-speaking patients who are limited to English-only services have poorer outcomes than those who receive language-appropriate care (8).

Because telephones are almost universally available (9,10), clinicians can use them to conduct health status assessments and provide self-care education for patients who have difficulty obtaining outpatient care. As part of a chronic disease management strategy, telephone services can improve outcomes (11,12) and decrease treatment costs (13). Telephone-supported diabetes care improves glycemic control (14,15). However, such programs can be labor-intensive and costly, and frequently are inaccessible to non-English speakers.

Automated calling systems represent a pragmatic and inexpensive way to improve telephone care. These systems use specialized computer technology to deliver messages and collect information from patients using their touch-tone keypad or voice-response technology. Automated telephone calls are acceptable to vulnerable patients, including non-English-speakers (16), and can be an effective way to monitor patients (17–20) and to promote behavior change (21–24).

We conducted a randomized, controlled trial of automated telephone assessment and self-care education calls with nurse follow-up among diabetic patients treated in a public health care system to determine whether this intervention could improve self-care, glycemic control, and symptoms.

From the Center for Health Care Evaluation/HSR&D Field Program (JDP, CAM) VA Palo Alto Health Care System, Palo Alto, California; Department of Health Research and Policy (JDP), Stanford University, Stanford, California; Roudenbush VA Medical Center (MW), Indiana University School of Medicine, and Regenstrief Institute for Health Care, Indianapolis, Indiana; Department of Medicine (SJM), University of California, San Francisco, California; VA Palo Alto Health Care System (FBK), Palo Alto, California, and Stanford University School of Medicine, Stanford, California; Department of Endocrinology (LMC), Santa Clara Valley Medical Center, San Jose, California.

Supported by the Clinical Research Grants Program of the American Diabetes Association and by the Health Services Research and Development Service and Mental Health Strategic Health Group, Department of Veterans Affairs.

Requests for reprints should be addressed to John D. Piette, PhD, Center for Health Care Evaluation, VA Palo Alto Health Care System, Menlo Park Division (152), 795 Willow Road, Menlo Park, California 94025.

Manuscript submitted February 8, 1999 and accepted in revised form July 22, 1999.

0002-9343/00/$–see front matter
PII S0002-9343(99)00298-3

METHODS

Patient Enrollment

Participants were enrolled from two general medicine clinics of a county health care system. Research assistants reviewed medical records of patients with scheduled appointments to identify adults with a diagnosis of diabetes mellitus or an active prescription for a hypoglycemic agent. We excluded patients who were >75 years of age, had a diagnosed psychotic disorder, disabling sensory impairment, or life expectancy of <12 months, or whose primary language was neither English nor Spanish. For patients with some fluency in both languages, we identified their primary language using an established scale (25). Potentially eligible patients were interviewed to exclude patients who controlled their glucose levels without hypoglycemic medication, were newly diagnosed (<6 months), planned to discontinue receiving services from the clinic within the 12-month follow-up period, or did not have a touch-tone telephone. Informed consent procedures were conducted according to a protocol approved by the Institutional Review Boards at the medical center and Stanford University. Randomization was based on a table of randomly permuted numbers (26). Neither providers, research staff, nor prospective participants had knowledge of group assignment until the patient had consented to participate.

Description of the Intervention

The core of the intervention was a series of automated telephone assessments designed to identify patients with health and self-care problems (27). These assessments were used to focus the efforts of a diabetes nurse educator on patients experiencing the greatest problems. The automated telephone calls also were used to deliver targeted and tailored self-care education messages.

Automated telephone calls. The automated calling component of the intervention was developed and implemented using a Teleminder Model IV automated telephone messaging computer (Decision Systems, Los Altos, California). The calls consisted of hierarchically structured messages composed of statements and queries recorded in a human voice. All calls were outbound (ie, to the patients) and were placed at the times patients indicated were most convenient for them. Using up to six attempted calls, we sought to determine patients' health status biweekly with a 5- to 8-minute assessment. Patients interacted with the system using their touch-tone keypad; responses were stored and determined the subsequent content of the message. Each query included a check for invalid responses and a prompt instructing patients to correct out-of-range values. Intervention patients received no training other than the general description provided as part of the informed consent process and a one-page summary provided in their enrollment packets.

During each assessment, patients reported information about self-monitored blood glucose readings, self-care, perceived glycemic control, and symptoms of poor glycemic control, foot problems, chest pain, and breathing problems. Assessments periodically included additional questions addressing issues unlikely to change on a biweekly basis (eg, whether the patient had a retinal examination in the prior year). At the end of each assessment, patients were given the option to listen to a randomly cycling diabetes "health tip." Health tips were 30 to 60 seconds in length and were based on literature published by the Centers for Disease Control and Prevention and the American Diabetes Association. Patients also were given the option to participate in a 3- to 5-minute interactive self-care education module focusing on diet and weight control.

After participating in the intervention for several months, patients were offered additional automated self-care education calls that focused on glucose self-monitoring, foot care, and medication adherence. Within these calls, patients reported specific barriers to self-care (eg, no glucose monitoring strips) and received tailored education and advice. Within the medication adherence segment of the calls, patients were asked about their adherence to insulin, oral hypoglycemic medications, antihypertensive medications, and antilipidemic medications. For each type of medication, patients without adherence problems received positive feedback and reinforcement. Patients reporting less than optimal adherence were asked about specific barriers and were given advice about overcoming each barrier.

Telephone nurse follow-up. Each week, the automated assessment system generated reports organized according to the urgency of reported problems, and the nurse used these reports to prioritize patient contacts. During follow-up calls, the nurse addressed problems reported during the assessments and provided more general self-care education. The nurse was located outside of the clinics and had neither face-to-face contact with patients nor ready access to their medical records. She had access only to medical record data that were abstracted at enrollment, automated assessment reports, and her notes from prior telephone contacts.

The nurse also made periodic calls to follow up on issues discussed in a prior week or check on patients who rarely responded to the automated calls. A small number of contacts was initiated by patients using a toll-free telephone number. Depending on the nature and acuity of patients' problems, the nurse contacted their primary care physician via fax, voicemail, or pager.

Spanish translation. We used a standard translation procedure to produce Spanish-language versions of the automated telephone messages (28). A bilingual, bicultural, first-generation Mexican-American translated the messages into Spanish, and a second bilingual speaker independently translated them back into English. Differences between the original English version and the back-translation were resolved through discussions among the two translators and the principal investigator. Before using the messages in the trial, they were pilot tested with nonenrolled Spanish-speaking patients. The intervention nurse was competent, but not fluent, in conversational Spanish.

Usual Care

Patients assigned to the usual care control group had no systematic monitoring between clinic visits or reminders of upcoming clinic appointments. Providers used their discretion to schedule follow-up visits. Additional visits were scheduled at the patient's initiative. Although a telephone triage nurse, a diabetes education clinic, and an interpreter service were available at the study site, demand for these services often exceeded capacity.

Data Collection and Measures

Survey data. At baseline and 12 months, trained interviewers surveyed patients over the telephone in their native language. During the survey, it was not possible to ensure that interviewers were blinded to a patient's group assignment.

For glucose self-monitoring, foot inspection, and weight monitoring, we measured self-care using a 5-point Likert scale (0 = "never" to 5 = "daily"). Patients were considered to have a problem with medication adherence if they reported that they "sometimes forget to take their medication," "sometimes stop taking their medication when they feel better," or "sometimes stop taking their medication when they feel worse." Patients reported their perceived glycemic control using a 5-point scale ranging from 1 = "poor" to 5 = "excellent." Although an imperfect measure of glucose control, greater perceived control has a consistent association with lower glycosylated hemoglobin (Hb A_{1c}) and serum glucose levels, and fewer diabetes-related symptoms (29). In addition, patients' perceptions of glycemic control often reflect both their average control as well as their experience with periodic episodes of hyperglycemia and hypoglycemia. Perceived glycemic control may capture the difference between actual control of glucose levels and patient-specific goals that vary owing to patient age, comorbid conditions, and physician practice styles. Finally, perceived glycemic control is correlated with other important outcomes, such as health-related quality of life, in ways that Hb A_{1c} and serum glucose levels are not (30,31).

During their interviews, patients reported whether they experienced each of 22 diabetes-related symptoms in the prior week, including symptoms of hyperglycemia (eg, "frequent urination at night"), hypoglycemia (eg, "shakiness or weakness"), vascular problems (eg, "pain in the calf muscles when walking"), or other problems (eg, "painful urination").

Medical record and laboratory data. At enrollment, we measured patients' height and weight wearing light clothing and calculated their body mass index (kg/m^2). Sociodemographic data were obtained at baseline from medical records and screening interviews. We abstracted information about active prescriptions, diabetes-related complications, and comorbid chronic diseases from medical records. Glycosylated hemoglobin and serum glucose levels were measured blindly at baseline and 12 months in a single laboratory. We used formulae provided by the manufacturer of the glycosylated hemoglobin assay to convert values to Hb A_{1c} units, with a normal range of 4.7% to 6.4%. We identified a priori both the mean Hb A_{1c} level and the proportion of patients within the normal range as outcomes.

Measures of health service use. Because it was unlikely that we would observe a decrease in resource use associated with improved glycemic control during the 12-month observation period, health service utilization was not a primary outcome. However, we monitored patients' inpatient and outpatient utilization to examine whether the intervention increased the appropriate use of preventive services such as retinal exams. Information about inpatient admissions was collected from the medical center's administrative databases and corroborated by patients' self-reports. We also were able to use these databases to identify podiatry clinic, ophthalmology clinic, and emergency department visits. We used patients' responses to survey questions to measure outpatient service use within the 6 months before their baseline and 12-month interviews.

Statistical Analysis

We used Student's *t* test, the chi-square test, and the Wilcoxon rank sum test to compare the baseline characteristics of intervention and usual care patients. Outcome analyses were conducted on an intent-to-treat basis, and all *P* values were two-tailed. Despite randomization, the intervention and usual care groups were not equivalent at baseline (eg, in terms of insulin use). To adjust for these differences, as well as for baseline values of endpoint measures, we used multivariate regression models, including ordinary least-squares regression for continuous outcomes and Likert scale scores, logistic regression for binary outcomes, and Poisson regression for symptom counts. The adjusted effects, with 95% confidence intervals, are presented.

RESULTS

Of the 588 patients identified as potentially eligible, 46 patients were excluded at the request of their physician,

Table 1. Sociodemographic and Clinical Characteristics of Intervention and Usual Care Patients at Enrollment

	Intervention (n = 124)	Usual Care (n = 124)	*P* Value
Sociodemographic characteristics			
Age (years)	56 ± 10	53 ± 10	0.07
Female gender	76 (61)	70 (56)	0.4
Race			0.7
White	36 (29)	36 (29)	
Hispanic	59 (47)	64 (52)	
Other	29 (23)	24 (19)	
Married	36 (29)	40 (32)	0.6
Living alone	22 (18)	18 (15)	0.5
Income <$10,000/year	73 (59)	71 (57)	0.7
Spanish speaking	30 (24)	34 (27)	0.6
Body mass index (kg/m^2)	34 ± 9	33 ± 8	0.6
Number of diabetic complications	1 (0–1)	1 (0–1)	0.6
Number of comorbidities	1 (1–3)	1 (0–2)	0.03
Self-care			
Glucose monitoring*	3.7 ± 1.7	3.5 ± 1.8	0.3
Foot inspection*	3.8 ± 1.5	4.2 ± 1.3	0.03
Weight monitoring*	1.8 ± 1.6	1.3 ± 1.4	0.007
Any medication problem	69 (56)	69 (56)	1.00
Glycemic control			
Hemoglobin A_{1c} level (percent)	8.8 ± 1.8	8.6 ± 1.8	0.3
Normal hemoglobin A_{1c} level†	10 (8)	9 (7)	0.8
Serum glucose (mg/dL)	233 ± 84	221 ± 106	0.4
Insulin	54 (44)	38 (31)	0.04
Self-reported control‡	2.7 ± 1.1	2.8 ± 1.1	0.5
Diabetic symptoms, median (interquartile range)			
All symptoms	5 (2–9)	5 (3–9)	0.7
Hyperglycemic symptoms	2 (1–4)	2 (1–4)	0.6
Hypoglycemic symptoms	1 (0–3)	2 (0–3)	0.4
Vascular symptoms	1 (0–1)	1 (0–2)	0.5
Other symptoms	1 (0–1)	1 (0–1)	0.9

Data shown as number (percent), mean ± SD, or median (interquartile range).
* 0 = never, 1 = <monthly, 2 = monthly, 3 = weekly, 4 = almost daily, 5 = daily.
† Less than 6.4%.
‡ 1 = poor, 2 = fair, 3 = good, 4 = very good, 5 = excellent.

148 declined participation, and 114 were not enrolled for some other reason (eg, they left the clinic before they could be approached). The remaining 280 patients were enrolled. Compared with patients who were potentially eligible but not enrolled, enrollees were somewhat more likely to be female (51% versus 59%, $P = 0.04$) and somewhat younger (mean age [± SD] 57 ± 10 years versus 55 ± 10 years, $P < 0.01$).

We collected outcome data at 12 months for 89% of enrollees (248 patients). Equal numbers of intervention and usual care patients failed to complete the study because they moved out of the area (7 patients in each group) or because they refused follow-up data collection (4 patients in each group). Fewer patients in the intervention group than in the usual care group died during the study (1 versus 4), and fewer were lost to follow-up (1 versus 4). In most respects, baseline characteristics of intervention and usual care patients were similar (Table 1). However, patients in the intervention group had more comorbidities, less frequent foot inspections, and more frequent weight monitoring. They were also more likely to be using insulin at baseline (44% versus 31%, $P = 0.04$).

Dose of the Intervention

Intervention patients completed an average of 1.4 automated assessment and self-care education calls each month (Table 2). Half of the patients completed 78% or more of their attempted assessments (interquartile range 44% to 91%). During completed assessments, patients reported their self-monitored blood glucose values an average of 80% of the time (median 86%, interquartile range 45% to 94%).

On average, patients had 6 minutes of nurse telephone contact per month. Most nurse contacts (72%) included

Table 2. Automated Telephone and Nurse Contact over the Year among Intervention Patients

	Total Contacts	Per Patient Contacts (Mean ± SD)
Automated telephone contacts		
Number of contacts of all types	2,123	17 ± 12
Number of assessment calls	1,631	13 ± 8
Home glucose readings	1,098	9 ± 8
Health tip selections	761	6 ± 6
Dietary module selections	574	5 ± 6
Number of self-care education calls	492	4 ± 5
Telephone nurse contacts		
Contacts of all types		
Total number of episodes	695	6 ± 4
Total time (minutes)	8,616	70 ± 13
Automated assessment follow-up		
Total number of episodes	319	3 ± 3
Total time (minutes)	4,233	34 ± 46
Other nurse-initiated contacts		
Total number of episodes	301	2 ± 2
Total time (minutes)	3,592	29 ± 31
Patient-initiated contacts		
Total number of episodes	75	1 ± 1
Total time (minutes)	791	6 ± 13

some discussion directly related to patients' glycemic control. Hypoglycemic medications (eg, adherence problems and side effects) were discussed in 45% of contacts, and glucose self-monitoring was discussed in 57% of contacts. In addition, nondiabetes medications were discussed in 32% of contacts, nondiabetic symptoms were discussed in 49% of contacts, and psychological problems, such as symptoms of depression and anxiety, were discussed in 18% of contacts.

Intervention Effects

In unadjusted analyses, intervention patients reported significantly better glucose self-monitoring, foot inspection, and weight monitoring at follow-up than did usual care patients ($P \leq 0.01$, Table 3). Intervention patients also were substantially less likely to report problems with medication adherence ($P = 0.003$). Adjusting for baseline values and insulin use had no appreciable effect on the differences in self-care between the two groups. After adjustment for baseline differences, the intervention decreased the proportion of patients with medication adherence problems by 21% (from 69% to 48%, $P = 0.003$).

Intervention patients had minimally lower Hb A_{1c} levels (0.1%) at follow-up than usual care patients. Adjustment for baseline levels and insulin use increased the magnitude of the estimated intervention effect to 0.3% ($P = 0.1$, Figure). In adjusted analyses, the intervention increased the proportion of patients with normal Hb A_{1c} levels by 9% (from 8% normal in the usual care group to 17% normal in the intervention group, $P = 0.04$). The intervention decreased serum glucose levels by 41 mg/dL ($P = 0.002$), and improved patients' self-reported glycemic control ($P = 0.005$). Among the patients using insulin at baseline, 50 (93%) of 54 intervention patients were still using insulin at follow-up compared with all 38 of the usual care patients. In addition, 2 of the 70 intervention patients and 6 of the 86 usual care patients who were using oral hypoglycemic agents at baseline were using insulin at follow-up.

In adjusted analyses (Table 3), symptoms of all types were less frequent at follow-up among intervention patients than among usual care patients. The greatest differences were in reported hyperglycemic and hypoglycemic symptoms.

During follow-up, 24% of intervention patients and 23% of usual care patients were hospitalized ($P = 0.9$); 48% of intervention patients and 40% of usual care patients were seen in the emergency department ($P = 0.2$). Similar proportions of intervention (22%) and usual care (26%) patients were seen in podiatry clinics ($P = 0.5$), and slightly more intervention (49%) than usual care (41%) patients were seen in ophthalmology clinics ($P = 0.2$). Intervention patients reported an average of three diabetes-related outpatient visits and six visits of all types during the final 6 months of follow-up, virtually identical to those among patients in the usual care group. Adjustment for prior visit rates and insulin use had no appreciable effect on the between-group comparison.

Subgroup analyses. Despite the small number of Spanish-speaking patients in the study, we observed signifi-

Table 3. Diabetes Self-Care, Glycemic Control, and Symptoms at Follow-Up among Intervention (n = 124) and Control (n = 124) Patients*

	Unadjusted Outcomes			Outcomes Adjusted for Baseline Values and Insulin Use				
	Intervention	Usual Care	*P* Value	Intervention	Usual Care	*P* Value	Difference	95% Confidence Interval
Self-Care								
Glucose monitoring†	4.2 ± 1.4	3.7 ± 1.7	0.01	4.1	3.7	0.03	0.4	0.04 to 0.7
Foot inspection†	4.7 ± 0.7	4.3 ± 1.3	0.006	4.7	4.4	0.02	0.3	0.1 to 0.6
Weight monitoring†	2.1 ± 1.7	1.6 ± 1.6	0.008	2.1	1.6	0.001	0.6	0.1 to 1.0
Any medication problem	55 (44)	78 (63)	0.003	48	69	0.003	−21	−34 to −7
Glycemic Control								
Hemoglobin A_{1c} level (percent)	8.2 ± 1.9	8.3 ± 1.9	0.8	8.1	8.4	0.1	−0.3	−0.7 to 0.1
Normal hemoglobin A_{1c} level‡	25 (20)	14 (11)	0.06	17	8	0.04	9	7 to 30
Serum glucose (mg/dL)	181 ± 68	220 ± 110	0.009	180	221	0.002	−41	−67 to −15
Self-reported control§	3.1 ± 1.1	2.8 ± 1.1	0.05	3.1	2.7	0.005	0.4	0.1 to 0.6
Diabetic Symptoms¶								
All symptoms	4 (1–7)	6 (3–10)	0.001	4.0	5.4	<0.0001	−1.4	−1.8 to −1.0
Hyperglycemic symptoms	1 (0–3)	2 (1–4)	0.003	1.6	2.3	0.0005	−0.7	−1.9 to −0.4
Hypoglycemic symptoms	1 (0–2)	2 (1–3)	0.002	1.1	1.6	0.001	−0.5	−0.7 to −0.2
Vascular symptoms	1 (0–1)	1 (0–2)	0.07	0.9	1.1	0.2	−0.2	−0.4 to 0.1
Other symptoms	0 (0–1)	1 (0–1)	0.11	1.0	1.3	0.07	−0.3	−0.6 to −0.0

* Unadjusted outcomes are reported as mean ± SD and adjusted outcomes as means, or unadjusted outcomes are number (percent) and adjusted outcomes are percent.

† 0 = never, 1 = <monthly, 2 = monthly, 3 = weekly, 4 = almost daily, 5 = daily.

‡ Less than 6.4%.

§ 1 = poor, 2 = fair, 3 = good, 4 = very good, 5 = excellent.

¶ Unadjusted outcomes are median count (interquartile range); adjusted outcomes are counts.

cant effects of the intervention on their glycemic control. The average endpoint Hb A_{1c} level among Spanish-speakers in the intervention group was 1.1% lower (95% confidence interval [CI] 0.2% to 1.9%) than among those in the usual care group, and six times as many intervention patients had normal Hb A_{1c} levels (18% versus 3%, $P = 0.05$). In addition, the mean serum glucose level at the end of follow-up was 71 mg/dL lower (95% CI 13 to 129 mg/dL) among patients in the intervention group, and intervention patients had 1.6 fewer symptoms (95% CI 0.0 to 3.2) than controls.

Among patients who reported at baseline that no physician had examined their feet in the prior 6 months (n = 77), those in the intervention group were somewhat more

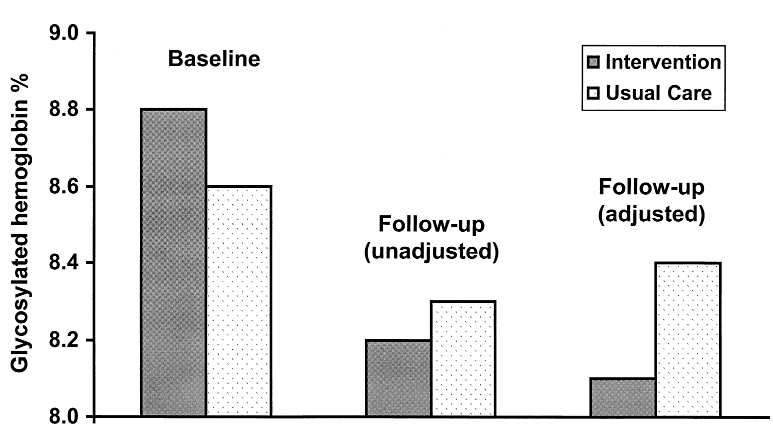

Figure. Mean glycosylated hemoglobin (Hb A_{1c}) levels among intervention and usual care patients. Adjusted follow-up means were calculated adjusting for baseline glycosylated hemoglobin levels and insulin use (any versus none).

likely to be seen in podiatry clinics during the study (19%) than those in the usual care group (7%, $P = 0.1$). Among patients who reported during their baseline survey that they had not had their eyes checked in the prior 6 months (n = 145), 57% of intervention patients were seen in ophthalmology clinics during the study compared with 37% of usual care patients ($P = 0.02$).

DISCUSSION

The results of this randomized, controlled trial suggest that automated telephone assessment and self-care education calls with nurse follow-up improved patients' self-care and glycemic control, and decreased their symptom burden. These improvements were achieved with an average of less than 6 minutes per month of nurse-patient contact. Through automated telephone assessments, the nurse was able to use time more judiciously, focusing on the patients who most needed assistance. The automated calling system also allowed patients to access language-appropriate self-care information and behavioral reinforcement.

Some of the greatest effects of the intervention were in the areas of self-reported glucose self-monitoring, foot inspection, and weight monitoring. Self-monitoring of glucose levels is an important component of diabetes self-care (32–34), although there have been only a few randomized trials of its effects on glycemic control among patients with type 2 diabetes (35). However, regular glucose self-monitoring is important for some patients, and many others may benefit during periods when they are at risk for poor control (eg, soon after a change in medication or during times of intercurrent illness). The benefits are most likely to be realized if self-monitoring is linked either to patient education or to medical intervention (eg, medication adjustment). The results of this study suggest that automated assessments with follow-up nurse telephone calls may be a useful strategy for linking self-monitoring to a clinical response.

Improved foot self-care results in fewer serious foot lesions and amputations (36,37). As with glucose self-monitoring, improvement in patients' foot self-care has the greatest effect on outcomes when it is linked to a provider-based intervention (38). The intervention evaluated in this study may provide a way to ensure that such linkages are possible.

We are not aware of any studies that have examined the independent effect of weight self-monitoring on health outcomes. However, behavioral programs that include weight self-monitoring can be moderately effective in decreasing obesity (39), and improvements for some patients have been large enough to have a long-term impact on glycemic control (40). With the advent of new drug therapies for obesity, weight self-monitoring may take on increased importance (41).

One of the unique contributions of this study is its implementation within a public health care system in which many patients have low incomes, little formal education, and psychosocial problems that complicate their diabetes care. Interventions such as the one we evaluated may improve public providers' ability to serve more patients using fewer staff. It also is encouraging that this system appeared to be effective in improving outcomes among Spanish-speaking patients, whose outcomes often are especially poor. Circumventing language barriers may be one way that interventions such as this one may improve patient outcomes.

Several limitations of this study must be considered. It was conducted at a single site, and telephone nursing services were provided by a single nurse. We are now performing a similar trial in a Department of Veterans Affairs health care system. Finally, many of the outcomes in this study were self-reported, and patients in the intervention group may have reported more favorable outcomes than actually occurred.

This study does not suggest that automated patient surveillance and education can replace clinical vigilance or the provider-patient relationship that is central to diabetes care. Automated systems are a way to augment service delivery in primary care. At the heart of the encounter between a patient and a clinician is the ability to uncover problems that may have gone unrecognized by patients and unanticipated by even the most sophisticated automated assessment algorithm (42). The provider-patient relationship itself is therapeutic, and lack of such a relationship can lead to poor adherence and dissatisfaction with care (43). With these caveats, we conclude that diabetes care supported by automated telephone assessments and patient education may be an effective means of improving vulnerable patients' self-care and glycemic control, and decreasing their symptoms.

ACKNOWLEDGMENTS

We thank Eunice Coeter and the clinicians and patients of the Moorpark Clinics, Santa Clara Valley Medical Center; Carol Gangitano, MSN, for her contribution as intervention nurse; and Edgar O. Alvarez, Dara J. Amboy, and Vivian Schiedler for assistance with translation, data collection, and data processing.

REFERENCES

1. The Diabetes Control and Complications Trial Research Group. The effect of intensive treatment of diabetes on the development and progression of long-term complications in insulin-dependent diabetes mellitus. *NEJM.* 1993;329:977–986.
2. The Diabetes Control and Complications Trial Research Group. Lifetime benefits and costs of intensive therapy as practiced in the diabetes control and complications trial. *JAMA.* 1997;278:25.
3. UK Prospective Diabetes Study (UKPDS) Group. Intensive blood-glucose control with sulphonylureas or insulin compared with con-

ventional treatment and risk of complications in patients with type 2 diabetes (UKPDS 33). *Lancet.* 1998;352:837–853.
4. UK Prospective Diabetes Study (UKPDS) Group. Effect of intensive blood-glucose control with metformin on complications in overweight patients with type 2 diabetes (UKPDS 34). *Lancet.* 1998; 352:854–865.
5. Kurtz SM. Adherence to diabetes regimens: empirical status and clinical implications. *Diabetes Educ.* 1990;16:50–59.
6. Bindman AB, Grumbach K, Osmond D, et al. Preventable hospitalizations and access to health care. *JAMA.* 1995;274:305–311.
7. Greenfield S, Kaplan SH, Ware JE, et al. Patients' participation in medical care: effects on blood sugar control and quality of life in diabetes. *J Gen Intern Med.* 1988;3:448–457.
8. Perez-Stable EJ, Napoles-Springer A, Miramontes JM. The effects of ethnicity and language on medical outcomes of patients with hypertension or diabetes. *Med Care.* 1997;35:1212–1219.
9. Anderson JE, Nelson DE, Wilson RW. Telephone coverage and measurement of health risk indicators: data from the National Health Interview Survey. *Am J Public Health.* 1998;88:1392–1395.
10. *Phoneless in America.* (Statistical Brief). Washington, DC: US Bureau of the Census; 1994:94–16.
11. Weinberger M, Tierney WM, Booher P, Katz BP. Can the provision of information to patients with osteoarthritis improve functional status? A randomized, controlled trial. *Arthritis Rheum.* 1989;32: 1577–1583.
12. Debusk RF, Houston Miller N, Superko HR, et al. A case-management system for coronary risk factor modification after acute myocardial infarction. *Ann Intern Med.* 1994;120:721–729.
13. Wasson J, Gaudette C, Whaley F, et al. Telephone care as a substitute for routine clinic follow-up. *JAMA.* 1992;267:1788–1793.
14. Weinberger M, Kirkman MS, Samsa GP, et al. A nurse-coordinated intervention for primary care patients with non-insulin-dependent diabetes mellitus: impact on glycemic control and health-related quality of life. *J Gen Intern Med.* 1995;10:59–66.
15. Aubert RE, Herman WH, Waters J, et al. Nurse case management to improve glycemic control in diabetic patients in a health maintenance organization. A randomized, controlled trial. *Ann Intern Med.* 1998;129:605–612.
16. Tanke ED, Leirer VO. Automated telephone reminders in tuberculosis care. *Med Care.* 1994;32:380–389.
17. Christ G, Siegel K. Monitoring quality-of-life needs of cancer patients. *Cancer.* 1990;65:760–765.
18. Searles JS, Perrine MW, Mundt JC, et al. Self-report of drinking using touch-tone telephone: extending the limits of reliable daily contact. *J Stud Alcohol.* 1995;56:375–382.
19. Mahoney D, Tennstedt S, Friedman R, Heeren T. An automated telephone system for monitoring the functional status of community-residing elders. *Gerontologist.* 1999;39:229–234.
20. Piette JD, Mah CA. The feasibility of automated voice messaging as an adjunct to diabetes outpatient care. *Diabetes Care.* 1997;20:15–21.
21. Leirer VO, Morrow DG, Pariante G, et al. Increasing influenza vaccination adherence through voice mail. *J Am Geriatr Soc.* 1989;37: 1147–1150.
22. Friedman RH. Automated telephone conversations to assess health behavior and deliver behavioral interventions. *J Med Syst.* 1998;22: 95–102.
23. Dini EF, Linkins RW, Chaney M. Effectiveness of computer-generated telephone messages in increasing clinic visits. *Arch Pediatr Adolesc Med.* 1995;149:902–905.
24. Leirer VO, Morrow DG, Tanke ED, et al. Elders' nonadherence: its assessment and medication reminding by voice mail. *Gerontologist.* 1991;31:514–520.
25. Marin G, Sabogal F, Marin BV, et al. Development of a short acculturation scale for Hispanics. *Hispanic J Behav Sci.* 1987;9:183–205.
26. Fleiss JL. The Design and Analysis of Clinical Experiments. New York: Wiley & Sons; 1986:390–416.
27. Piette JD. Moving diabetes management from clinic to community: development of a prototype based on automated voice messaging. *Diabetes Educ.* 1997;23:672–679.
28. Brislin RW, Lonner WJ, Thorndike EM. Cross-Cultural Research Methods. New York: Wiley & Sons; 1973.
29. Piette JD, McPhee SJ, Weinberger M, et al. Use of automated telephone disease management calls in an ethnically diverse sample of low-income patients with diabetes. *Diabetes Care.* 1999;22:1302–1309.
30. Weinberger M, Kirkman MS, Samsa GP, et al. The relationship between glycemic control and health-related quality of life in patients with non-insulin-dependent diabetes mellitus. *Med Care.* 1994;32:1173–1181.
31. The Diabetes Control and Complications Trial Research Group. Influence of intensive diabetes treatment on quality-of-life outcomes in the Diabetes Control and Complications Trial. *Diabetes Care.* 1996;19:195–203.
32. Butler RN, Rubenstein AH, Gracia AG, Zweig SC. Type 2 diabetes: patient education and home glucose monitoring. *Geriatrics.* 1998; 53:60–67.
33. Consensus Panel Statement. Self-monitoring of blood glucose. *Diabetes Care.* 1996;19(suppl 1):S62–S66.
34. Walker EA, Cypress ML. Self-monitoring: the patient-practitioner alliance. *Nurse Pract Forum.* 1991;2:175–177.
35. Faas A, Schellevis FG, Van Eijk JTM. The efficacy of self-monitoring of blood glucose in NIDDM subjects: a criteria-based literature review. *Diabetes Care.* 1997;20:1482–1486.
36. Malone JM, Snyder M, Anderson G, et al. Prevention of amputation by diabetic education. *Am J Surg.* 1989;158:520–524.
37. Pieber TR, Holler A, Siebenhofer A, et al. Evaluation of a structured teaching and treatment program for type 2 diabetes in general practice in a rural area of Austria. *Diabet Med.* 1995;12:349–354.
38. Mayfield JA, Reiber GE, Sanders LJ, et al. Preventive foot care in people with diabetes. *Diabetes Care.* 1998;21:2161–2177.
39. Maggio CA, Pi-Sunyer FX. The prevention and treatment of obesity: application to type 2 diabetes. *Diabetes Care.* 1997;20: 1744–1766.
40. Wing RR, Koeske R, Epstein LH, et al. Long-term effects of modest weight loss in type 2 diabetic patients. *Arch Intern Med.* 1987;147: 1749–1753.
41. Hollander PA, Elbein SC, Hirsch IB, et al. Role of Orlistat in the treatment of obese patients with type 2 diabetes. A 1-year randomized double-blind study. *Diabetes Care.* 1998;21:1288–1294.
42. Naylor CD. Grey zones of clinical practice: some limits to evidence-based medicine. *Lancet.* 1995;345:840–842.
43. Leopold N, Cooper J, Clancy C. Sustained partnership in primary care. *J Fam Pract.* 1996;42:129–137.